

REALIZING OPPORTUNITIES FOR THE 21ST CENTURY THROUGH RESILIENT GLOBAL VALUE CHAINS

MINING & CONSTRUCTION



Large open-pit iron mine
located in Europe



REALIZING OPPORTUNITIES OF THE 21ST CENTURY THROUGH RESILIENT GLOBAL VALUE CHAINS

By 2030, growing population, increasing urbanization rates, e-mobility and increased dependence on electronics will boost demand across the mining and construction sectors. New technologies and disruptive innovations will drastically change the current landscape – autonomous vehicles, IoT connectivity, robotics and 3D printing will become the norm.

In addition the coronavirus pandemic and the Great Lockdown is likely to considerably shape the future of the Mining and Construction industry. The effects of the pandemic on economies will persist in the short, medium, and long term affecting specific-industry trends and thus changing the landscape of many industries. The pandemic will likely have a dual impact on the Mining & Construction industry: in the short run the effect is mixed whereas, in the long run, the expected future trend will need a deeper understanding of the complex value chains to ensure rebuilding resilient value chains in IsDB member countries.

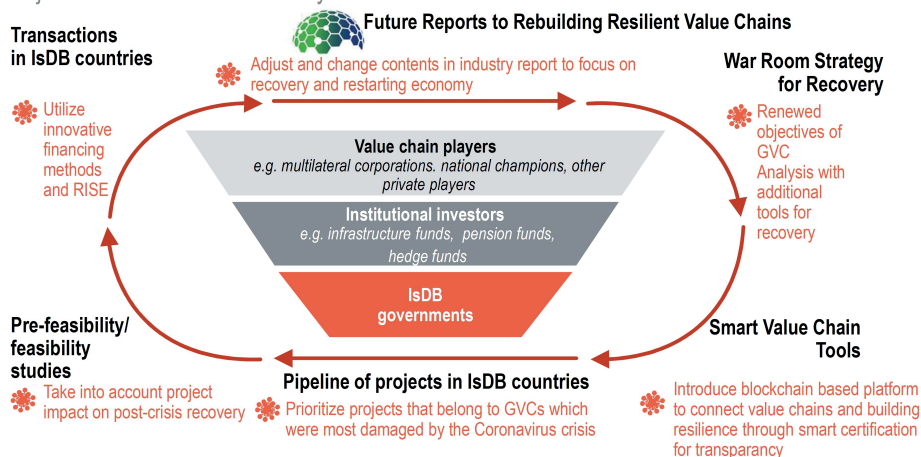
IsDB Member Countries need to take action now to create additional value from their abundant resources, increase their productivity and transform their business models

in order to support stable growth and innovation. Within this report, IsDB offers an in-depth view on key trends and initiatives that will shape the future of its 57 members until 2030 and beyond.

These initiatives require strong partners who jointly drive investments and disseminate knowledge in IsDB Member Countries. Looking ahead, such investments will unlock IsDB Member Countries' potentials for adequate employment and equitable living conditions, while providing private sector partners access to some of the fastest growing economies worldwide.

To create and sustain a virtuous cycle for partnership and investment, the IsDB adopted a new business model that aims to Make Markets Work For Development. The new business model integrates strategic programming at the global level, country level, and even operations level. The Figure below is a demonstration of this integrated approach.

Adjusted New Business Model cycle





Dr. Bandar M. H. Hajjar

FOREWORD

A MARKET OF POTENTIALS – 57 COUNTRIES OFFERING GROWTH AND INVESTMENT POTENTIAL ACROSS A SET OF CORE INDUSTRIES

In a context of global pandemic, as IsDB member countries respond to the crisis, they must also prepare their economies for the medium and long-term scenarios, as the health crisis is likely to, structurally, affect many industries. Member countries must adapt and adjust their industrial policies to be future-ready and maximize benefits from their keys industries under rapidly changing technological trends.

IsDB's 57 Member Countries include many of the fastest growing economies worldwide. Jointly, IsDB Members represent the purchasing power of almost one quarter of the world's population. The joint GDP of IsDB Members amounts to roughly 7 trillion USD. With GDP growth rates of up to 8% per year, the economies of IsDB's Member Countries have much potential to further increase their market share in the global economy.

IsDB has identified a set of core industries, in which its members offer distinguished competitive advantages. Mining and construction industries are considered core since they the engines of many of IsDB Member Countries' economies. IsDB Member Countries hold vast mineral reserves. These countries account for 11 percent of global mining production but are home to 15 percent of global mineral reserves. On the mining side, most Member Countries have great potential to unlock significant value-add for their economies by expanding into processing and manufacturing of minerals. On the construction side, they can reap the benefits of large employment opportunities from the industry, especially given many are resource-rich in construction minerals.

In addition, the general trend of the mining and construction industry is favorable. The industries account for around 15 percent of annual global GDP, contributing approximately USD 13 trillion in total. In 2018, the worldwide construction industry alone provided employment for almost 200 million people.

DRIVING DEVELOPMENT, GROWTH AND INNOVATION TOGETHER – A NEW APPROACH TO DOING BUSINESS WITH THE ISLAMIC DEVELOPMENT BANK

The President's 5-year program (P5P) puts an emphasis on strengthening the competitiveness of Member Countries in strategic industries through public investments and private resource mobilization. To sustainably drive modernization and growth, IsDB positions strong partnerships between the private and public sectors at the core of its strategy. IsDB aims to mobilize various partners to collaborate on a strategic basis to promote the competitiveness of the mining and construction industries. Multilateral development institutions can participate in the co-financing of mega projects, especially for energy in mining while private investors can provide targeted FDI in a fair and win-win partnership with member countries. In all these cases, IsDB can be a catalyst and a central focal point for fruitful collaboration.

With its sector insights provided and its critical view on the challenges as well as on the opportunities and potentials ahead, this futures report provides a valuable base line and starting point for future collaborations.

IsDB



البنك الإسلامي للتنمية
Islamic Development Bank

EXPOSITION

The Year 2020 marks a key milestone for globalization forcing the world nations to make an important choice: “To Deglobalize” or “To Reglobalize”. In light of the expansion of protectionism globally, the steady increase in the population with at least 40 million young men and women annually entering the job market, and the acceleration of structural challenges as a result of the fourth industrial revolution and the Covid-19 pandemic, the world sits at a crossroad with major trade-offs to make.

This publication belongs to a series of publications that aim to create a feasible pathway for Reglobalization or the active evolution and reform of globalization by world leaders to make it more Resilient, Smart, and Inclusive. This book demonstrates, for instance, how resilience in Global Value Chains can be achieved while maintaining optimal efficiency. By capitalizing on the intrinsic comparative advantage of developing countries, global markets can have alternatives that are as efficient in times of crisis. This not only makes globalization more resilient but also inclusive of nations that have been left behind historically.

The Future is a series of publications, led by the IsDB Department of Strategy and Transformation (DoST), dedicated to forecasting economic trends, emerging global priorities, and helping Member Countries to be better prepared to meet them. The chief aim of the series is to help create global coalitions that are driven by a shared vision of the future of humanity and the world.

Dr. Ahmed Elkhodary
Director of Strategy and Transformation
Islamic Development Bank (IsDB)

EXECUTIVE SUMMARY

The mining and construction sectors are fundamental to many IsDB economies. Adopting a forward-looking industrial policy can enable member countries to capture more value from mining and construction through higher revenue, more diversified economy, and an increased number of skilled jobs.. If decisive action is taken today, especially under a context of a volatile global economy, by 2030 IsDB Member Countries can ...

- ... capitalize on the overall growth of both industries, expected to cumulatively expand by 7 trillion and account for c. 17% of global GDP, compared to the c. 15% today
- ... create additional skilled jobs, both directly and indirectly attributable to the industries – expansion into processing can triple the number of employees in the sector
- ... unlock more from their mineral potential by increasing global production levels from the current c. 11% to c. 15% – equivalent to the IsDB share of global reserves
- ... turn the existing IsDB construction trade deficit into a surplus

HOW WILL THE INDUSTRY LOOK LIKE WITH THE GLOBAL PANDEMIC

Disruption is inevitable – several innovative technologies and techniques will enhance productivity

- The mines of the future will be smart – advanced analytics and Internet of Things (IoT) will enable data-driven decision making, and autonomous vehicles, robotics and workforce augmentation will become the norm
- The coronavirus pandemic is likely to put a renewed focus on preventing natural volatilities thus accelerating the already existing environment sustainability trends in both mining and construction. Political pressure is like to nudge all industry stakeholders towards a higher willingness to accelerate these trends.
- Stronger overall emphasis on environmental impact and sustainable development – stricter regulations will be enforced, while new separation techniques will be enabled by advancements in molecular science and bioengineering

- Construction will rely on more productive solutions (e.g. 3D printing and modular construction) to gradually phase out manual labor and traditional methods – equipment such as exoskeleton suits will augment human capabilities
- Widespread adoption of Building Information Modeling will allow for digital connectivity and improved collaboration between key stakeholders across the construction lifecycle

Increased reliance on critical minerals/ materials will boost demand across the mining and construction sectors

- Growing population and increasing urbanization levels will drive demand across both sectors – in a 2030 outlook, the construction industry is projected to increase by 50 percent
- E-mobility developments, shifting consumer trends and increased dependence on electronics will reiterate and increase the importance of mining
- Metals such as nickel will play a critical role in EV batteries, while aluminum production needs to satisfy the increased reliance on lightweight materials from the aviation and automotive industries – demand surges expected

MINING AND CONSTRUCTION SECTORS – WHERE ARE ISDB MEMBER COUNTRIES NOW?

IsDB Member Countries hold vast mineral reserves but often remain untapped – significant potential to increase production

- IsDB Member Countries account for 11 percent of global mining production but are home to 15 percent of global mineral reserves – further opportunities stem from enhancing exploration activities (e.g. via deep earth imaging)
- High reserves-to-production ratios allow for mining production increases across several IsDB Member Countries without compromising the long-term sustainability of the industry – West Africa is one of the main reservoirs of untapped reserves



HOW READY ARE ISDB MEMBER COUNTRIES FOR THE FUTURE?

Most IsDB Member Countries show a strong focus on extraction – potential to unlock additional value by expanding into processing and even manufacturing

- Mineral-rich countries should pursue downstream integration – degree of processing depth depends on key competitive advantages (e.g. affordable energy)
- Establishing manufacturing and processing facilities (i.e. upstream integration) is viable for countries with high levels of domestic/ regional consumption, even in the absence of mineral resources
- Value chain expansion into processing will lead to an increase in domestic workforce qualification due to the specific technical skills required - however, additional employment in processing will be offset by increased automation in mining



HOW TO UNLOCK THE POTENTIAL OF ISDB COUNTRIES IN A HIGHLY VOLATILE WORLD?

There are several opportunities to turn the key challenges of IsDB Member Countries into competitive advantages

- Renewable energy generation is a cost-effective and sustainable solution to meet the high energy demand of the mining and construction sectors
- IsDB Member Countries display vast potential in renewables, such as solar and hydro – alternative financing models (e.g. BOOT and PPA) could bridge the investment gap

- Major improvements in the construction sector also possible by adopting energy-efficient solutions and alternative fuels; the latter can lower CO₂ emissions by up to 40% in energy-intensive materials (e.g. cement), reduce costs and drive the circular economy

IsDB Member Countries should take a stance as either early adopters or innovation leaders – groundbreaking solutions often create competitive advantages

- Development of extensive know-how in targeted technological innovations envisaged – 3D printing is a potential solution for affordable housing
- Investments in innovation hubs/centers should be pursued – providing the collaboration platform as well as incentives for SMEs and startups to operate
- Strong government commitment required by incorporating innovation as part of the countries' national strategy

Private sector is crucial to development of the mining and construction sectors across IsDB Member Countries – new collaboration models will help share risk and unlock growth potential

- Collaboration between IsDB Member Countries can unlock their full potential, thereby driving socio-economic growth, by leveraging country-specific advantages and collectively overcome inherent development barriers
- Unlocking private investment will require fair risk-sharing in large-scale projects and increased regulatory stability; easier access to financing for smaller players and the intelligent allocation of knowledge and capital (“smart finance”) to the sectors with highest potential will foster innovation

KEY QUESTIONS TO BE ANSWERED BY THE PUBLICATION

How will the Industry look like
with the Global Pandemic?

How and where is value
being created in the global
mining and construction
sectors? – And how are IsDB
Member Countries positioned in
the market?

How can public and private
players work together to
spark sustainable, equitable
and profitable sector growth
in all IsDB Member Countries?

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A photograph of a construction site with a crane and a building under construction. The image is framed by a red diagonal line pattern on the left and bottom. A white text box is overlaid on the bottom left of the image.

Worker making use of virtual
reality technology on a construction site



1

**HOW WILL THE
INDUSTRY LOOK
LIKE WITH THE
GLOBAL
PANDEMIC?**

The Global Pandemic will reshape global demand for mining and construction

Growing population and increasing urbanization levels will drive demand across both sectors, while shifting consumer behavior is expected to boost demand and criticality for minerals. However, the pandemic shock is also likely to structurally shift consumption patterns and labor market habits, thus impact the path of future industry trends. IsDB Member Countries must stand ready to adapt and build resilient value chains.

Improved productivity through full automation of large-scale mines

Technological innovations such as autonomous vehicles, robotics and workforce augmentation expected to become the norm
Increased reliance on advanced analytics and Internet of Things (IoT) will enable data-driven decision making

Widespread adoption of innovative and digitally integrated construction methods

Highly productive solutions (e.g. 3D printing and modular construction) will gradually phase out traditional construction methods

Widespread adoption of Building Information Modeling will tackle complexity across the construction lifecycle

Emphasis on improving environmental footprint

Alleviating mining impact through stricter regulation, gradual shift to renewable energy sources and increasing focus on recycling

Reducing footprint in the construction sector by adopting energy-efficient solutions and alternative fuels

Low industrialization levels as main hurdle, despite a more broad spectrum of challenges

Under-developed industrialization levels to be improved by addressing investment gaps, poorly developed infrastructure and inadequate workforce qualification

1.1

GLOBAL TRENDS AND THEIR IMPACT ON THE MINING AND CONSTRUCTION SECTORS

The coronavirus pandemic and the Great Lockdown since early 2020 has severely affected the global economy with short-term, medium-term and long-term consequences on many industries. The health crisis has created severe economic crisis across the globe. The immediate impact of the crises are loss of life, job losses, and trillions of dollars of lost production, leading to deep recessions in most countries. However, the effects of the pandemic on economies are likely to persist in the short, medium, and long term affecting specific-industry trends and thus changing the landscape of some economic sectors

The pandemic will likely have a dual impact on the Mining & Construction industry: in short run the effect is mixed whereas in the long run the expected future trend will likely accelerate.

The pandemic-induced global crisis hit the construction industry hard. Both residential and nonresidential construction is likely to experience an immediate negative impact as retail companies and small businesses struggle. Infrastructure construction is expected to slowdown as public debt mount in the face of large recession spending. More specifically, demand for construction materials such as cement, iron & steel, glass, and

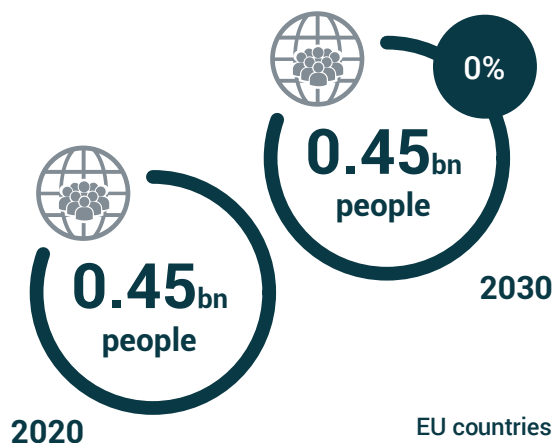
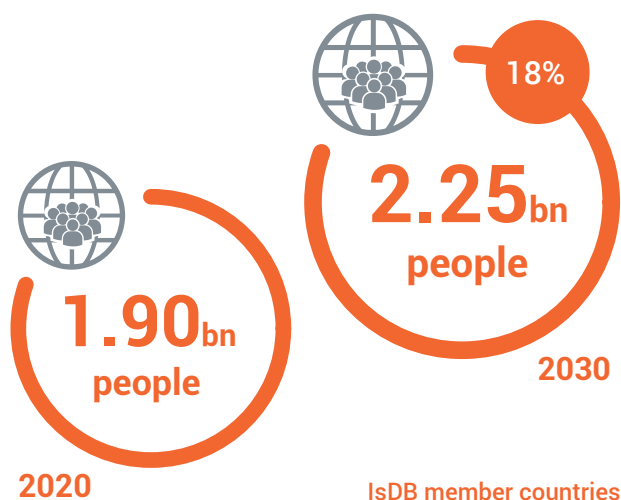
ceramics, will fall; which will likely hurt more severely production of cement and iron & steel in IsDB member countries where there is already production overcapacity.

The immediate impact on the Mining industry is however mixed. As disruptions in supply with mine closures and disruption in world demand as the pandemic continues price volatility will persist. The shock on mining affects many member countries producing metals such as nickel, aluminum, manganese, zinc, cobalt, tungsten, lead, copper, tin and rare earth metals; precious metals (gold, silver and platinum); and diamond. However, falling energy prices may dampen the negative shock given the industry's energy costs are substantial (lowering marginal costs of production).

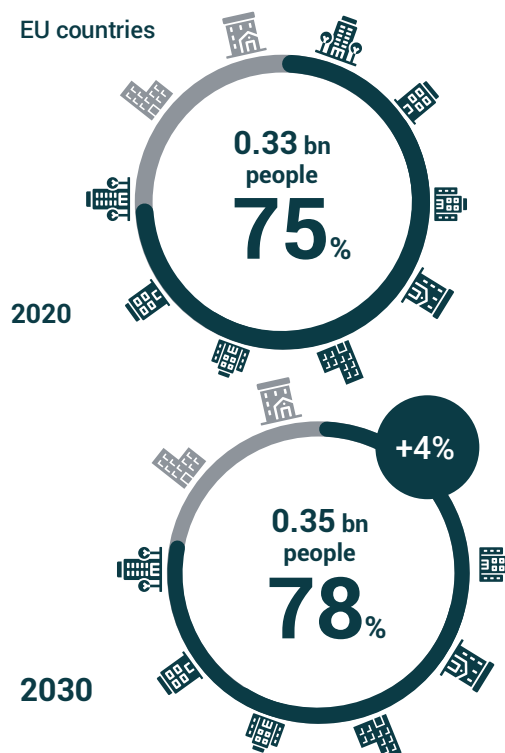
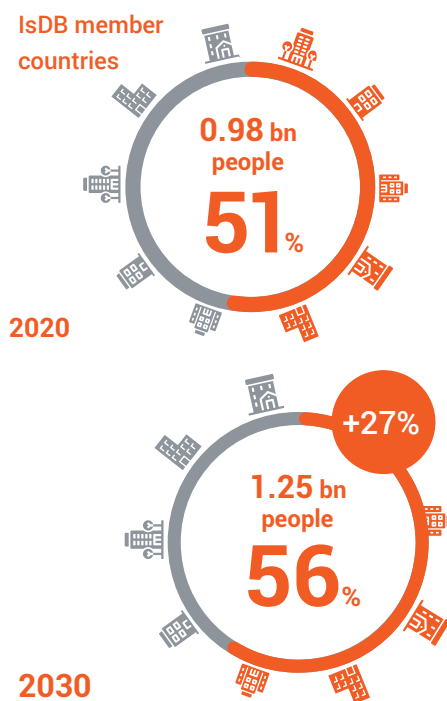
Overview of Mining and Construction sectors

The mining and construction sectors power a large share of the world's economy. Together, these two sectors account for around 15 percent of annual global GDP, contributing approximately USD 13 trillion in total. Over the coming decade, both industries are expected to be shaped by a number of megatrends ranging from population growth and greater environmental awareness to rapid advances in technology and digitization. They will ultimately reshape both the demand structure and the manner in which companies deliver value.

Population growth, 2020-2030



Share of urban population [%], 2020-2030



Inevitably, the megatrends will also give rise to a number of urgent challenges for countries, but also open up new avenues or opportunities for stakeholders along the value chain. In many cases, IsDB member countries will need to introduce structural changes in response: vertical integration, shifting their focus to more value-adding segments, developing new business models, to name just a few. As part of the current section, the trends and some of their potential implications are explored in greater detail, with the aim of depicting one facet of the future industry landscape.

POPULATION GROWTH

The global population is expected to grow from 7.8 billion to 8.6 billion by 2030. With an increasing number of people, the demand for housing and consumer goods is also augmented – growth will be evident for items such as nickel-based batteries, copper-based electronics and steel-based infrastructure. In turn, the increased demand translates into a sizeable increase in overall capital investment in manufacturing facilities.

IsDB member countries account for around a quarter of the global population and approximately 44 percent of forecasted growth. To put this roughly into context, for every additional person in developed countries, roughly 60 other individuals will originate from developing countries. Between 2020-2030, IsDB member countries will outpace

the average world population increase by around 10 percent. In this regard, Nigeria, Pakistan and Indonesia are the leaders in terms of population size, among IsDB member countries. Going forward, significant growth is expected to be observed across Sub-Saharan Africa, Asia and Latin America, regions that already face significant challenges in terms of basic infrastructure and living standards.

INCREASING URBANIZATION

Around 60 percent of the global population will be city-dwellers by 2030, compared to 56 percent today. Cities occupy just three percent of the Earth's surface area but account for 60 to 80 percent of energy consumption and at least 70 percent of carbon emissions. They also produce more than three-quarters of global GDP.

Sustainable development requires a transformation of the way raw materials needed for urban spaces are sourced and a rethinking of the way the building process is performed. Fast-growing cities rely on adequate infrastructure, which puts pressure on the construction sector. At the same time, increasing the level of basic services – access to clean water and a reliable electricity supply, for example – requires more minerals and construction materials. Looking forward, growing urban and intra-urban mobility needs will also drive further demand for electric vehicles, trains, airplanes, as well as potentially drones reflecting a higher need for metals.

GLOBAL TRENDS AND THEIR IMPACT ON THE MINING AND CONSTRUCTION SECTORS

GROWING ENVIRONMENTAL AWARENESS

Scientists agree that human activity is a major factor contributing to climate change. The regional impacts of climate change however, differ. In Africa, scarcity of freshwater is likely to increase, while in Oceania natural disasters are expected to grow in both magnitude and frequency.

Growing environmental awareness, tighter legislation and more effective enforcement are likely to have a strong impact on both the mining and construction industries. Furthermore, the proliferation of adverse environmental impact as a result of industrial activities can also provoke social unrest, which can act as a catalyst for change. Mining strikes across some of the IsDB member countries are illustrative in this respect.

CHANGING CONSUMER BEHAVIOR

Shifts in consumer behavior are influencing the mining and construction industries: higher spending power requires greater input of minerals for the manufacturing of electronics and durable goods, while sustainable business models shift the value potential towards processing and refurbishing.

At the global level, the adjusted spend per capita has grown by more than 30%, in the last decade. Part of this spend is increasingly directed towards electronics. In addition, the prevalence of sharing economy models for urban transportation augments the demand for electric vehicles (e-cars, e-scooters, e-bikes). All of these require more minerals such as nickel for batteries, copper for wires and motor windings, aluminum for structural elements.

In the same time, consumers are slowly shifting towards sustainable consumption models due to increased environmental awareness. Equally, companies are facing

increased pressure from authorities to optimize the environmental footprint. Also driven by economic incentives (e.g. steel more cost efficient to recycle), growing recycling rates will tilt the value creation balance more towards processing, rather than extraction, in the mining sector. In construction, refurbishments aimed at higher energy efficiency can further diversify the revenue streams and contribute to the sector's growth.

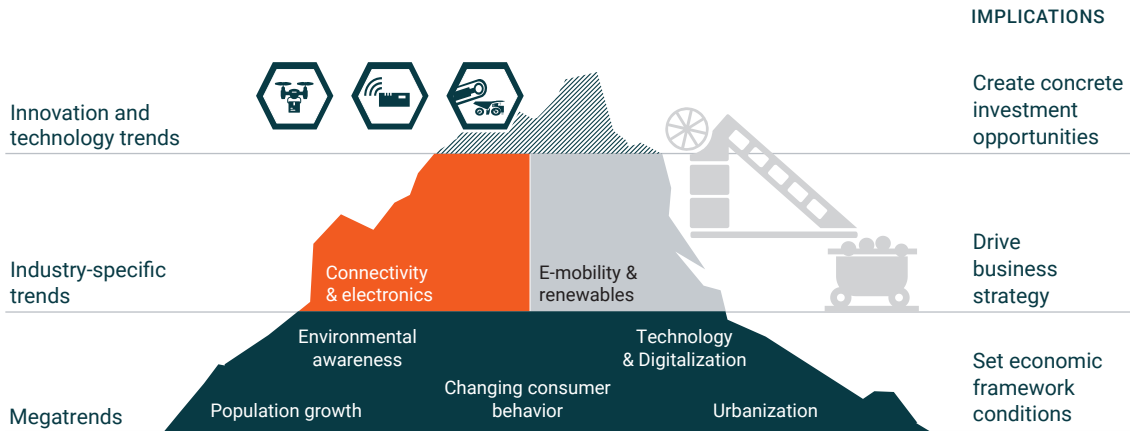
ADVANCES IN TECHNOLOGY AND DIGITALIZATION

Technology is increasingly permeating every aspect of society. By 2030, it is expected that three-quarters of people around the globe will be connected via the Internet, compared with just half today. On-the-go access technology such as tablets and smartphones will further drive this trend. For the mining and construction sectors this means greater transparency and almost uninterrupted access to key information on-site, such as miners using GPS positioning. The connectivity also facilitates greater workforce mobility, as construction workers in developing countries learn about employment opportunities in more developed countries with labor shortages, for instance.

Digitalization is changing the fabric of business processes in mining and construction, as it is the case with many other industries as well. Today, mining in most developed economies involves complex coordination of machinery and human operators, but humans are still in the driver's seat. Advances in technology and digitalization mean that decisions will increasingly be taken automatically using artificial intelligence based on data algorithms, fundamentally reshaping operations.

Focus on: Mining

Industry-specific trends in Mining



How is the mining industry expected to develop in the decade to 2030 and beyond? Two major trends can be regarded as meaningfully driving up demand: the increased use of electronics built around the Internet of Things (IoT), and the expansion of e-mobility and renewable energy.

The trend toward incorporating more and more **electronics** into manufactured goods is forecast to accelerate, driven by what is known as "Industry 4.0" – the fourth revolution in manufacturing, involving the use of interconnected smart systems, machine-learning, advanced analytics, augmented reality, artificial intelligence and the like. The enhanced connectivity offered by 5G technology, for example, requires metals with low electrical resistance.

As urbanization and the trend towards "smart houses" continue, electronics will be embedded in an ever-wider range of items. Testing has begun already on a range of initiatives being tested that aim to tackle the everyday problems of urban life, such as traffic congestion, pollution, crime and the high cost of living. The scope of such solutions is likely to expand over the coming decade and beyond.

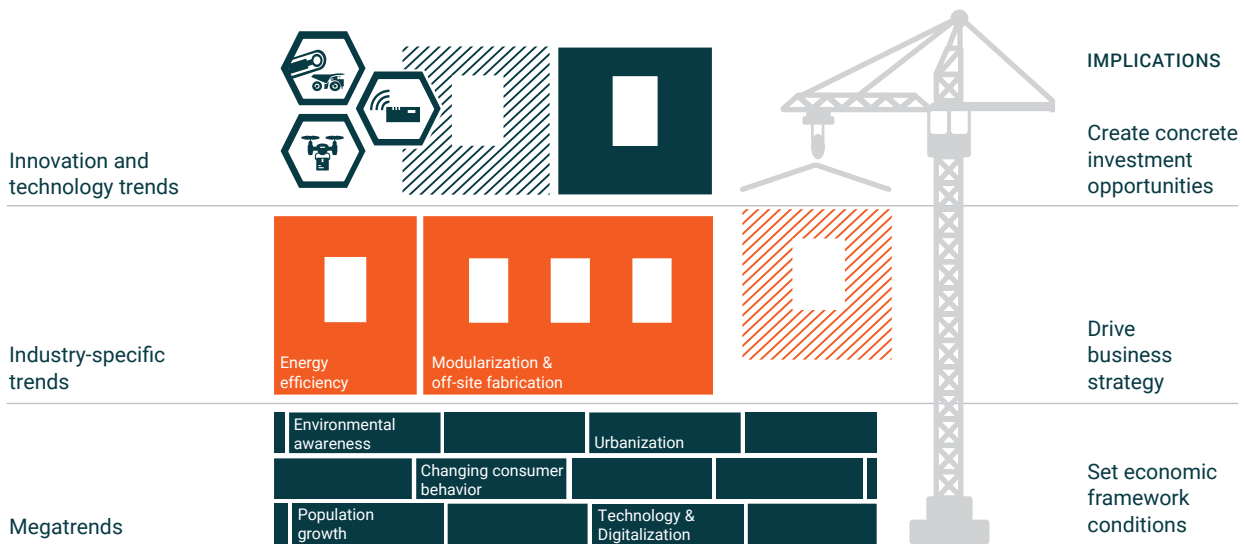
"Wearables" – electronic devices incorporated into apparel or worn directly on the body – are another growth

area. This segment roughly doubled in size between 2018 and 2019, from around 180 million units shipped to more than 300 million, representing an increase of more than 70 percent. Today, one smart watch or smart wristband is sold for every ten smartphones. Smart electronics are becoming omnipresent in human activity and increasingly embedded in the fabric of our lives.

Furthermore, major shifts in consumption related to **e-mobility and renewable energy** are foreseen by industry experts. Developments here will drive demand for electricity storage, i.e. batteries, which in turn will require increased production of metals such as cobalt, copper, nickel and rare-earth elements. Electric vehicles require two to four times more copper and ten times more nickel per vehicle than conventional internal combustion vehicles; while also requiring a significantly greater quantity of cobalt, at around nine kilograms per vehicle. By 2030, more than 20 million new electric vehicles are forecasted to be registered on an annual basis worldwide. That means twenty times more battery capacity required every year for the transportation sector alone – on top of the significant additional capacity required for large-scale hybrid energy storage and renewable energy.

Focus on: Construction

Industry-specific trends in Construction



Two major trends are expected to significantly influence the focus and building practices of the construction sector within the upcoming decade – higher prevalence of pre-fabricated components, as well as a growing emphasis on the energy efficiency of buildings and construction materials fabrication.

Pre-fabrication refers to the assembly of components, ranging from individual parts to complete building rooms, in the factory rather than on site. These "pre-fab" sections are then transported to the construction site, where they are assembled and stacked. Developers face growing pressure on productivity, with clients demanding increased efficiency and shorter development timelines. This is driving the trend toward modular structures, which can deliver time savings of 30-50 percent compared with the conventional approach of building from raw construction materials. Using pre-fabricated sections also increases workplace safety. Accordingly, the pre-fabrication market is expected to grow annually by around USD 10 billion – a CAGR of six to seven percent – in the period to 2025.

At the same time, customers, regulators and developers themselves are increasingly focused on **energy efficiency** stretching across the full lifecycle of buildings. This topic has recently risen to the top of the agenda for all stakeholders, driven by the larger megatrend toward increased environmental awareness. Globally, buildings are responsible for an estimated 40 percent of energy consumption (around 70 percent of which relates to residential buildings) and more than one-third of global CO₂ emissions. For residential buildings, energy consumption depends largely on the number of people living in the building and its total floor area, with the main improvements possible in heating, lighting and cooking.

To meet the goals of the Paris Climate Change Agreement, buildings will need to be an estimated 30-percent less energy intensive per square meter by 2030. For the industry, this translates into a stronger focus on energy efficiency in both building renovations and new builds, with developers taking the environmental footprint of buildings over their entire lifespan into account.

Masdar City is a sustainable urban development project in Abu Dhabi (United Arab Emirates) where current and future renewable energy and clean technologies are showcased, marketed, researched, developed, tested and implemented.



GAME-CHANGING INNOVATIONS AT A GLANCE

Innovations in mining

The mining sector is generally conservative when it comes to adopting new innovations. From its inception until the early 1800s, significant advances came only in the form of using better materials for tools – stone, bronze, then iron. Until the early industrial revolution, most mining practices relied on human power. This changed over the course of the following hundred years, with steam-operated pumps and internal combustion engines (ICEs) significantly increasing output, while inventions such as dynamite optimized extraction techniques.

In most developed economies, modern mining entails complex coordination between machinery and human operators, but humans are still in the driver's seat – for the time being, at least. This contrasts with the situation in less developed economies, which rely heavily on artisanal and small-scale mining operations.

Hereinafter are listed a number of innovations that are set to transform the global value chains for minerals in the period to 2030 – from the spread of advanced analytics to improvements in environmental management.

ADVANCED ANALYTICS

Advanced analytics is currently reshaping the mining sector, where it largely serves to optimize exploration and extraction. New analytical techniques enable the use of data from multiple sources to be consolidated and analyzed in view of making more precise decisions. Around 35 of the 57 IsDB countries display limited or no mineral resources. However, many of them still lack comprehensive data on resources, such as a country-wide scan showing what minerals it possesses. Advanced analytics can help make sense of complex data such as overlapping multi-spectral satellite data or the results of **deep earth imaging**, which combines seismic and electromagnetic imaging with advanced data-

processing techniques. Countries need the full picture to be able to develop a holistic approach to mining rather than piecemeal strategies focused on individual resources.

AUTOMATION AND ROBOTICS

Innovations here include autonomous vehicles, tele-operated machinery and robotic equipment and are just some of the innovations transforming the mining industry. For example, the Syama goldmine in Mali is one of the world's leading mines on the use of fully **autonomous trucks**, robotic loaders and drills. Operators report measurable benefits from implementing the new technology, including increased productivity, lower maintenance costs and extended machine life. Advances are occurring across terrestrial, underground as well as aerial equipment. Autonomous **drones**, for instance, bring immediate benefits in monitoring and inspection, inventory management and infrastructure maintenance.

WORKFORCE AUGMENTATION

Advanced human-machine interfaces such as "**virtual labs**" and "**digital twins**" enable remote management of complex operations. One UK-based company, for instance, uses digital twins that virtually simulate physical operations to remotely track haulage activities at its copper mining site in Chile.

On-site workers can also benefit from the new technology, through the use of **augmented reality** used in maintenance and **virtual reality** in training. Investments in software for mine management will undoubtedly be a top priority for both large and mid-sized players in the coming years.

SUPPLY CHAIN DIGITALIZATION

A number of innovations are influencing supply chain digitalization. Although the adoption of **blockchain** has been slow so far, within five to ten years its impact is expected to be transformational. Recent trials have centered around responsible sourcing, which is particularly important for artisanal and small-scale mining, and for conflict minerals.

3D printing – or "additive manufacturing", as it is often referred to – is another major innovation for supply chain operations. The potential for on-site part production could well be disruptive, resulting in increased productivity through less downtime for maintenance, improved operating expenditure (OPEX) due to lower inventory, and a smaller environmental footprint thanks to less waste in end-to-end processes.

RENEWABLE ENERGY

Issues such as increasing energy costs from conventional sources, power surges and interruptions to supply due to poor infrastructure and demand volatility are paving the way for further development of renewables. This trend is strengthened by growing environmental pressure on mining operators. Most IsDB countries are located in areas with high solar irradiance and therefore enjoy significant potential for integrating **photovoltaics** into the energy production mix of their mining sites. In Burkina Faso, for example, several investments in solar energy are underway, aiming to decrease dependence on diesel-powered generators for mines. An additional advantage of developing solar plants is that local communities can benefit from part of the energy generated, or use it entirely after the mine closes, improving quality of life in areas close to mining sites.

INNOVATIVE ENVIRONMENTAL MANAGEMENT

Innovations in waste treatment, air emissions and water contamination have the potential to significantly reduce negative environmental impacts. Innovations are occurring along three main dimensions: storage/sequestration, conversion (for example, waste-to-energy), and recovery. At the same time, falling battery costs for mining vehicles and equipment could lead to substantial improvements in the quality of air in mines. Lastly, electric hauling trucks also generate 95 percent less carbon emissions.

Further scientific advancements are forecasted by industry experts to take place in **molecular science and bioengineering**. For instance, experiments have shown that specialized bacteria can be used to recover minerals from residual copper waste lakes.

1

**Augmented and
virtual reality**

Mining operators face a shortage of digitally skilled workers who are able to master the new technological landscape. This is a challenge in both developed and developing economies, but is more pressing in the latter due to the lower overall digital literacy of local populations.

SOLUTION

The solution lies in long-term technical education, as one would expect. However, rapid solutions are also required on the short-term. Virtual reality and augmented reality can be of use here. For example, one alumina processing operator in Australia uses virtual reality to train refining operators: Operators learn using a virtual replica of the alumina refinery, surrounded by equipment similar to that found in real-life situations. High-risk, realistic situations can be accurately simulated in the virtual environment and trainers can teach participants remotely, often from thousands of miles away. Using virtual reality, beyond being convenient, is also effective: Research shows that employees retain knowledge gained from virtual reality training three to four times longer than from standard computer-based point-and-click training.

Equipment providers and mining operators are also exploring the use of augmented reality, which involves overlaying virtual elements onto physical objects. Applications are particularly evident in equipment maintenance. For example, maintenance operators can

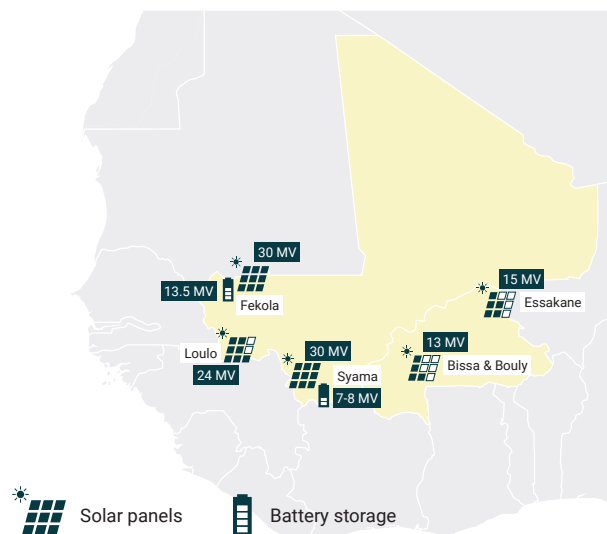
quickly access real-time data from equipment and then superimpose machine diagrams from user manuals. Downtime is reduced, as some preliminary checks can be performed virtually without the need to shut down the machinery. In addition, augmented reality leads to less human error, as the software can identify the right equipment and guide operators along every step of the maintenance procedure.

IsDB OPPORTUNITIES

Applications of augmented and virtual reality can prove effective for many IsDB member countries experiencing workforce qualification gaps with regard to the operation of new technology. Operators can simply follow the software-based instructions while performing real-life operations and where necessary, expert human support can be virtually accessed.

Benefits to IsDB member countries can extend far beyond more efficient maintenance operations. Simulating potentially life-threatening situations such as the placement and subsequent detonation of blast charges can reduce error rates and increase overall safety. Miners are then able to observe how the mine's environment will react to their actions, with potential mistakes identified and individually addressed. Preparing miners can also translate into significant cost savings resulting from the otherwise expected clean-up and delayed production costs.

2 Solar power plants for mines



Many mining operations, particularly in Africa, are located in remote areas and consequently rely on power from on-site generation solutions such as diesel generators. These generators produce more than 1,000 tons of CO₂ a year for every MW installed – the equivalent of one person flying around the world non-stop 250 times. Added to this is the environmental footprint of the related logistics and the complexity of transporting the fuel.

SOLUTION

Given that most IsDB countries are in regions with high solar irradiation, implementing photovoltaic technology - solar power - is an obvious solution. Already, West African states such as Mali and Burkina Faso, for example, have seen many solar power plants planned and commissioned recently.

Apart from its environmental advantages, **photovoltaic technology is economically attractive**. It offers rates of return of around 20 percent and reductions in operating costs of up to 40 percent, depending on the existent energy mix. The social impact is also not to be underestimated. Solar plants typically have a "social license to operate", under which mining operators are expected to support local communities in exchange for the rights of mineral extraction. This means employing local labor – 75 to 100 local workers during the construction phase and 40 more planned for the operating phase, in the case of the 15 MWp solar power plant at the Essakane open-pit goldmine in

Burkina Faso. It also means generating low-cost power for local communities after the site closes, as in the case of the Loulo goldmine.

Given the inherent reliance on daylight associated with solar power plants, 24-hour operability could pose a concern. As a solution, these plants can be installed in combination with conventional generators, forming what are known as hybrid power plants. To fully reap the rewards of sustainable power generation however, opting for battery storage capacity could prove an alternative.

IsDB OPPORTUNITIES

Governments of IsDB member countries may wish to consider building on-grid energy infrastructure for mining companies under Power Purchasing Agreements (PPA), if financing is available. This approach allows for a risk reduction of capital-intensive investments by securing energy purchases for longer periods of time, while also turning a profit relatively early on. For example, a 5 MWp solar power plant was commissioned at the Rosebel goldmine in Suriname after the mining operator entered into a ten-to-fifteen-year agreement to purchase power, with breakeven expected after just five to seven years.

Solar power can also prove to be a viable solution for mining companies confronted with significantly underdeveloped and highly unreliable power grids. Investment in solar plants can provide power independence while lowering operating costs in the process.

ON-SITE RENEWABLE POWER

Generation capacities reliant on non-depletable resources e.g. solar, wind, hydro to generate power and capable of functioning independently from the grid system operators thereby offering.

HIGH ACCURACY GPS & SATELLITE IMAGING

A satellite-based radio navigation system used to pin-point a specific locations with a relatively high degree of accuracy used to identify potential mineral resources.

AUTOMATION & REMOTE CONTROL

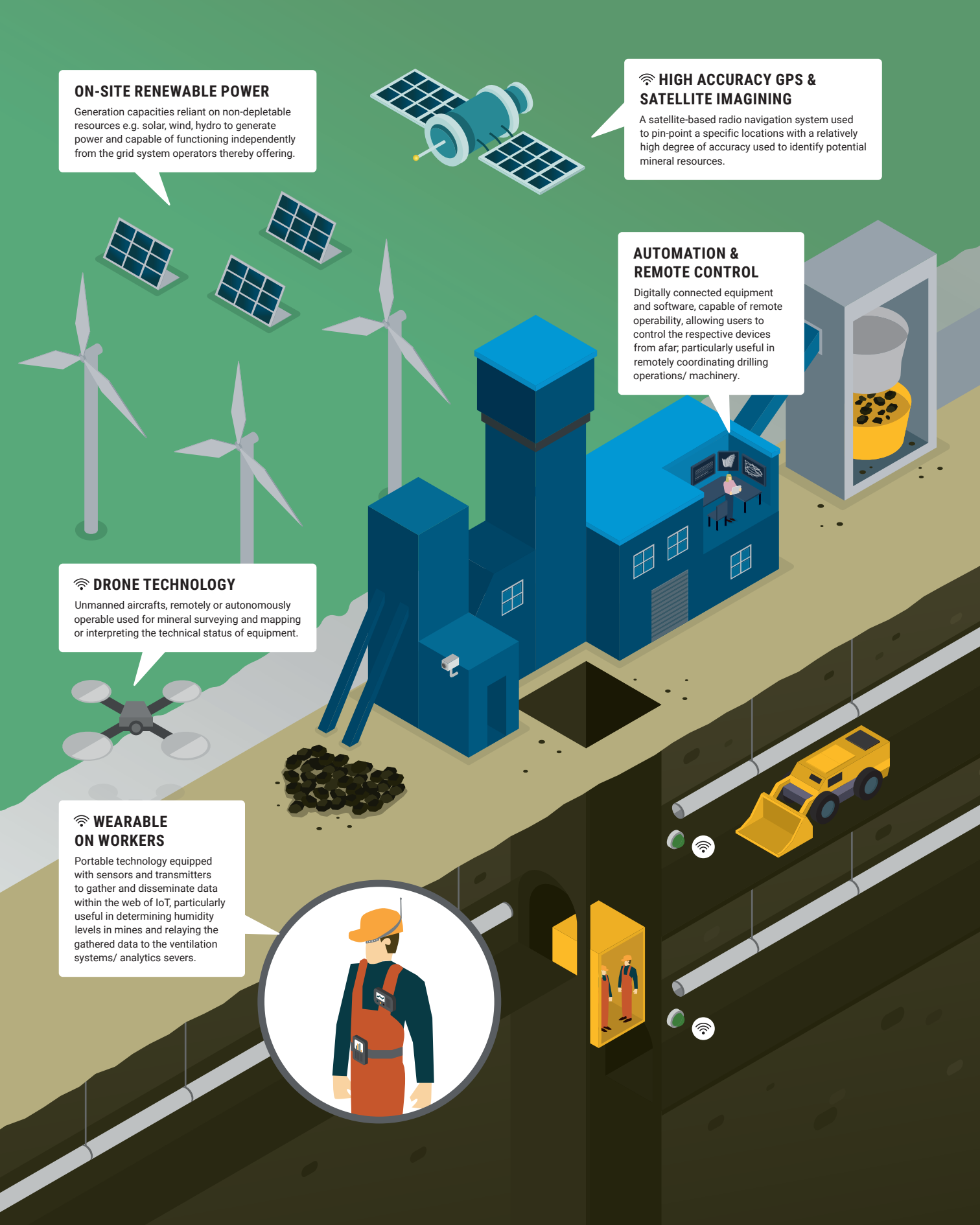
Digitally connected equipment and software, capable of remote operability, allowing users to control the respective devices from afar; particularly useful in remotely coordinating drilling operations/ machinery.

DRONE TECHNOLOGY

Unmanned aircrafts, remotely or autonomously operable used for mineral surveying and mapping or interpreting the technical status of equipment.

WEARABLE ON WORKERS

Portable technology equipped with sensors and transmitters to gather and disseminate data within the web of IoT, particularly useful in determining humidity levels in mines and relaying the gathered data to the ventilation systems/ analytics servers.



An isometric illustration of a modern mining operation. In the top left, a large grey processing building has two white bins filled with dark material. A blue pipe leads from this area towards a central yellow dump truck. To the right of the truck is a 3D printer. In the center, a worker in a yellow uniform stands near a blue ventilation pipe. Below this, a yellow autonomous haul truck is shown in a dark underground tunnel. To the right of the tunnel, a yellow haul truck is parked next to two charging stations. In the bottom right, a large white building with blue windows and a blue roof houses a control room with multiple monitors and a worker. The background features green hills and a grey sky.

3D PRINTING AND MODULAR EQUIPMENT

Manufacturing technology allowing for efficient operations through supply of on-demand spare parts for the maintenance of equipment and vehicles.

3D IMAGING

Virtual, 3 dimensional representation of certain areas or objects, particularly useful in portraying the topography of both open pit and underground mines, thereby improving visualization and reducing the need for geologists' physical presence.

VENTILATION & AIR CONDITIONING ON DEMAND

Digitally integrated ventilation and air conditioning systems, reliant on sensors and remotely or autonomously capable of controlling air flow and temperature.

AUTONOMOUS & ALTERNATIVE POWERED VEHICLES

Alternatively fueled (i.e. electricity or hydrogen) autonomous vehicles allowing for cost-efficient and non-hazardous operations around the mine.

ADVANCED ANALYTICS & MACHINE LEARNING

Methods and tools permitting projections based on statistical interpretations and capable of identifying trends/ patterns - used for example to improve the efficiency of drilling operations or to optimize processing facilities to reduce utilized energy and down-time.

1.2

GAME-CHANGING INNOVATIONS AT A GLANCE

Innovations in construction

The construction industry is driven by demographic trends. With the world's urban population growing by 200,000 people each day, the need for new homes to house these new city-dwellers is self-evident. However, the expansion of the world's cities also requires the development of new social, transportation and utility infrastructure to support them.

Historically, the construction sector has been slow to adopt and implement new technology in the past, lagging behind many other global industries. This is partly due to its fragmented, project based nature. As a result, the productivity of the sector has remained largely unchanged for several decades.

What does the coming decade hold for the industry? The expert input points towards a period of rapid transformation. Faced with a backlog of delayed adoption of new technology, the industry is taking bold steps into the future, with more than USD 10 billion invested in new technology over the last decade. The key objectives cluster around the reduction of construction costs and improvements in resource efficiency.

Five key dimensions in which the industry is innovating are of particular importance to IsDB member countries. These are areas where transformation is already beginning to take place and will rapidly expand in the future: smart production, workforce augmentation, intelligent materials, connected construction site, and alternative fuels and low emission energy generation.

SMART PRODUCTION

"Smart production" refers to areas such as prefabricated manufacturing (for example, off-site, ready-furnished assemblies), the increased use of robotics (for example, autonomous drones) and new fabrication techniques (for example, 3D printing). Marriott International used a **modular**

construction approach in a recent project, for example, producing more than 600 hotel rooms off-site in Poland and shipping them to the construction location in London. The resulting reduction in on-site work is estimated to range between 80 to 90 percent.

Another innovative smart production technique is **3D printing**. Among IsDB member countries, Saudi Arabia leads the way here. Early in 2019 it acquired the world's largest 3D construction printer with the aim of mass-producing houses.

WORKFORCE AUGMENTATION

Building Information Modeling (BIM) will potentially disrupt the construction industry. BIM is a digital planning method for construction projects, whereby users create digital representations of physical places and objects. At the same time, the platform helps users share project information throughout the entire construction lifecycle. For instance, a German startup uses an advanced BIM solution to support its construction site managers, engineers and facility managers. The company claims a 60 to 70-percent reduction in working time and around seven percent lower overall project costs.

Innovative technology is also finding application on a human, physical level in the form of battery-powered **exo-skeletons**. Full-body exoskeletons lifting up to 100 kg are currently commercially available under a "robot-as-a-service" subscription model, mitigating the need for high upfront capital expenditure (CAPEX). At the same time as boosting workers' efficiency, the groundbreaking technology benefits health and safety.

INTELLIGENT MATERIALS

Intelligent materials currently focus on the issues of energy efficiency and structural integrity. In the area of **smart floors**, for example, kinetic floors are available that generate around 5W of electricity for every step via the piezoelectric effect. Multiple areas of application are under investigation, such as powering lights from foot traffic in railroad stations, busy streets, airports and the lobbies of office buildings. One contractor in Central and Eastern Europe, for example, uses the 30,000+ steps of foot traffic generated almost daily in the front lobby of its office building to produce the equivalent of one month's electricity consumption for a medium-sized apartment.

Another innovation is **smart glass**. The Dubai Frame, an architectural structure resembling a picture frame, has a photovoltaic façade measuring more than 1,200 sq m. The multi-functional glass generates a 30 to 40-percent saving in the building's energy costs and a 20 to 25-percent saving on heating, ventilation and air-conditioning (HVAC). Other innovative solutions include photovoltaic curtain walls, skylights, canopies and even floors.

CONNECTED CONSTRUCTION SITE

The connected construction site integrates technologies associated with "Industry 4.0", with the goal of converting manual tasks into automated, efficient workstreams. This covers a broad range of areas, from embedded sensors, digital ledgers/blockchain-enabled transactions and robotic process automation to autonomous transportation fleets.

The **smart helmet**, for example, can allow building contractors to gather real-time data on every worker. The smart helmet is linked to distributed mesh network technology across the site that constantly monitors the worker's location and enables a two-way alert system

between workers and safety managers. Using this innovative tool, constructors can track activity, create reports, automate worksite attendance and logistics, and improve their understanding of bottlenecks and inefficiencies.

ALTERNATIVE FUELS AND LOW EMISSION ENERGY GENERATION

Innovations in the area of waste management and energy have applications across the entire value chain. The cement industry is one of the leaders of utilizing waste and excess materials, using them as **alternative fuels** in the production process. Utilizing alternative fuels as an energy source has two-fold effect. First, it reduces the environmental impact of the cement industry by reducing the direct CO₂ emissions arising from the industry by up to 40%, and in addition, it reduces the amount of waste which ends up in landfills.

In addition, the industry is increasingly building efficient, **low emission energy generation** facilities. Electricity accounts for roughly one-third of the total costs of steel production, for example. Aside from conventional improvements, breakthroughs in the Concentrated Solar Power technology can significantly decarbonize the steel and cement industries. IsDB member countries could potentially build solar power plants in coastal areas with strong solar irradiation, for example, in Saudi Arabia. This would increase price competitiveness as well as generate environmental benefits.

1

**3D printing in
construction projects**

Many IsDB member countries are facing a shortage of housing and related infrastructure – a particularly pressing problem where populations are expanding rapidly. Saudi Arabia, for example, is planning to build more than 1.5 million residential units by 2030. As part of this effort it has launched the Building Technology Stimulus Initiative, which aims to increase domestic sourcing of construction materials to 70 percent and cut construction costs by between five and 20 percent, all the while keeping building timelines to less than 90 days. In the process, the country hopes to provide Saudi nationals with around 7,000 direct and indirect jobs in the construction sector.

SOLUTION

One of the ways Saudi Arabia plans to realize its ambitious housing goals is via the implementation of innovative 3D printing technology. This new technique offers significant advantages over traditional construction methods. In 2018, for example, the Saudi government ran a pilot project to construct an 80 sq m house using 3D printing. As a result, the roughly 50 structural elements were ready within one week and the entire house was fully completed (including roof, windows, heating, ventilation, electrics and plumbing) by the fifth week.

The cost and time savings offered by 3D technology, especially when combined with other on-site innovations, range between 20 to 25 percent. Thus, for every four to five

houses built using traditional methods, the new technology can deliver one extra house for the same total costs and within the same timeline.

Following the government's lead, the private sector in Saudi Arabia has also started investing heavily in 3D printing technology. Early last year, a Saudi construction company bought one of the world's largest 3D construction printers, capable of producing buildings up to nine meters high. One large Middle Eastern building materials company has also invested approximately USD 6 million in setting up a 3D printing prefabricated concrete factory.

IsDB OPPORTUNITIES

The benefits of 3D printing in construction are not just limited to developers, of course. Using the new technology reduces the cost of ownership and speeds up development timelines. As a result, housing becomes more affordable and accessible for local populations – a significant social benefit.

Particularly beneficial to developing countries, 3D printing can overcome certain inherent infrastructural barriers. Given its relative simplicity, this upcoming technology can be adopted by smaller, more regional players with relative ease. Additionally, the "digital" component makes monitorization and process optimization significantly easier, while allowing stakeholders access to real-time data thereby fostering collaboration.

2

Building Information Modeling

IsDB member countries are anticipated to exhibit an above industry average growth in construction by 2030. An obvious result will be an increase in the number of buildings, both commercial and residential. A less obvious implication is the impact increased volumes will have on local authorities, entrusted with providing construction companies the necessary permits as well as ensuring compliance. Furthermore, as technology is embedded in any construction, the complexity of integrating suppliers increases exponentially.

SOLUTION

Building Information Modeling (BIM), or the use of a digital platform based on the 3D modeling of physical places and objects, although technologically feasible for some time now, has finally instigated disruption within the construction industry.

The United Arab Emirates has seen significant growth in construction, by 2017 having accounted cumulatively for more than half of construction in the region covered by the Gulf Cooperation Council (GCC). As early as 2013, Dubai mandated the use of BIM for all buildings 40 stories or higher, projects with a large surface area, special facilities such as hospitals and universities, and any projects requested by the Foreign Office. This was extended in 2015 to all buildings 20 stories or higher.

The large-scale adoption of BIM eases collaboration between stakeholders. It also boosts transparency, making

any changes to the project design or execution visible to all. Further benefits occur along the entire value chain, including optimization of the building area and the chance to develop clear construction methodology, thanks to the ability to display the entire structure digitally both before it is built and during the construction process.

In 2020 Dubai extended the application of BIM yet again, consolidating the permitting systems between the municipality and the building development committee. The overarching aim of the government is to continue boosting the sector by creating cost savings for current initiatives and, in parallel, attracting further investment. It is expected that these measures will help raise the country's global ranking for "ease of doing business" from its current fifth place.

IsDB OPPORTUNITIES

IsDB member countries, particularly with those with booming populations such as the cities of Lagos in Nigeria and Jakarta in Indonesia, could reap similar benefits from following Dubai's example. BIM implementation will also benefit member states with ambitious construction projects such as Saudi Arabia's NEOM. Transparency over any proposed/ expected project modifications will result in accurate, real-time cost simulations while also signaling any potentially non-compliant activity (e.g. a proposal that might affect current licenses).

PRE-FABRICATION & MODULAR CONSTRUCTION

The off-site construction of an entire building unit or specific elements with this aims of increasing control and reducing overall costs

AUGMENTED WORK-FORCE – EXOSKELETONS

Equipment capable of amplifying certain human abilities, in this case significantly increasing strength to allow workers to lift heavier items, reduce potential hazards and improve overall health conditions.

ADVANCED BUILDING MATERIALS – SMART GLASS

Materials used in construction that offer additional properties, in this case, glass that allows for the manual management of the amounts of light or heat passing through.

DRONE TECHNOLOGY

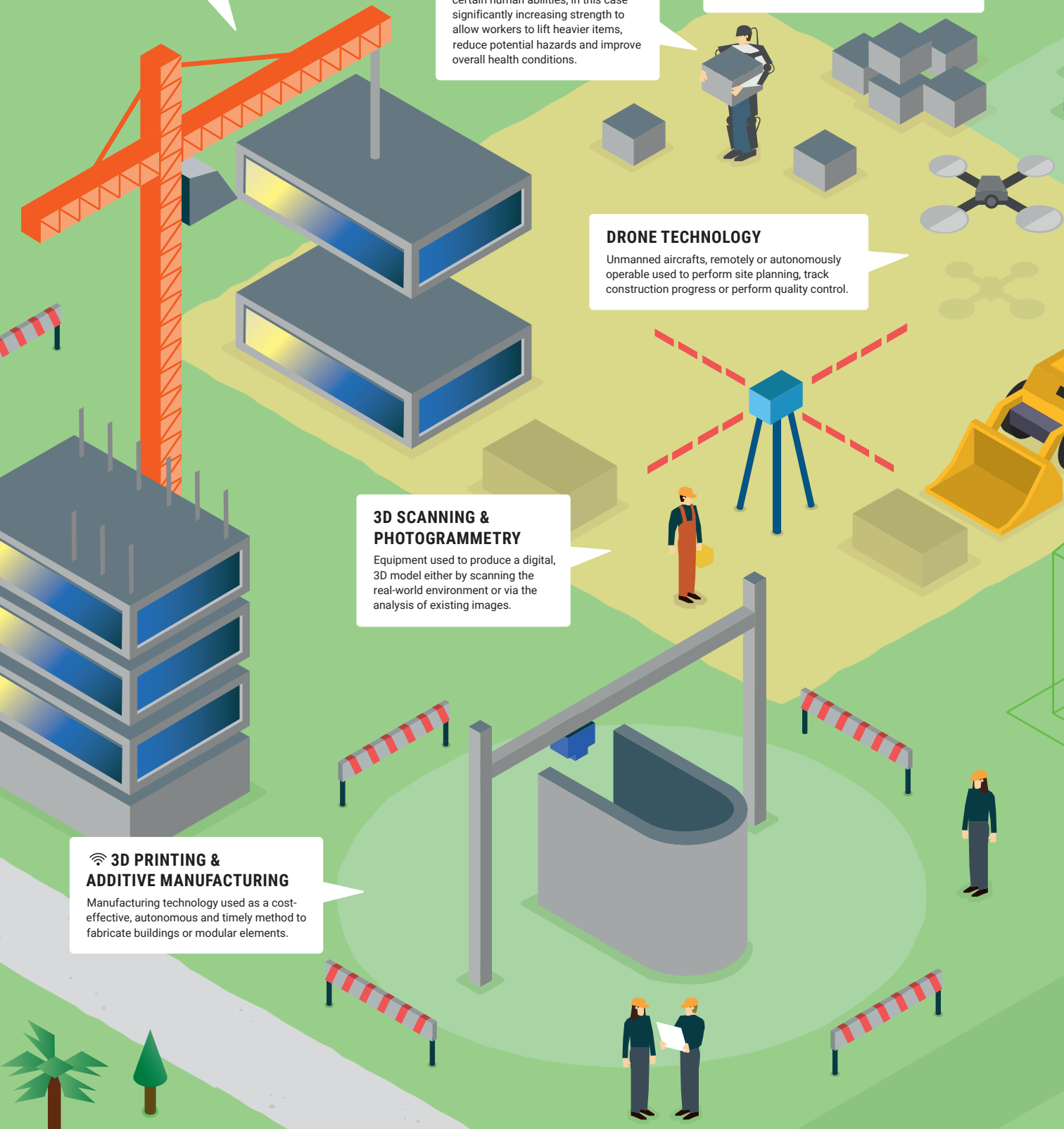
Unmanned aircrafts, remotely or autonomously operable used to perform site planning, track construction progress or perform quality control.

3D SCANNING & PHOTOGRAMMETRY

Equipment used to produce a digital, 3D model either by scanning the real-world environment or via the analysis of existing images.

3D PRINTING & ADDITIVE MANUFACTURING

Manufacturing technology used as a cost-effective, autonomous and timely method to fabricate buildings or modular elements.





BUILDING INFORMATION MODELING –

A digital platform used to aggregate and store construction-related data for accessibility by key stakeholders, while offering digital representations of the construction projects in scope.

WIRELESS MONITORING & CONNECTED EQUIPMENT

Tools and software that allow critical data gathering in a more efficient manner, operable from frequently used electronics (i.e. phones) and offering more accurate readings than traditional methods.

AUTONOMOUS ALTERNATIVE POWERED VEHICLES

Alternatively fueled (i.e. power or hydrogen) autonomous vehicles allowing for cost-efficient and non-hazardous operations around the construction site.

AUGMENTED & VIRTUAL REALITY

Equipment capable of mapping digital elements onto a real-world environment or re-creating the real-world environment virtually, allowing for an overview of entire construction projects as well as providing various data points.

Going beyond the global trends affecting the mining and construction industries, and the key innovations with the potential to reshape the industries' global value chains, the focus of this sub-chapter falls on the challenges facing the industries over the next decade and beyond. What factors could limit the development of mining and construction, preventing them from realizing their full potential in IsDB member countries? Four major areas where challenges exist have been identified.

PHYSICAL CAPITAL

Limited mechanization is a challenge for artisanal mining and makeshift construction material operations, which frequently also suffer from poor health and safety conditions for workers. Many IsDB member countries have outdated or inefficient technology compared to more developed economies, leading to large productivity gaps and loss of value. Limited processing capacity is also an issue, leading many countries to focus on exporting raw materials rather than processing them in the country, with consequent loss of value. Lastly, many IsDB member countries also suffer from poor infrastructure, such as unreliable power grids and poor access to transportation hubs, all of which prevent efficient operations.

HUMAN CAPITAL

Problems here take a long time to resolve, which makes early action all the more imperative. Many IsDB member countries suffer from insufficient employment opportunities for local workers, the result of both increasing automation and expanding populations. Moreover, it can often happen that workers do not have time to reorient themselves to new technology, nor are they qualified enough to do so. This problem of "technological illiteracy" impacts further

development of the industries in many regions.

INVESTMENT CAPITAL

Investment capital refers to the inflow of financing into key initiatives such as updating production equipment or retraining the workforce. Some IsDB member countries face problems with regard to basic framework conditions such as stable governance and regulation, which ultimately drive predictability for investors in terms of expected returns over the mid to long-term. Stability is particularly important for mining and construction, which are capital-intensive industries with multi-year investment return periods.

LONG-TERM SUSTAINABILITY

Long-term sustainability refers to the fragile link between exploiting natural resources and extracting sufficient value add for investors, while at the same time enabling local communities to improve their living standards without adverse impacts on the environment. In mining, this means prioritizing environmentally beneficial practices – for example non-cyanide extraction of gold – over short-term profitability. In the construction industry, the key challenge is controlling the amount of waste generated during the entire building lifecycle, as well as the overall energy efficiency of the processing phases for materials. Ensuring long-term sustainability also means guaranteeing direct gains not just for equity holders but for the local communities in which they operate, too. Local residents have the right to benefit from the irreversible depletion of their reserves. In mining, this gives rise to "social contracts" between mining operators and communities or government, whereby the companies are expected to transfer more of the value generated to their local regions.



DEEP DIVE

Artisanal and small-scale mining

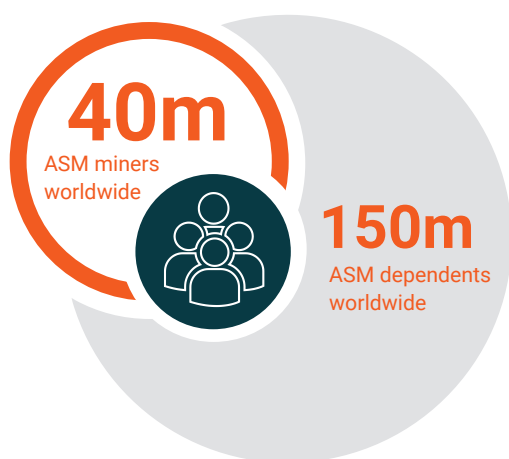
Artisanal and small-scale mining (ASM) entails all mining practices that do not use industrial methods. It is mostly performed manually with rudimentary tools. ASM is increasingly prevalent around the globe. In 2017 an estimated 40 million people worked directly in the sector, a more than 30 percent increase compared to 2014. Although productivity levels are far lower than for industrialized mining, ASM accounts for more than one-fifth of the global extraction volumes of minerals such as tin, gold and diamonds.

Given ASM's important contribution to local job provision, it is often a key industry topic. ASM provides jobs for rural communities thereby gradually increasing local consumption; large-scale mining on the other hand, contributes to national budgets and can improve long-term perspectives if revenues are wisely spent.

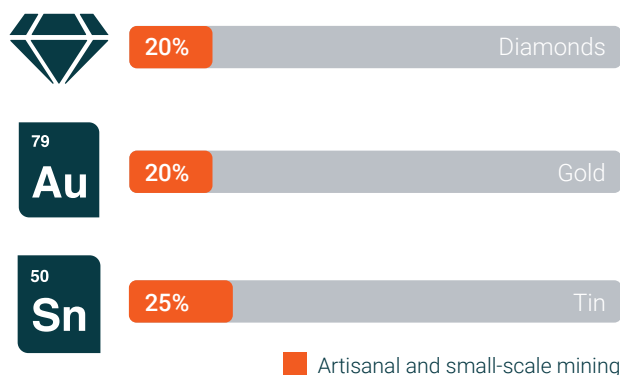
One of the main issues associated with ASM is the fact that it is generally performed by an untrained workforce

without access to adequate tools, guidelines or safety procedures. The impact on the environment can be significant. For example, the use of mercury to separate gold can poison the soil and waterways, and ultimately reach food supplies. The impact on miners can be similarly grave: ASM is linked to an increased risk of respiratory illnesses resulting from particles released by blasting and drilling activities, for instance.

The high risk, unsafe working conditions and overall negative impact of ASM are seen in many countries. Among the ISDB countries, Indonesia, for example, accounts for around one-quarter of the tin mined globally, roughly 90 percent coming from the islands of Bangka and Belitung. Local residents often view ASM as a way to get rich quick, thereby seeking employment in large mining operations or engaging in unlicensed activity. Indeed, 30 to 40 percent of the islands' population is estimated to work in the mining sector. ASM is also widespread in the Democratic Republic



Global mining output, 2017



of Congo (DRC), where it accounts for 20 to 25 percent of the country's cobalt production – roughly two-thirds of total global production. Many families rely on ASM as a means of survival; the country has an estimated 250,000 artisanal miners, more than 35,000 of whom are children.

The problems related to unregulated ASM are manifold. Accidents are common due to the lack of regulation and safety procedures: It is estimated that tens of deaths occur each year in countries where ASM is prevalent. Causes of death can be gruesome, such as being buried under rocks when hand-dug tunnels collapse.

ASM has damaging effects on the environment, too. In certain areas, mining activities on land can lead to the generation of large craters that often flood with water, affecting plantations and natural habitats. Additionally, the chemicals used for mineral separation can end up in waterways, harming the aquatic wildlife. ASM can also cause the coral reef irreparable damage, affecting both the natural habitat and the livelihoods of nearby fishers.

If left unregulated, ASM can place a heavy burden on both local communities and the environment. Formalizing activities – in other words, introducing frameworks and regulations – can have many benefits. Thus, providing jobs in rural areas can lead to increased local purchasing power and limit the rate of urbanization. Ultimately, regions where few alternatives exist can enjoy economic development. Mali, for example, sources more than 30 percent of its gold from the million or so people in the country working in ASM. Part of the government's strategic agenda is to promote the sustainable development of ASM in the gold industry as a means of providing employment and reducing poverty. However, the country still has some way to go, and the recent revision of its mining code is insufficient to provide the sector with the formalization it needs.

PROMOTING SAFE ASM

The severe negative consequences of unregulated and unsafe ASM call for decisive action by governments. IsDB countries can pursue a number of strategies aimed at mitigating unwanted results – or better still avoiding them altogether – as they gradually formalize the sector:

- **Equip and train.** Providing miners with the right equipment and training can significantly reduce unwanted practices. In Senegal, for example, giving miners equipment capable of extracting gold without using mercury has not only increased yields, but also eliminated mercury-related poisoning.
- **Provide financing.** IsDB member countries should consider introducing financing schemes for ASM miners, such as micro-financing and government loans. This would facilitate the acquisition of tools and safety equipment by workers.
- **Certify and audit.** Certifying minerals creates transparency about where they come from and how they have been produced – for example, indicating that mercury was not used to separate gold. Auditing downstream activities is also advisable, for example requiring tin smelters in Indonesia to account for the source of their tin.
- **Control exports.** Establishing checks at borders and in busy mining zones can reduce ore and mineral smuggling, a common problem in some Southeast Asian and African countries.
- **Raise awareness.** Miners are often themselves unaware of the dangers associated with ASM. Raising awareness can help avoid poor practices, increase safety for workers and reduce negative environmental impacts. Miners educated in this way often pass on this information to their peers, too.



Wind turbines providing renewable energy close to a gold mine in Europe operated with the help of heavy machinery



2

MINING AND CONSTRUCTION SECTORS – WHERE ARE WE NOW?

Mining importance expected to increase

Demand increase expected for most minerals given increased utilization in modern technology, albeit with different dynamics

Potential to increase production across several IsDB member countries based on high, untapped proven reserves

Construction industry projected to grow by 50 percent

Increase in construction industry through 2030 exceeding global GDP growth – high growth rates within IsDB countries particularly in West Africa, Middle East and Southeast Asia

Regional opportunities in construction materials production

IsDB countries expected to establish national capacities to meet domestic/regional demand; strong competitive advantages required to compensate for global overcapacities in medium-term

Aluminum & nickel show significant growth potential

The surge of EV technology and nickel's role as a primary source for batteries will significantly drive demand

Demand for aluminum expected to grow by 5 percent per year driven mainly by increased use of lightweight materials

Good prospects for IsDB member countries to expand across the value chain

Strong current focus on extraction – potential to unlock additional value by expanding into processing and manufacturing

Both downstream and upstream integration viable depending on available resources or domestic/regional consumption

IMPORTANCE OF THE MINING AND CONSTRUCTION SECTORS

Impact on economy, employment, investment and environment

MINING

It is impossible to imagine the modern world without mining. Alongside agriculture, mining is fundamental to sustaining the growing needs of humanity as any raw material can be either cultivated or mined. Currently, the industry is estimated to account for one to two percent of global GDP, or more than USD 1 trillion.

Mining provides humanity with the metals and other naturally occurring elements that are essential for many technological devices, particularly in the realm of electronics. For example, around one-quarter of the mass of an iPhone is aluminum, while another 14 percent or so can be attributed to iron, with smaller traces of copper, zinc, gold and other elements also present. **No truly viable substitutes exist for these materials.**

In terms of sustainability, it is worth noting that most metals can be recycled infinitely, with significant energy gains in comparison to mining and processing. However, the extent to which recycling actually takes place around the world varies by specific material and geography. This variation, combined with growing consumer demand, will most likely lead to continued dependence on mining in the coming decade and beyond.

The development of the mining industry has the potential to increase employment rates, attract foreign direct investment, and stimulate economic growth — particularly in countries with lower income levels. Furthermore, by integrating the United Nations Sustainable Development Goals (SDGs) into the way mining is performed can create immediate and meaningful benefits for a wide range of stakeholders. Strategically focusing on key areas influenceable by mining such as SDG 7 (renewable energy), SDG 8 (jobs and economic growth) and SDG 9 (innovation and infrastructure), can provide for a direct economic

impact, while mitigating indirect effects such as SDG 15 (life on land). The off-grid hybrid wind farm and solar plant powering one of Mauritania's iron mines for example, has not only overcome the country's lack of power infrastructure, providing the mine self-sufficiency, but has also alleviated part of the operation's carbon footprint while providing jobs for the local community in the process.

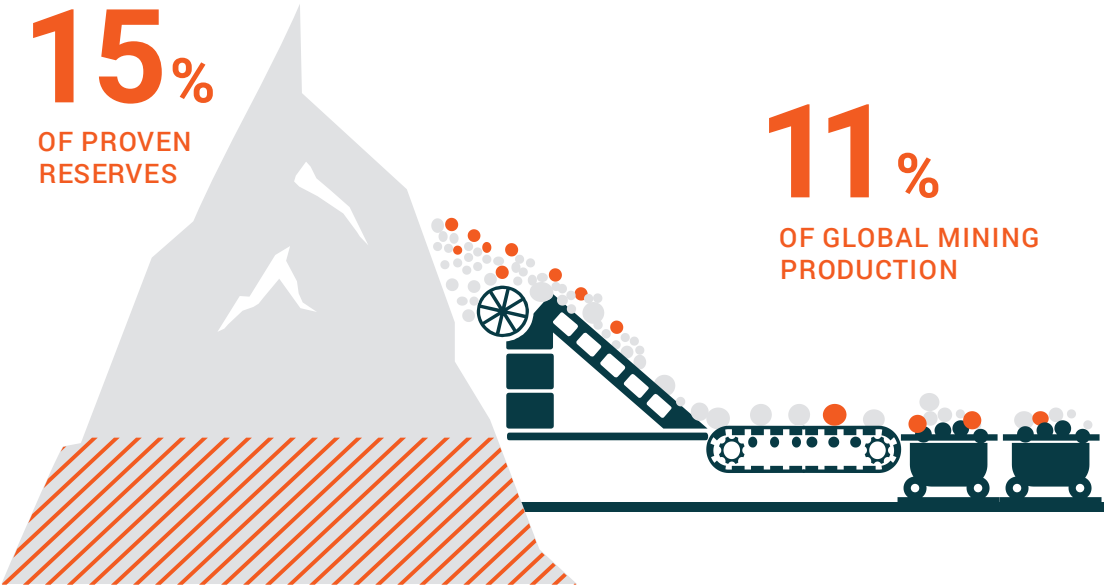
IsDB member countries account for almost one-quarter of the world's population. Several countries rely heavily on the mining industry in their economies; in turn, they themselves contribute significantly to the global economy, accounting for around **11 percent of total mining production**. In the case of four minerals (nickel, aluminum, tin and manganese) and one precious metal (gold) IsDB member countries account for approximately 15 to 25 percent of the global output, highlighting a very strong positioning on these sub-sectors.

There is however a difference between production and reserves: IsDB member countries account for 11 percent of production but are home to **15 percent of global reserves**. One of the best illustrative examples in this regard is copper, a sought after material for electronics and electric vehicles. On copper, IsDB countries hold 1 in every 10 tons of proven reserves, but cumulatively amount to only 6 percent of the global output.

With many IsDB member countries displaying high reserves-to-production ratio at the national level, it appears to be additional potential to increase current output and, subsequently, improve the economic circumstances of these countries, without comprising the long-term sustainability of the industry.

MINING: ILLUSTRATION | IsDB global benchmarking

IsDB member countries account for ...



IsDB member countries



Rest of the world

2.1

IMPORTANCE OF THE MINING AND CONSTRUCTION SECTORS

Impact on economy, employment, investment and environment

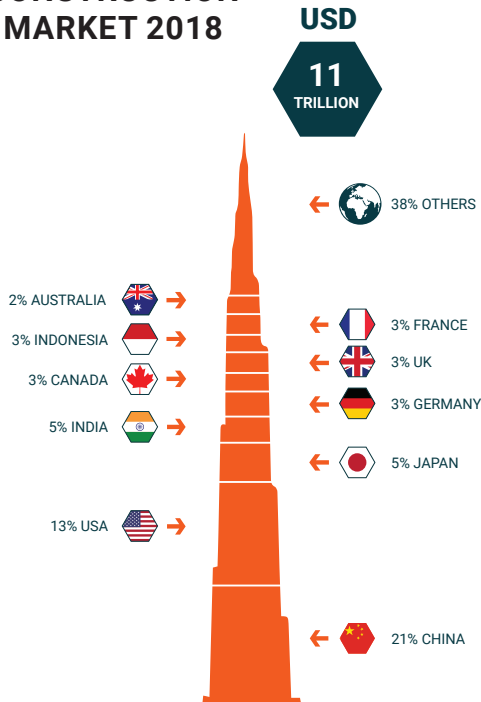
CONSTRUCTION

The construction industry is highly correlated with the development of other sectors, as well as to the global economic growth. Positive economic outlooks and economic prosperity drive up the demand for housing, office space, production buildings, warehousing and distribution units. In 2018 the worldwide construction

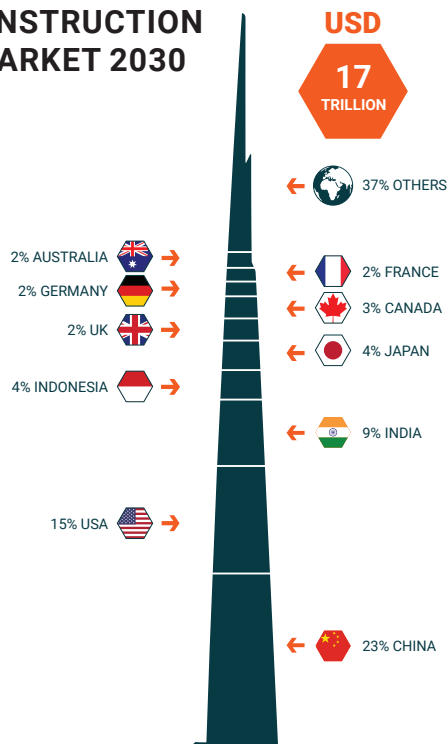
industry contributed 13 percent to global GDP. Valued at around USD 11 trillion, it provided employment to almost 200 million people. **By 2030 the industry is expected to grow to a total value of USD 17 trillion** – a growth rate of around four percent per annum, more than one percentage point higher than global GDP growth.

CONSTRUCTION: ILLUSTRATION | IsDB global benchmarking

CONSTRUCTION MARKET 2018

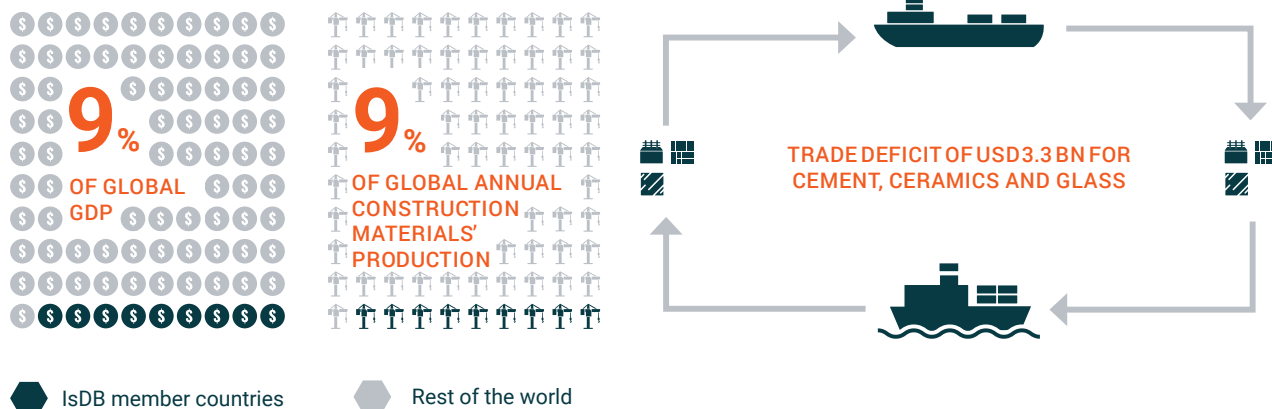


CONSTRUCTION MARKET 2030



CONSTRUCTION: ILLUSTRATION | IsDB global benchmarking

IsDB member countries account for..



The largest construction markets in 2018 were China, the United States and Japan. Over the coming decade, China is expected to increase its share slightly from 21 percent of the global market in 2018 to 23 percent in 2030. The expectation is to see a similar development in the United States, whose share will grow from 13 to 15 percent. India will likely move up into third place, more than doubling its share from four to nine percent of the global market. Indonesia, IsDB member country, is expected to move into fourth place with four percent of the market, up from the eighth in 2018.

The sector's contribution to GDP goes far beyond its direct outputs in the form of construction works. Investments in the construction industry are crucially important for developing countries, where real estate and infrastructure projects not only bring significant benefits to the lives of citizens, but also improve the business prospects of the country. In mature economies, developing new commercial and residential areas and improving infrastructure likewise make a key contribution to economic growth.

Globally, IsDB countries account for almost 12 percent of the total construction industry (2018). Annual growth is expected to outperform the global average at more than five percent a year. Indonesia and Nigeria are expected to be one of the top performers with growth rate of over six

percent. In terms of regional dynamics, emerging markets in the Asia Pacific region are expected to represent the largest growth market in the coming decade, followed by Sub-Saharan Africa.

In terms of segments, the construction industry can be split into three main categories – residential buildings, non-residential buildings and infrastructure. The non-residential segment is the largest by market value, accounting for 36% in 2018, followed by the residential one with 34% and infrastructure with 30%. On the 2030 horizon, largest growth is expected in the non-residential buildings and infrastructure segments.

Construction materials and other inputs to the construction industry represent around 40 percent of the total industry and were worth around USD 4 trillion globally in 2018. The largest segment is iron and steel, followed by cement, ceramic products and glass. IsDB countries currently account for less than ten percent of global production of these materials. This is roughly in line with their GDP, but around 14 percentage points lower than their share of global population. Moreover, the roughly USD 3.3 billion trade deficit for cement, ceramics and glass in IsDB countries indicates that there is strong latent demand there that cannot currently be satisfied by domestic production. These imbalances indicate a clear opportunity for investors.

2.1

IMPORTANCE OF THE MINING AND CONSTRUCTION SECTORS

Both the mining and construction industries are fundamental pillars of economic development – mines provide humanity with the raw materials to create vehicles, equipment and modern-day technologies while construction provides us with places to live and work, as well as the infrastructure connecting them.

To paint a representative picture of the current state of the industry in IsDB member countries, **18 different industries** were analyzed, accounting for the key trends that are expected to shape the industry over the coming decade, as well as the most pressing challenges and exciting opportunities.

Construction materials Industry metals Precious metals/gemstones // Global market size (2018)

780
bn USD

IRON &
STEEL



310
bn USD
CEMENT

90
bn USD

GLASS



205
bn USD

CERAMICS



42
bn USD

MANGANESE



9

bn USD



RARE EARTH
METALS

27
bn USD

LEAD

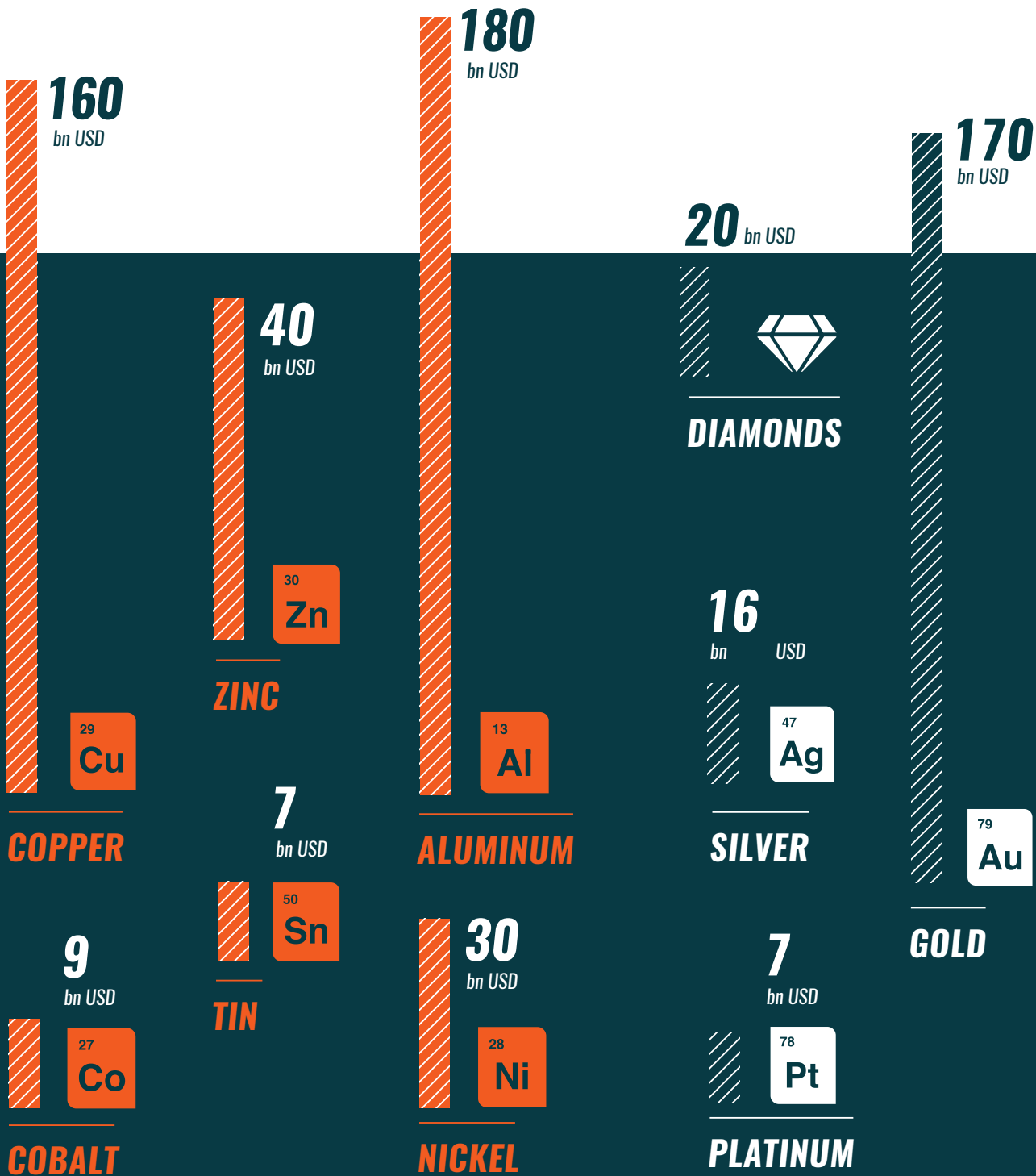


4

bn USD



TUNGSTEN



IsDB COUNTRIES' CURRENT POSITIONING

Mineral extraction is the backbone of many IsDB economies

In the previous section the importance of the mining and construction industries was addressed, as well as their vital role in the global economy and the economic significance for IsDB member countries. What role do individual IsDB countries play in the various segments that make up the industries? Where are they particularly strong? Where do they show room for improvement? And what are the most exciting opportunities for investors? The insights depicted herewith are drawn from the detailed analysis of different industry segments – the key activities performed at different stages of production.

Understanding the positioning on the global value chains for the materials in scope can prove highly insightful for outlining the way forward. For instance, countries such as Indonesia and Kazakhstan enjoy global significance in the production of certain materials (i.e. gold, copper and tin), while many other IsDB member countries operate on a smaller scale with fewer minerals but in many instances with high national importance (i.e. Gabon with manganese or Guinea with bauxite).

MINING

IsDB member countries as a whole enjoy a dominant position in nickel, aluminum, tin, manganese and gold, accounting for between a fifth and a quarter of the globally mined output of each of these metals. An overarching prevalent imbalance is observed, with many IsDB member countries showing **strong positioning when it comes to extraction, but often sub-developed when it comes to processing**. They frequently lack the necessary capacity (plants, machinery, infrastructure) and are therefore compelled to export the metal ores for processing. The global value chains show that in many cases, processing is where a

large proportion of the added value lies – meaning that IsDB member countries are currently missing out on potential profits. For example, Guinea is a leading global producer of bauxite, which is essential for the production of aluminum, but it has very limited processing facilities. However, having greater capacities in extraction as compared to processing is not necessarily problematic across all materials. For precious metals, diamonds, copper and zinc, the market for production is in fact approximately three times larger than that for processing.

Although establishing processing capabilities is indeed a recurrent theme for most IsDB member countries, additional opportunities also exist. Indonesia, for example, is developing several mineral processing facilities and is now well positioned to expand further downstream. By embracing nickel's strategic importance and capitalizing on the country's vast reserves, Indonesia could establish a foothold in the manufacturing segment and derive additional value-add. Progress in this direction is already evident with lithium battery capacities estimated to begin production by 2023. Diversifying into other metals for battery production (i.e. nickel) could also prove highly beneficial.

Recycling also presents an exciting opportunity for IsDB member countries currently focused on extraction. With suitable investment, individual nations will be able to develop their processing capacity and enter the growing recycling segment – provided, of course, that they can achieve the necessary critical mass for this to be economically feasible.

Recycling is a major topic in the mining industry, and one that is set to grow in importance over the coming decade and beyond. Most metals allow for infinite recyclability, with significant energy gains in the process. For example, recycling aluminum generates around 95-percent energy

savings compared with extracting and processing it. However, different minerals are recycled at different rates in different countries. This fact, combined with growing consumer demand for minerals overall, means that although recycling becomes more important, mineral extraction is unlikely to face a decline any time soon.

Mining is widespread in IsDB member countries, but development opportunities in extraction with the potential to attract investors can still be found. In the case of aluminum, for example, the current reserves-to-production ratio in IsDB member countries indicates that mineral reserves are still underexploited. Performing this analysis on Guinea for example showcases that production at current levels can continue for about another 150 years. By contrast, currently identified nickel and manganese reserves are large, but the long-term sustainability should be considered when planning production.

CONSTRUCTION

IsDB member countries are relatively strong in cement, producing around 12 percent of global output and generating a trade surplus of USD 180 million (2018). But in other construction materials, such as glass and steel, IsDB countries as a whole suffer from a trade deficit of around USD 2.6 billion. This indicates a lack of capacity to meet domestic demand.

In many IsDB member countries, **capabilities for processing certain construction materials are much more developed than for mining**. Several countries, for example, focus exclusively on processing, for which they import raw materials. Thus, in the iron and steel industry, Egypt, Saudi Arabia and the United Arab Emirates have a limited presence in extraction, with almost insignificant levels of

iron ore production, but are strong in processing. Turkey and Iran, on the other hand, are active at both ends of the spectrum, carrying out both extraction and processing – demonstrating strong potential for further development across each.

Overall, the **outlook** for the mining and construction industries across IsDB geographies **is positive** and **significant opportunities for investment exist**. As such, both extraction and processing capacities could be selectively developed in a sustainable manner. The task for the countries themselves is now to create an attractive environment for external players to engage in local industries. They can do this by introducing incentives for foreign direct investment (FDI), smoothing collaboration between national stakeholders and outside investors, and ensuring a favorable regulatory environment based on international best practices. Stakeholders in the mining and construction industries must place a clear emphasis on sustainable development, prioritizing the United Nations Sustainable Development Goals.

IsDB COUNTRIES' CURRENT POSITIONING

Cement, iron & steel, gold, aluminum and nickel

As observed in the earlier section, the IsDB identifies 18 key global value chains as a basis for analyzing potentials, opportunities, challenges and risks within the mining and construction industries. Not all of these areas present the same level of potential. Five global value chains are presented for closer analysis: cement, iron and steel, gold, aluminum, and nickel. For each of these segments the components making up the global value chain are analyzed, the challenges facing the sector identified, the trends for the period to 2030 and beyond outlined and the positioning of IsDB member countries highlighted.

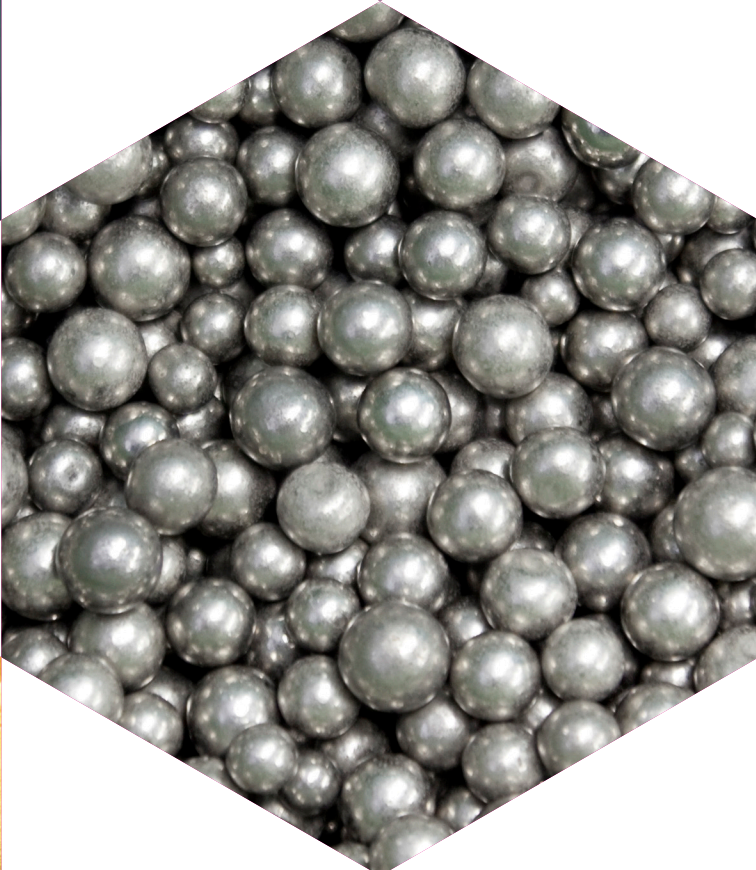
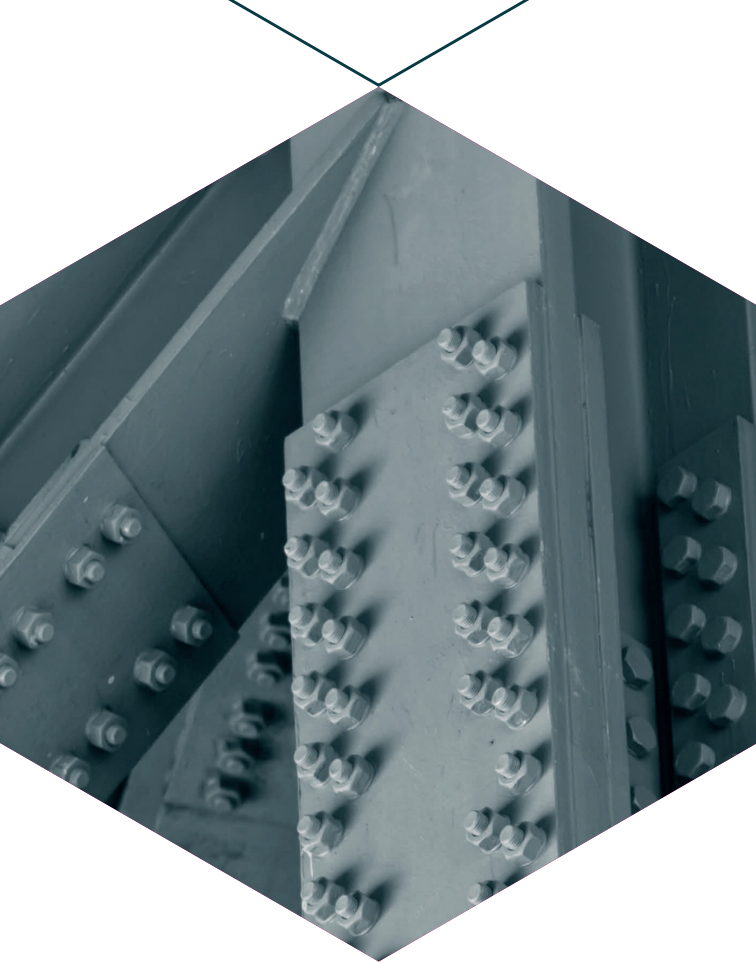
Cement is a particularly important area for investors as it is the most commonly used construction material, forming the basis for all three sectors of construction, namely residential, non-residential and infrastructure. Global cement market was estimated at USD 310 billion in 2018. Approximately 160 countries around the world produce cement. The industry is a largely regional, as transporting cement long distances would be too costly to be profitable. The global value chain offers many development opportunities due to the abundant local availability of input factors, combined with growing cement consumption in many IsDB member countries.

Steel merits closer investigation because it is the most valuable construction materials. In 2018 the market value was an estimated USD 780 billion, meaning that it accounted for roughly two-thirds of the global mining sector. Iron and steel also forms a bridge between the mining industry and the construction sector as it encompasses the mining of iron ores and the multiple processing phases involved in steel production.

In terms of minerals, **aluminum** with USD 180 billion and **gold** with USD 170 billion represent the largest markets. Gold is the most important mineral for IsDB countries, both due to its high value and the fact that it is widely mined. IsDB countries also have significant reserves of both gold and bauxite (the main aluminum containing ore), so these are two areas that show sustainable, long-term potential.

Despite the annual market value of **nickel** is only approximately USD 30 billion, the industry is of interest because it is likely to develop dynamically in the period to 2030 and beyond. This is due to the fact that nickel is used in the production of batteries for electric vehicles, a sector poised to expand rapidly. Batteries will likely account for up to 30 percent of total nickel demand through 2030, compared to just five percent today. Investors should note that IsDB member countries display a strong global market position in nickel, amounting to around one quarter of global supply.





INSIGHTS INTO GLOBAL MINING AND CONSTRUCTION INDUSTRIES

From production to processing and key product categories

Global value chains indicate how various "input factors" are transformed and combined through different steps to create finished products, extending across different geographies.

They enable the understanding of the key stages at which value is added – in production/extraction, primary processing, secondary processing and so forth. This creates a useful framework for examining the opportunities, risks and market potential arising at each stage of the process.

Seven key elements within the value chains for the mining and construction industries are of relevance. Each value chain starts with **input factors** ①. Input factors refer to mineral reserves, machinery and equipment (excavators, drills, trucks etc.) and other materials that are required in later processing stages.

Once the input factors are in place, the **production & extraction phase** ② can begin. In the mining industry, this means the extraction of the mineral ores from their deposits and the separation of the ore to remove major impurities by means of crushing or milling, for example. This step makes transporting the mineral more cost effective. In the construction industry, this phase also involves extraction – for example, the extraction of clay to form ceramics. The resulting product is generally known as "concentrate".

Next, the mineral or construction material is generally transferred from the excavation/ mining site to a processing plant for **primary processing** ③. In the case of minerals this usually involves "smelting", or heating the concentrate to separate it into its different elements. Construction materials such as iron and steel and also glass require a form of smelting, but other construction materials do not: They can be separated by simply grinding the raw materials, as in cement production, for instance. Primary processing

also includes **recycling**, or the separation of certain minerals from metal scraps.

The final step in the production process is **secondary processing** ④. This involves further separating out impurities to produce the final state of the mineral or construction material in question. For minerals, the most commonly used separation technique is refining, which generally involves the use of heat or electrolysis to obtain purity levels greater than 99 percent. For construction materials, secondary processing actually involves adding more elements to the mix to produce the final product, for example, blending clinker with gypsum and other additives to produce cement.

The global value chain analysis also enables the identification of the **most relevant product categories** ⑤, by estimating the percentage of the total market represented by each of the finished products. Also examined are elements such as **trading and logistics/infrastructure** ⑥, which are relevant at various stages of the process.

The final element highlighted in the global value chain analysis is **market size** ⑦. It refers to the combined revenues of both the mining/extraction stage and the two processing stages (including recycling). The market size does not account for the profitability of each stage, which can vary significantly.

The methodological approach entails a simplification of the real workings of the industry, but the value chain analysis focuses on the understanding of the processes and the activities involved in each segment, and the value that each of these create. Moreover it allows for comparability when identifying potential or making investment decisions, given that the same framework can be applied to each of the minerals and construction materials examined.

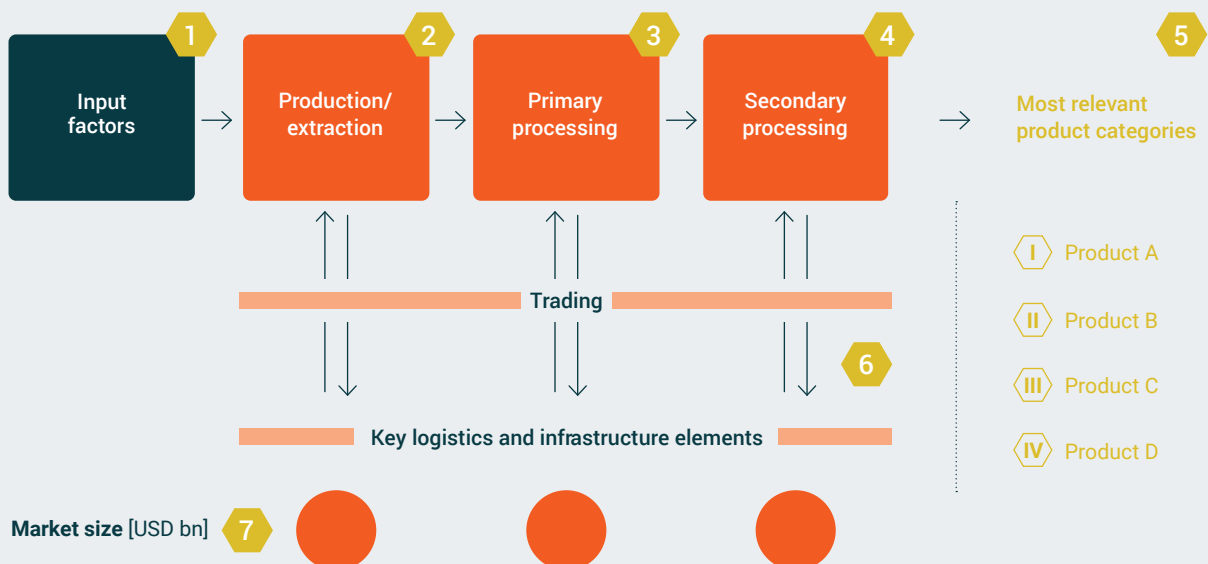
Specifically, global value chains create a framework for answering the following critical questions:

Which areas of each global value chain show the greatest market potential?

What are the main trends driving demand and shaping the global value chains?

How are IsDB member countries currently positioned and how can they unlock the most value?

Exemplary global value chain overview



CEMENT

- **IsDB countries produce 12 percent of global cement, with all but four countries having production capacity**
- **Sustainability is a major challenge – cement production causes 5 percent of man-made CO₂ emissions; alternative fuels as potential solution**
- **Globally the industry is facing short-term overcapacity, although the situation may differ by region**

2030 AND BEYOND – CONSTRUCTION MARKET TO CONTINUE SUSTAINED GROWTH

The market is forecasted to show strong long-term growth, reaching a value of USD 480 billion by 2030. The anticipated CAGR is an estimated three percent through 2025, and five percent after that. The major growth driver is represented by the construction industry, as cement is used in all three key segments (residential, non-residential, infrastructure). Increasing urbanization, currently at 55 percent and due to reach 60 percent by 2030, will significantly impact the shape of the global value chain.

New construction projects in emerging countries such as China, India and Indonesia will drive growth in cement consumption. Some governments, such as that of the UAE, are investing strongly in construction. Projects such as the Jubail II industrialization program in Saudi Arabia and the planned megacity Neom will also drive demand. In Western Europe and North America, on the other hand, growth will be driven more by the need to modernize infrastructure.

CHALLENGES – GREENHOUSE GAS EMISSIONS, HIGH ENERGY USE

The cement industry faces sustainability issues. Expanding

global economies are leading to rising demand for construction materials, which has a profoundly negative impact on the overall level of greenhouse gas emissions. Cement production is responsible for five percent of total anthropogenic carbon dioxide emissions and seven percent of industrial fuel use, with clinker production being the dominant pollution-producing step in the value chain. Finding ways to reduce both energy needs and reliance on fossil fuels is a top priority for cement companies.

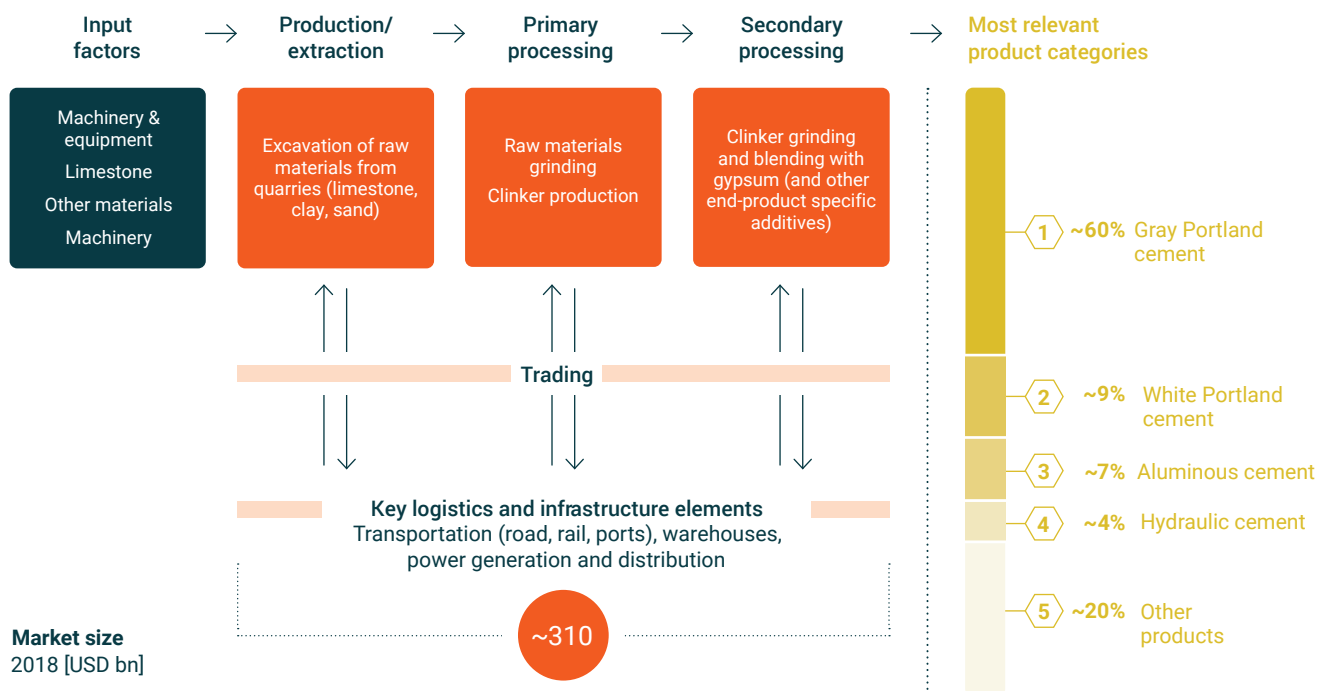
Alternative fuels such as waste-to-energy using municipal waste, biomass and non-hazardous industrial waste present interesting opportunities, albeit in the long term. These alternative fuels not only reduce the CO₂ footprint, they increase cost competitiveness. Reducing the clinker factor is another key lever, for example by choosing alternative cements. Ordinary Portland cement has a 95 percent clinker factor whereas limestone Portland has just 65 percent.

Governments are currently driving the shift to less energy-intensive and greener cement production. New regulations replacing the traditional use of gas or coal are being implemented, including in some IsDB member countries. The UAE, for example, has introduced a public-private partnership scheme co-financed by the Ministry of Presidential Affairs to build a USD 40 million waste-to-fuel facility specifically for the cement industry.

POSITION OF ISDB COUNTRIES – REGIONAL VARIATION, OVERCAPACITY

Turkey is world's fourth-largest cement producer, with a total annual production of 84 million tons. Other key IsDB countries are Indonesia and Egypt, ranked sixth and tenth respectively, followed closely by Iran and Saudi Arabia.

The African continent has the lowest level of cement



The global cement market was worth USD 310 billion in 2018 and provides employment for an estimated 1.2 million people. Cement is a vital commodity for construction due to its use in both mortar and concrete production. It is predominantly used in residential buildings (around 60 percent), with infrastructure accounting for just under one-quarter of consumption.

Cement is produced in almost 160 countries around the world, either in integrated cement facilities or by grinding imported clinker. China is the industry leader, producing more than the rest of the world combined. IsDB member countries account for 12 percent of

worldwide volume, with only Somalia, Palestine, Chad and Guinea-Bissau lacking production capacity.

Transporting cement is expensive so customers traditionally buy from local sources. As a result, global trade amounts to just three or four percent of total supply. Top exporting countries include a number of IsDB member countries, among them Indonesia and Saudi Arabia.

Most cement companies are vertically integrated, as simply extracting raw materials generates low profits. The top-ten companies worldwide account for 40 percent of global production, with the remainder of the market being highly fragmented.

consumption per capita, with average annual consumption of approximately 120 kilograms per capita in West Africa, far below the global average of 520 kilograms. By contrast, countries in the Middle East and Southeast Asia such as Indonesia are growing at above-average rates thanks to rising GDP and expanding populations, necessitating both residential and non-residential construction projects.

Although the situation varies by country, in the short-term the industry will be characterized by global overcapacity. This trend will also affect IsDB member countries: Saudi

Arabia, for instance, currently has overcapacity of around 40 percent following expansion by established players. Nevertheless, cement production remains a highly localized business and can potentially form part of the industrial backbone of most IsDB member countries, contributing to the creation of skilled jobs. Forecast growth in demand opens up opportunities for investment – particularly in new, more sustainable production processes.

IRON & STEEL

- **West Africa is potentially a massive opportunity for iron ore – newly discovered reserves could represent up to 15% of global supply**
- **The global iron mining industry is worth an estimated USD 180 billion, but IsDB member countries only supply around cent of total iron ore**
- **The steel industry is worth USD 780 billion, but it has recently seen overcapacity, which is expected to continue in the short to medium-term**

2030 AND BEYOND – GROWTH DRIVEN BY CONSTRUCTION AND AUTOMOTIVE

Construction, as the largest end-user industry, fundamentally shapes the outlook for steel. Construction is expected to expand in the coming years due to the continuous growth of emerging countries, especially large developing economies such as India.

Automotive, another important end-user industry, is also growing in terms of its demand for steel, although it is likely to see a growing trend toward substitution, with more lightweight elements such as aluminum and carbon fiber going forward. Overall, growth of the steel market is forecast at a CAGR of two to three percent through 2030.

CHALLENGES – ENVIRONMENTAL CONCERNS, OVERCAPACITY AND PROTECTIONISM

Steel production has a significant impact on the environment: Every ton of steel produced in 2017 led to around 1.8 tons of CO₂ emissions and generated significant amounts of pollutants. Tighter regulations on pollution are now forcing the industry to develop sustainable production processes. Directives are in place or planned in several countries. For

example, China has enforced production restrictions on heavy industry in response to its severe environmental problems and the government has ordered mills in key regions, accounting for 60 percent of steel capacity in the country, to meet ultra-low emission standards by 2020.

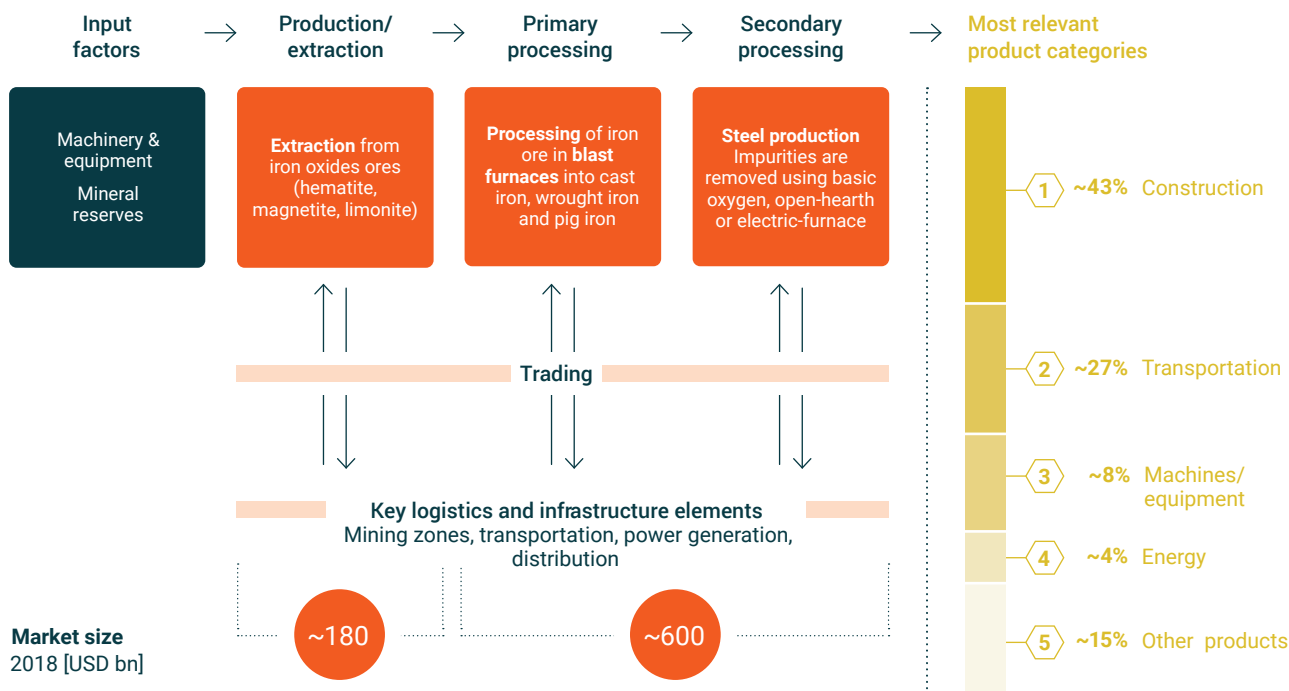
Recycling could be one solution to the environmental problem. Using ferrous scrap to produce steel reduces carbon emissions by more than one ton for every ton of steel made. By 2030, scrap is expected to account for more than half of Chinese steel production, and similar measures are needed worldwide. Japan, for example, has prohibited the disposal of household appliances and now achieves a recycling share of 98 percent of total scrap metals on market. Inevitably, this shift towards scrap usage will reduce demand for primary producers.

The industry is currently marked by overcapacity, a situation that is likely to persist over the next few years. Since 2008, crude steel production as a percentage of available capacity has fluctuated, hitting its lowest values in 2015 at a utilization rate of just 70 percent. This level has slightly improved recently but significant change is not expected in the short-term.

Overcapacity raises uncertainties about the advisability of building new steelmaking facilities. Protectionist measures may also lead to volumes being even more concentrated on a limited number of countries than they are at present, potentially leading to regional price differences across markets.

POSITION OF IsDB COUNTRIES – OPPORTUNITIES IN WEST AFRICA

Of the total global proven reserves of iron ore, around 17 percent are found in IsDB countries, with Sierra Leone ranked fourth worldwide according to the latest estimates.



The global mining industry for iron, around 90 percent of which is used as the raw material for steel, was worth an estimated USD 180 billion in 2018. The steel industry itself is worth USD 780 billion worldwide.

Thanks to its unique combination of strength, recyclability and relatively low cost, steel plays an essential role in the construction

sector. The most commonly sold type is the highly versatile carbon steel, which represents around 80 percent of total supply. China is the world's biggest steel-producing country, supplying more than half of global supply. The country is also mainly responsible for the increase in crude steel production, which has almost doubled since 2000.

In fact, many experts believe that West Africa could represent the new frontier in terms of iron ore production. Recently discovered reserves represent around 15 percent of the world's total proven deposits and there is significant potential to transform the region into an important exporter. In 2019, for instance, a China-backed joint venture won the rights to exploit a giant iron ore deposit in Guinea, at Simandou, one of the world's richest reserves of high-grade iron ore, with an estimated volume of two billion tons.

Currently, Iran is the only IsDB country that features in the global top ten for iron ore mining, accounting for around two percent of production, followed by Kazakhstan, ranked eleventh. Mauritania, Turkey and Sierra Leone all produce less than one percent of global output, and the total

production volume of IsDB countries is around five percent.

In terms of steel production, among the IsDB member countries only Turkey appears in the top-ten global ranking, at no. 9, with Iran coming in eleventh. Further increasing domestic steel production in countries with high negative trade balances (as is common in the Middle East and Africa) would increase pressure on global utilization rates and potentially lead to further plant closures. Consequently, ramping up investments in building local production and processing facilities should only be pursued if strong, sustainable competitive advantages can be achieved – reliable, low-cost energy sources and strong supply-chain and logistics infrastructure, for example.

ALUMINUM

- Demand will grow by nearly _____ cent through 2030, driven by increasing use of lightweight materials by the aviation, automotive and packaging industries
- IsDB member countries account for around 30 percent of global bauxite reserves, but are less strong in terms of aluminum production
- Guinea has the world's biggest reserves of bauxite, while the Middle East is gaining presence in processing

2030 AND BEYOND – AVIATION, AUTOMOTIVE AND PACKAGING

Annual consumption of aluminum is expected to grow by nearly five percent through 2030, driven mainly by lightweight materials for the aviation and automotive industries. For example, aluminum is used in various parts of vehicles, including body, chassis and wheels, and the share of aluminum content out of a potential maximum is projected to increase from around 25 to 45 percent in the period 2018-30. Aluminum plays an even more important role in the expanding market for electric vehicles, where its share is set to rise from around 30 to 55 percent. Demand is also expected to increase in the packaging segment, with global demand for aluminum cans forecast to rise by three percent annually, driven particularly by Asia, the Middle East and Europe.

CHALLENGES – SUSTAINABLE LEVERAGE OF BAUXITE RESERVES

The bauxite mining industry is of crucial importance to countries such as Guinea, where it accounts for 60 percent

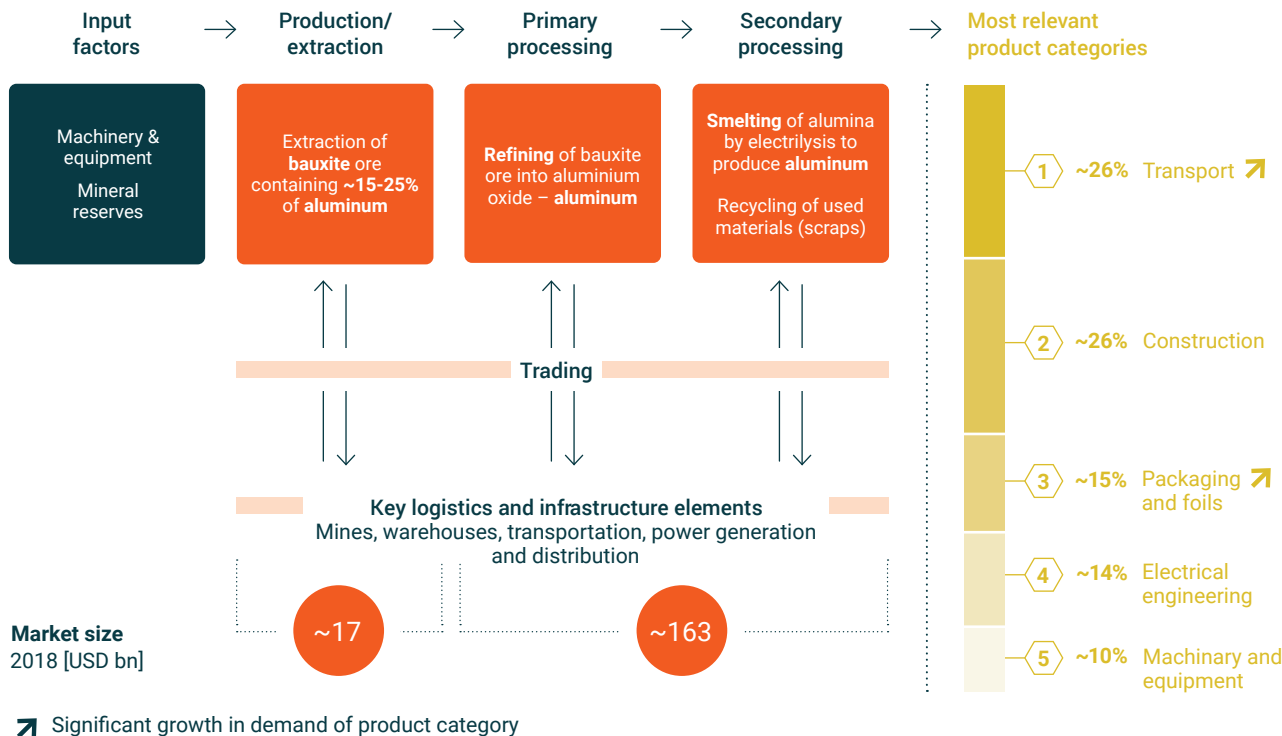
of total exports. Increasing global demand for aluminum gives such countries a chance to grow their mining sectors further and thereby accelerate economic development. The key here will be to expand across the value chain and diversify the economy by developing related industrial sectors rather than relying solely on commodity exports.

Foreign investments play an essential role here. For example, the government of Guinea is working with a consortium involving Chinese producer Shandong to develop a new primary processing plant in Guinea. The total investment is expected to be as high as USD 1.2 billion, including the construction of infrastructure such as new railroads. This will enable Guinea to expand its presence across the aluminum value chain, capturing higher shares of value creation. At the same time, such investments must be carefully monitored in order to avoid environmental damage to farmland, water sources and air quality.

The treatment of the environmentally hazardous "red mud" (a highly alkaline residue from bauxite refining) should be a key industry concern. Innovative techniques such as sea water neutralization have been increasingly used to manage the impact of bauxite residue, especially in Australia. Also, treatment technologies such as "dry stacking" and "dry disposal" raise red mud solid content up to 80%, decreasing liquid levels that present a hazard for fertile soils and groundwater in case of leakage.

POSITION OF IsDB COUNTRIES – A KEY INDUSTRY

Proven reserves of bauxite are in excess of 30,000 million tons, of which IsDB member countries account for around 30 percent. Guinea leads the way here, with proven volumes of 7,400 million tons of bauxite ore – about one-quarter of global reserves – while Indonesia also has significant reserves of around 1,200 million tons.



Total world production of new aluminum is around 60 million tons a year. When accounting also for the quantities of recycled aluminum, the total market was worth around USD 180 billion in 2018. The global market for bauxite, from which aluminum is produced, is worth just a small fraction of this at around USD 17 billion.

Bauxite deposits are usually found near the surface, which makes extracting them via open-pit mining both easy and economically viable. The bauxite is then refined into aluminum oxide – or alumina – the process producing a residue known as "red mud", which can be an

environmental hazard if disposed of in rivers or seas due to its alkalinity; however, it can also be used as a raw material as it is rich in iron and scandium. Finally, aluminum is produced via smelting.

Aluminum is produced via smelting, and it is used in a wide range of industries, with about a quarter going to the transportation sector, mainly for road vehicles and airplane parts, and another quarter going to the construction sector. Around 15 percent of total demand is used for packaging, where aluminum is popular as a food-contact safe material which does not corrode.

Global production of bauxite was approximately 311 million tons in 2018, with IsDB countries responsible for roughly 22 percent of global supply. Guinea is the world's third-largest producer, accounting for 16 percent, or 50 million tons, in 2018. The top-ten producing countries worldwide also include Saudi Arabia and Kazakhstan, ranked eighth and ninth respectively.

Emirates Global Aluminum (EGA) is one of the world's top producers of aluminum, operating two smelters in the UAE with a capacity of 2.5 million tons. The company is currently investing in a new bauxite mine in Guinea, forecast to make

a total direct and indirect annual contribution of USD 700 million to the Guinean economy and create 1,000 permanent jobs. Overall, the aluminum industry is developing strongly on the Arabian Peninsula, which is home to several large producers including Alba in Bahrain (annual capacity of one million tons) and Ma'aden in Saudi Arabia (0.7 million tons).

GOLD

- **Gold the most important mineral for IsDB countries due to its widespread production and high value**
- **IsDB member countries account for around 20 percent of global production – gold is the main economic driver in countries such as Burkina Faso, Togo, Suriname and Mali**
- **West Africa offers significant opportunities thanks to its vast, easily minable resources and low production costs**

2030 AND BEYOND – INVESTMENT BY CHINA, INCREASED REGULATION

Gold is particularly important due to its role as a financial product. It is widely considered an established alternative investment option, often perceived as countercyclical to other financial instruments and independent from fiat currency.

In terms of the international mining market, China is currently driving a rise in mid-scale mining operations in West African countries, including Burkina Faso, Ghana and Guinea. At the same time, the role of "gold streaming" and royalty companies – companies that do not own mines themselves but provide capital to gold miners in return for gold at a greatly discounted price is growing.

On the demand side, ethical consumerism may well drive down future demand for jewelry made from gold. However, this may be offset by increasing demand from the expanding middle classes in India and China in particular.

In terms of technology, more environmentally friendly reagents are currently being tested as replacements for cyanide, used in large-scale mining (LSM) to separate gold from undesired materials. In the past, cyanide has caused major environmental damage, such as in the 2000 Baia

Mare spill in Romania. Further downstream, innovative technologies such as blockchain are being employed to track and trace gold, strengthening responsible sourcing schemes by enabling digital record-keeping. Such efforts are partly in response to the European Union's Conflict Minerals Regulation, which will come into effect in 2021. The United States has enforced similar regulatory policies requiring publicly-listed companies to check their supply chain for gold originating in conflict zones.

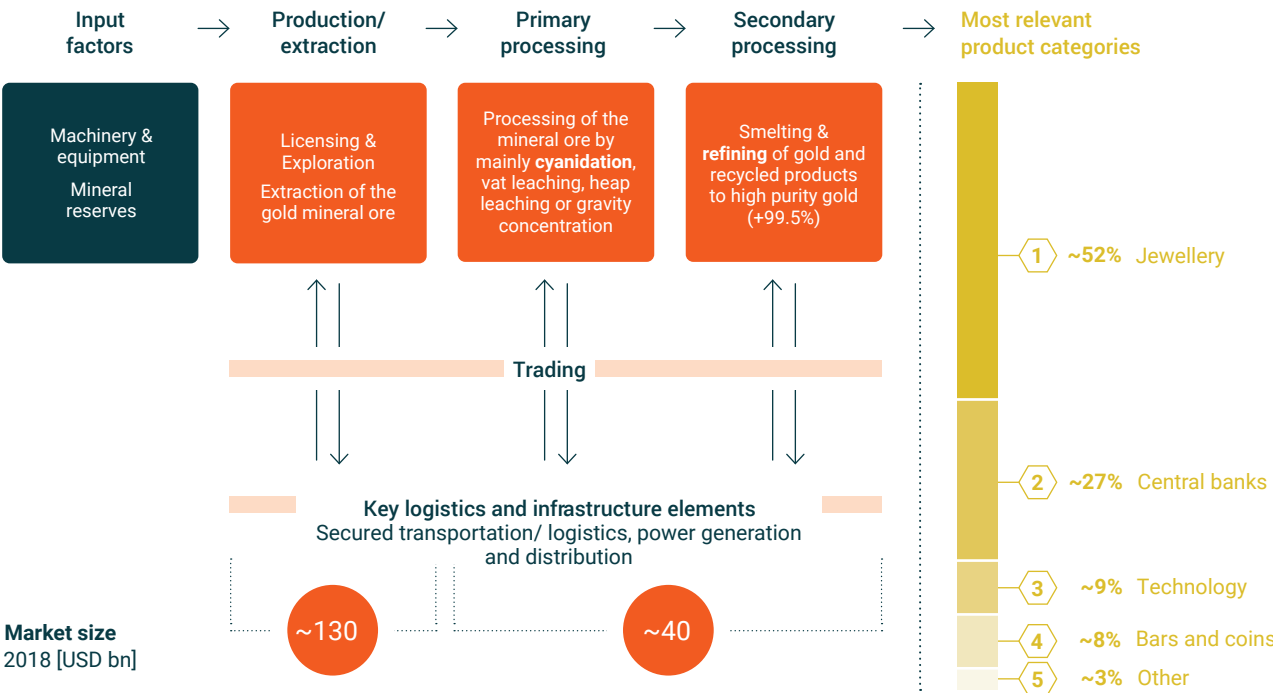
CHALLENGES – HEALTH, ENVIRONMENTAL AND ETHICAL ISSUES

A major challenge in gold production is the use of mercury to isolate gold in artisanal and small-scale mining (ASM). This can severely damage the health of miners, as well as polluting the environment. Increasingly consumers are also raising ethical concerns with regard to the sector's environmental footprint and the use of revenue from gold mining to fund armed conflict.

POSITION OF IsDB COUNTRIES – MAJOR GLOBAL PLAYERS, ROOM FOR ACTION

Gold is the most important mineral for IsDB member countries, due to both its high value and the fact that it is widely mined. IsDB countries account for around a fifth of global production, with Indonesia – the only IsDB member country in the global top ten – contributing six percent of world supplies (2018). In addition, Sudan ranks eleventh with almost three percent of world production, while Uzbekistan and Kazakhstan are placed twelfth and fourteenth, each accounting for around two percent of global gold production.

Many IsDB member countries rely heavily on gold for their economies: Mali and Burkina Faso, for example, contribute a



At the end of 2017, an estimated 190,000 tons of gold existed above ground and 54,000 tons in reserves below ground. The total market volume of the above-ground stock of gold was an estimated USD 7.3 trillion, while the market size in 2018 based on annual demand was an estimated USD 170 billion.

Gold is mined in more than 90 countries, of which just under half produce more than ten tons a year. Mining activities are widespread, with around 23 percent of all newly-mined gold coming from Asia, 19 percent from Africa, 17 percent from Central and South America, 16 percent from North America, and 14 percent from the Commonwealth of Independent States. IsDB countries account for roughly 21 percent of gold mine production globally.

Primary processing usually takes place close to the mines. Secondary processing is mostly performed elsewhere, with around two-thirds of the world's gold refined in Switzerland. Among IsDB countries, the United Arab Emirates and Turkey also have large refining facilities.

After refining, gold enters the bullion trade, from where it continues towards its various uses, such as in jewelry (52 percent), bars and coins for investment (27 percent) and in technology (nine percent). As gold is indestructible, in theory all the gold ever mined is still accessible and available for recycling; indeed, around one-quarter of total annual demand is supplied from recycling.

total of around three percent to the world production. But the industry is also vital for countries producing limited volumes, such as Suriname, Guyana, Kyrgyzstan and Togo. Despite this, many developing countries within the IsDB have not as yet carried out a comprehensive resource assessment – a crucial step going forward. IsDB member countries should also strive to develop clear legal frameworks, enforced in practice, to enable them to capture the revenue from gold exported from their deposits.

Indonesia, Uzbekistan and Kazakhstan, which enjoy high-grade deposits, relatively good infrastructure and political stability, are likely to remain important global players in the period to 2030 and beyond. Experts are also predicting a boom for gold in West Africa, where significant reserves have been identified that are relatively easy to mine.

NICKEL

- The industry is facing significant shifts due to e-mobility – batteries could make up 30 percent of demand by 2030
- Indonesia is the world's largest producer of nickel, accounting for one-quarter of global supply but just 13 percent of the processing market
- In 2020 Indonesia reinstated its export ban on nickel ore, aiming to further expand domestic processing

2030 AND BEYOND – SHIFTS IN THE VALUE CHAIN, NEW TECHNOLOGY

The nickel industry is expected to see significant shifts in the value chain as developments in e-mobility change the split of product categories. Battery use is forecast to represent up to 30 percent of total nickel demand by 2030, while global demand for steel is expected to fall to 50 percent. Despite short-medium term price volatility the outlook through 2030 is positive, with the overall market expected to pass the USD 50 billion mark.

New technology such as the Direct Nickel Process for laterites is facilitating increased levels of production and pushing down processing costs. At the same time, growing demand for Class I nickel is set to create opportunities for mines focusing on sulfidic ores – although these are of less relevance to IsDB countries.

Indonesia, as the world's largest producer of nickel, needs to tap into the potential market growth. To do so it will require additional processing capacity tailored to laterites. Partnerships with battery producers could be a way to achieve local production of subcomponents, allowing the country to capture a larger share of processing and expand further downstream. Failure to act, on the other

hand, coupled with the potential price disconnect due to the undersupply of Class I nickel and oversupply of Class II nickel, could erode the country's international position.

CHALLENGES – ENVIRONMENTAL ISSUES, CLASS 1 NICKEL

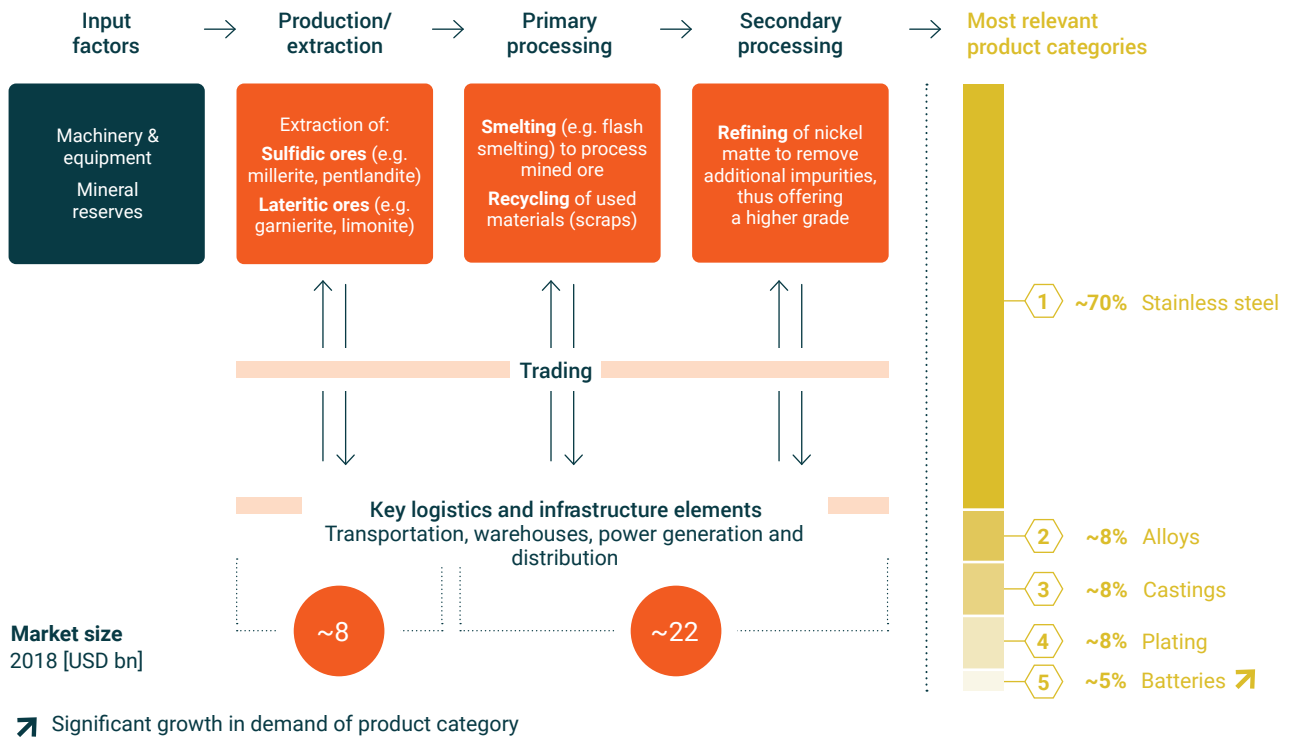
A major challenge facing the nickel industry is the environmental damage caused by extracting and processing nickel pig iron (NPI). NPI is favored in China and parts of Southeast Asia as a lower-grade alternative to ferronickel in steel production. Several Chinese producers have moved operations to Indonesia in an attempt to capitalize on the country's reserves and the fact that regulation in Indonesia is limited and often weakly enforced.

Another challenge facing producers is how to extract more Class I nickel. Demand for Class I nickel is likely to grow due to the expected increase in sales of electric vehicles, where it forms a core component of the battery. Global leaders such as Indonesia will need to expand into the battery supply chain in order to avoid excessive dependency on other product categories, especially steel, which use the potentially cheaper Class II nickel.

POSITION OF IsDB COUNTRIES – INDONESIA IS THE GLOBAL NO. 1

IsDB member countries together account for around 26 percent of global nickel mining production. Indonesia itself accounts for 25 percent of global production, the next most important player in the IsDB being Turkey, ranked no. 21 globally. IsDB member countries are home to just under a quarter of global nickel reserves.

In January 2020 Indonesia reintroduced its nickel export ban, first introduced in 2014. The aim of the ban is to support the country's processing facilities. Its initial



The global market for nickel at the end of 2018 was worth an estimated USD 30 billion. Of this, mining/extraction accounted for some USD, 8 billion with the remainder represented by primary processing and secondary processing, including recycling.

Mining activities are centered in roughly 25 countries, with sulfides found deep underground primarily in South Africa, Canada and Russia, and the more easily accessible laterites located in Indonesia, Australia and the Philippines. Sulfides, although generally less expensive to process, tend to be more difficult to mine and result in a high degree of pollution during the separation process. Laterites, on the other hand, are not contaminated with sulfur and so cause less pollution during separation; however, the process is very energy-intensive and often costlier than for sulfides.

Nickel is fully recyclable. Countries with low reserves, such as the United States, capitalize on this fact by sourcing a large proportion of production from metal scraps – around 40 percent. However, on a global level, only 15 percent or so of nickel is recovered from recycled sources. In terms of usage, over two-thirds of all nickel produced currently goes into the production of stainless steel.

Nickel players tend to either integrate across the value chain or confine themselves solely to processing. The market is fairly condensed, with the top-ten players making up just under two-thirds of global processed nickel output. More than 70 percent of all nickel exports currently go to China.

introduction in 2014 led to a loss of around 30,000 jobs in the country's mining industry, but also the creation of nine new smelting facilities, in turn generating 17,500 new jobs with higher skill level and greater perceived stability. The impact of the initial ban was significant, pushing domestic value creation up from USD 1.1 billion in exports to USD 1.5 billion. The environmental impact was mixed, however, as lower deforestation rates were offset by additional

waste from smelters, as well as air and water pollution. The reinstatement of the ban is expected to add to market volatility in terms of price, contributing to global market uncertainty in the short-term. It will also likely have a significant impact on nickel supply in China, which currently sources around 40 percent of its imports from Indonesia.



DATE: 20/10/2014
FOLIO: 010
OPERARIO: VICTOR FERNANDEZ

CONTROL DE OPERACIONES DE MANTENIMIENTO - EQUIPO (GERMAN)

| NO. | LOCAL | NOME | CLASSE | ASSISTENTE | TIPO DE |
|-----|------------------|---------|---------|------------|---------|
| 001 | Planta Principal | Gerente | Gerente | Gerente | Gerente |
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| 019 | Planta Principal | Gerente | Gerente | Gerente | Gerente |
| 020 | Planta Principal | Gerente | Gerente | Gerente | Gerente |

Employees of mining company monitoring iron extraction site from control room, ensuring safe and efficient operations



3

**HOW READY
ARE ISDB
COUNTRIES FOR
THE FUTURE?**

No "one size fits all" approach can be applied to IsDB member countries to unlock their vast potential

Three heterogeneous country clusters with similar market characteristics were formed in order to conduct future-readiness assessments and derive recommended actions

Innovation and full downstream integration are key levers for global champions

Investing in innovation hubs and technical education to bridge the skill gap and improve international competitiveness

Accessing manufacturing via industry partnerships will fully unlock mineral potential and partially hedge for risks

Strategic objectives: best-in-class regulation and stability

Regional players to fully capitalize on local opportunities and tap into global potential

Embracing energy-efficient solutions in construction to build strong competitive advantages

Developing extensive know-how in targeted technological innovations (e.g. 3D printing) to lead large-scale deployment

Boosting investor confidence will allow national contributors to gain processing foothold

Developing critical transport and power corridors to ensure that basic industry requirements are met

Engaging in public-private partnerships to improve workforce qualification – technical institutes, training centers

Fostering regulatory stability and improving ease of doing business

3.1

STARTING POINT FOR IsDB MEMBER COUNTRIES

Three main clusters with similar market characteristics

To identify patterns and investment opportunities, as well as to better tailor recommendations and actions, three country clusters were created among IsDB member countries. The country clustering was based on key parameters such as production output, proven reserves, processed volumes and trade dynamics across the 18 different minerals and construction materials.



Global champions

Countries with vast reserves and global relevance in terms of production. Increasingly, they are also significant processors of key minerals and construction materials.

Republic of Indonesia
Islamic Republic of Iran
Republic of Kazakhstan



Regional players

Countries that make a significant economic contribution in either mining or construction. However, in some cases they are unable at present to meet domestic demand for building materials such as steel and glass.

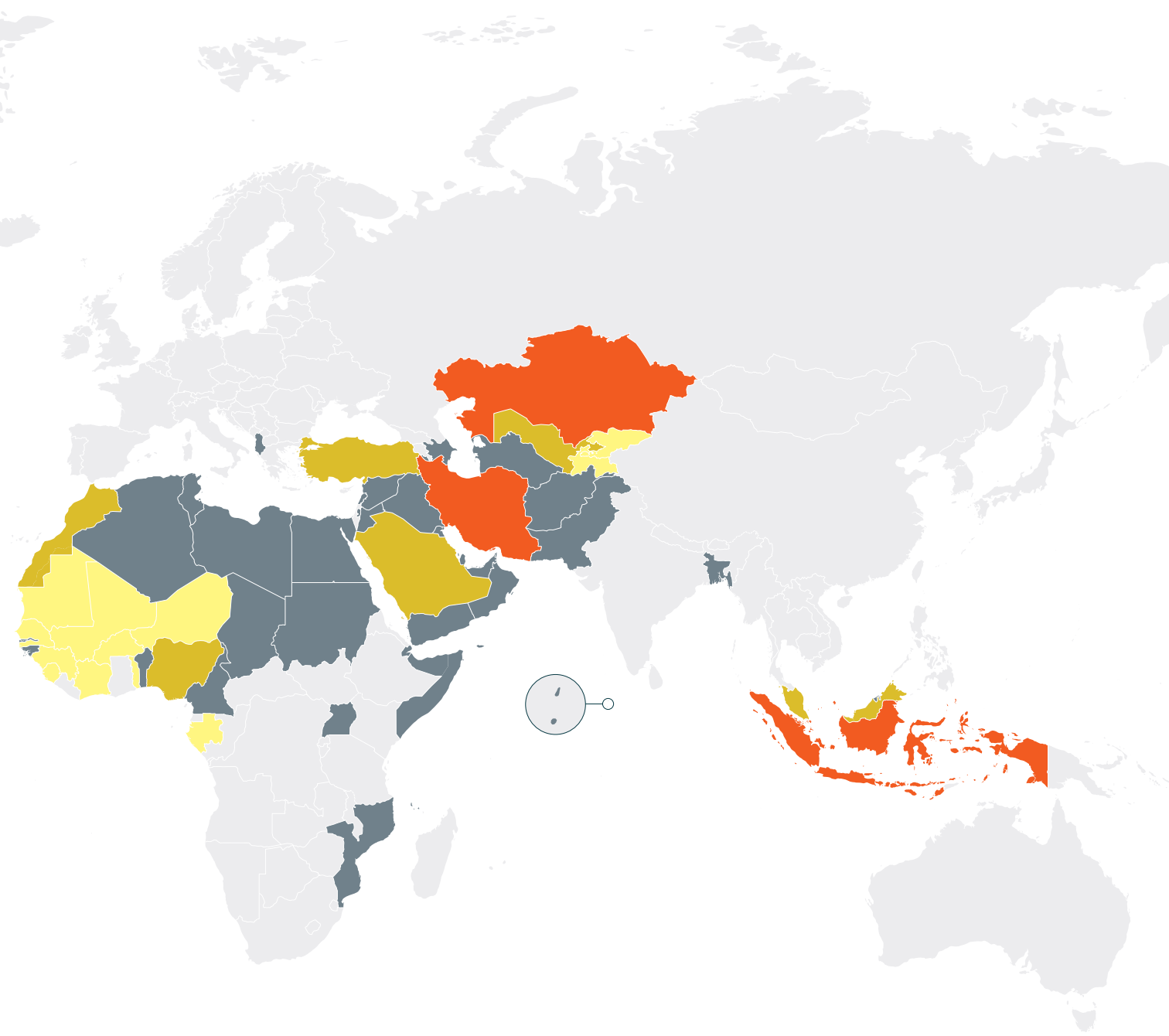
Malaysia
Kingdom of Morocco
Federal Republic of Nigeria
Kingdom of Saudi Arabia
Republic of Turkey
Republic of Uzbekistan



National contributors

Heavy reliance on the mining sector, which contributes more than ten percent to their economies. In construction, their performance is low to moderate.

Burkina Faso
Republic of Côte d'Ivoire
Republic of Gabon
Republic of Guinea
Cooperative Republic of Guyana
Kyrgyz Republic
Republic of Mali
Islamic Republic of Mauritania
Republic of Niger
Republic of Senegal
Republic of Sierra Leone
Republic of Suriname
Republic of Tajikistan
Republic of Togo



STARTING POINT FOR IsDB MEMBER COUNTRIES

After exploring the status quo of the global industries and highlighting the expected market dynamics, several key questions remain unanswered. What is the current positioning of IsDB member countries and what are the main implications for them? What is their future potential and what are the key actions they need to undertake in order to fully unlock it? This chapter aims to address these questions and more, providing a comprehensive understanding of the IsDB member countries in a global context.

Although certain differences such as economic development, demographics or geographic position exist, several similarities are also observable. To navigate this inherent complexity, identify relevant patterns and draw meaningful conclusions applicable to IsDB member countries, a clustering approach was employed. The clustering accounted for country-level competitive advantages, such as availability of natural resources and production output, as well as trade dynamics across the 18 different minerals and construction materials to identify emergent similarities and recurrent elements.

Industry best practices are frequently suitable for application across several cluster members based on the basis of their intra-group similarities. What's more, as the location of a country is not always a factor for its success, clusters allow for knowledge transfer across different geographies. For instance, identifying the success factors behind industrial developments, such as the establishment of processing facilities and analyzing the enablers that ensued (e.g. policy, education or infrastructure), can serve as a learning opportunity for other countries.

Employing a cluster-based approach ensures a holistic perspective across IsDB member countries, focused on the

overlapping elements and revealing the key competitive advantages these countries have leveraged, as well as the different areas for improvement that can present major obstacles for their development.

Global champions are countries that contribute more than two percent of global output for five or more minerals or construction materials. These leading countries have significant resources of several minerals or materials. Some have established extraction or processing capabilities: Indonesia, for example, is a global leader in nickel extraction and has strong capabilities in coal, gold and tin. Others have huge mineral reserves: For instance, Kazakhstan is home to more than 40 percent of global tungsten reserves, alongside other minerals such as copper and zinc.










The countries in the second cluster, **regional players** are contributing more than one percent of global production for between one and three minerals or construction materials. Regional players generally have a presence beyond their national borders and focus more on either mining or construction. For example, Saudi Arabia has a highly developed construction industry, while Uzbekistan has significant production of gold and copper.

The third cluster is represented by **national contributors**. It encompasses countries with one globally relevant mineral, and where mining accounts for more than ten percent of GDP. In general, the construction sector in these countries shows a low to moderate level of development, in line with their overall economic position. They are generally dependent on one specific mineral: bauxite in the case of Guinea, for example, or manganese in Gabon. They focus mainly on extraction and have limited capabilities in terms of processing.

Building site and multiple cranes in the United Kingdom



LAYING THE FOUNDATION

| | | |
|------------------------|--|--|
| SECTOR CAPABILITIES |  Energy | Build capacity & ensure supply continuity Build sufficient capacity to cater for industry needs. Supply continuity throughout the day/ seasons can be achieved through balanced energy mix (e.g. RES coupled with quick start plants) and proper grid maintenance. |
| |  Transport | Ensure main corridors Develop a transportation master plan that covers major mining and processing sites and align main corridors with other major economic points of interest. Ensure long-term continuity of main projects (e.g. rail, seaports). |
| |  Innovation | Swiftly adopt technology Ensure that advancements in selected, affordable technologies are rapidly adapted and adopted to national needs. Investing in the technical centers and SMEs can positively reflect on the local industries. |
| |  Workforce qualification | Build technical know-how and skills Offer a balanced skillset via investments in technical and vocational training institutes. Such developments are necessary to bridge the skill gap and provide industry with adequate labor force. |
| SECTOR COMPETITIVENESS |  Exploration | Achieve transparency over resources Identify and codify existing resources in the form of a geological map, thereby turning them into proven reserves. This will provide potential investors with the necessary information to consider local investments. |
| |  Competitiveness | Industrialize Develop industrial facilities beyond outdated and often artisanal processes. Facilitate additional resource processing to increase the country's overall mineral rents and overall industry attractiveness. |
| FRAMEWORK CONDITIONS |  SDG contribution | Safeguard environmental principles Ensure the adoption of basic environmental protection principles and eliminate hazardous workplace practices where technologically possible. |
| |  Governance & Regulation | Ensure stability and incorporate best practices |
| ACCESS TO FINANCE |  FDI | Improve ease of doing business and ensure right support for investors |

National contributors

CREATING COMPETITIVE ADVANTAGES

Choose LCOE over CAPEX/ MWh

Invest in new capacities or modernize existing plants with the aim of lowering the levelized cost of energy (LCOE) – Affordable energy is one of the key drivers for industrialization.

Do not create additional costs

Ensure the construction of a well-developed network allowing for optimized transportation of goods, in cost effective manner. Industry and end-users will therefore benefit from fast and reliable deliveries.

Achieve leadership in selected technologies

Prioritize technologies where competences are already high (e.g. 3D printing), striving to become an industry leader. Countries can thus benefit from a first-mover advantage and consolidate their global market position.

Focus on specialized higher education

Develop higher educational institutions, particularly in relevant industry fields e.g. engineering, architecture. This will allow the formation of highly qualified engineers and technical experts.

Ensure continuous exploration efforts

Stimulate investments in exploration activities to ensure long-term industry sustainability. By partnering with local incumbents or providing certain incentives (i.e. fiscal), the continuous search for new mineral deposits could reveal significant, previously untapped reserves. This will further drive national industry development and ensure constant and sustainable mineral reserves, a particular necessity as production volumes increase.

Modernize and build scale

Focus on increasing the capacity and efficiency of existing facilities (consolidation to be also pursued). This would lead to economies of scale and lower cost of operations, increasing industry competitiveness.

Foster energy efficiency & circular economy

Invest in energy efficiency, while ensuring environmentally responsible actions. Foster the usage of alternative fuels i.e. waste management systems, paving the path to a circular economy.

Announce regulatory changes in advance, consult with key stakeholders and avoid last-minute legislative changes – Stability is at the core of investment decision-making as investors, particularly when large capital requirements are involved, generally look to avoid unpredictable and unstable environments.

Incorporate regulatory best practices/ industry norms – Important investors are deterred from 'unchartered legislative territories'.

Attract foreign investors by improving the overall business environment in the country. Key applicable measures: protect private property rights, reduce bureaucracy and digitalize public services, tackle corruption among the public administration.

Introduce dedicated institutions to support companies considering investing in the country, providing them with information about available opportunities and facilitating administrative and regulatory procedures.

Regional players and global champions

FOSTERING SUSTAINABILITY

Decarbonize and shift from fossil fuels

Develop the construction and mining sectors in a sustainable manner by making decarbonization and shifting to alternative/ renewable energy a priority, thereby minimizing the associated environmental impact.

Establish clear targets and capitalize the available natural resources e.g. hydro, photovoltaics or geothermal.

Shift to efficient transportation modes (e.g. rail, sea) and phase out old, highly polluting and energy inefficient vehicles or rolling stock.

Foster innovation ecosystem

Establish and support an innovation-centric development strategy. Invest in technology hubs and finance tech startups. Engage in public-private partnerships, to foster development of disruptive discoveries.

Adapt educational policies based on demand

Tailor public policies to support public-private collaborations. Adapt educational policies and curricula to account for both current and future needs of the industry, favorably positioning the local workforce.

Build state-of-the-art facilities

Ensure the adoption of leading industry technologies to cater for the most efficient operations/ lowest production costs. Implement gratification mechanisms (i.e. for high efficiency).

Long-term wellbeing over short term profits

Make sustainability a priority in the future development of the mining and construction industries. Prioritizing long-term societal well-being over opportunistic short-term profits can translate into overall economic gain.

FUTURE READINESS ASSESSMENT

Why readiness matters?

All IsDB countries have potential. However, realizing that potential will not necessarily be easy. In the previous section the IsDB member countries were clustered into three groups based on their overall resources and the contribution (local, regional or global) made by their mining and construction sectors. This section investigates their readiness to compete in the global value chains – and how their competitiveness is likely to change over the coming decade.

To this end, the following section contains a detailed examination of three nations considered representative of the IsDB countries in general. The first is Kazakhstan, representing the Global Champions cluster. The second is Saudi Arabia, representing Regional Players. And the third is Guinea, representing National Contributors. Before moving on to the detailed country analyses, the methodology used to determine a country's readiness is explained.

READINESS ASSESSMENT METHODOLOGY

The methodology employed is designed to produce a comprehensive overview of both the current situation of the mining and construction sector in each of the representative countries and their potential positioning in 2030. It also highlights specific areas where these countries should take action to improve their global competitiveness.

Four key dimensions were evaluated with respect to readiness: access to finance, sector competitiveness, sector capabilities and framework conditions. For each of these dimensions, a series of three or four indicators were analyzed. In total, the methodology entailed screening across 15 indicators for the mining sector and 14 for the construction sector.

The dimensions chosen allow to assess a country's degree of industrial readiness to integrate into the global

industry and compete on the open market. They are based on criteria from international organizations such as the United Nations and the World Bank, industry associations and public bodies, as well as expert opinion and project experience. Combined, the dimensions and indicators provide a holistic view of the current state of a country's mining and construction sectors, and highlight where specific actions are required to advance this position.

In the graphics the country's current level is indicated for each indicator with a gray line, and its potential future position with a blue line. Key areas for action are marked with red lightning symbols; these are areas where countries can add the most value and optimize their development in the period to 2030.

DIMENSIONS AND INDICATORS

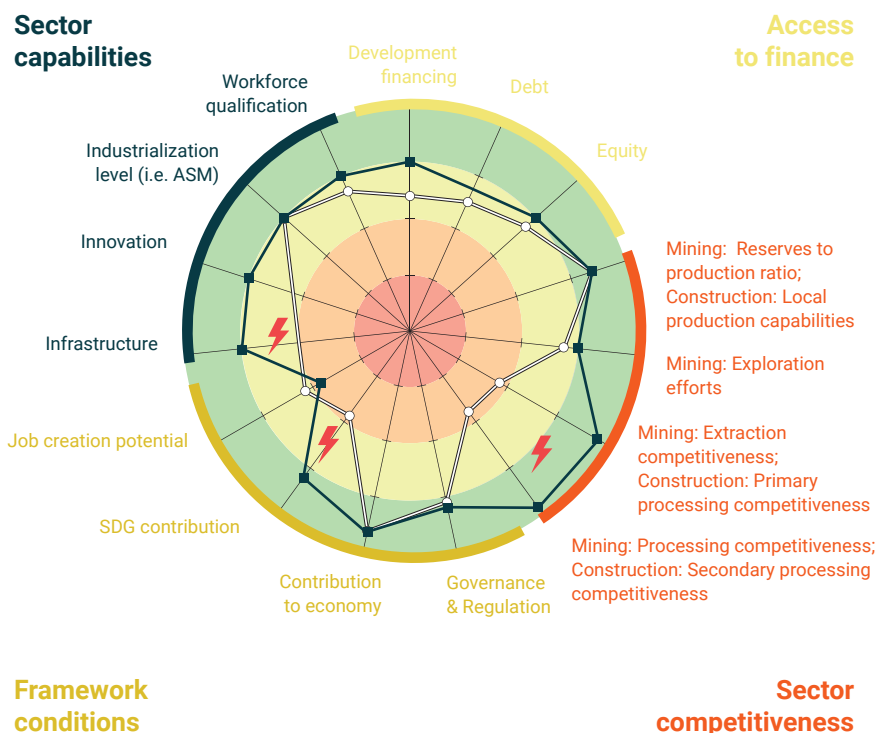
Access to finance: Private investments represent one of the main financing pools for the mining and construction sectors, providing equity in the form of local investments or foreign direct investments (FDI). As the industry develops, debt financing becomes also more important, funding new projects and providing liquidity. Finally, development institutions are an additional source of financing, supporting socially and economically important projects which the private investors and the banking system did not manage to finance.

Sector competitiveness: For the mining sector, the starting point here is the level of proven reserves in a country, which is also related to the degree of exploration performed so far. Once the reserves are discovered, they should be extracted efficiently and processed into higher value-add materials. For the construction sector, the existence of production capacities was examined, followed by primary processing efficiency, sometimes

Assessment dimensions



Future readiness assessment



complemented by further value addition through secondary processing.

Sector capabilities: Four indicators for both mining and construction were considered. Workforce qualification measures how well qualified workers are along the global value chain, on the assumption that better qualified workers generate greater value. Level of industrialization is important as consolidated markets generally employ best practices across the board, whereas fragmented markets rely on inefficient methods, such as artisanal and small-scale mining. Innovation indicates how advanced the sector is in terms of technology and processes. Finally, access to infrastructure is critical, as a reliable energy supply is needed for efficient processing, and good transportation infrastructure and cross-border connections drive the final cost of products.

Framework conditions: Job creation potential means the number of jobs potentially existing in the sector and how much workers could earn, with higher-paying jobs in the industry favored over lower-paying jobs. Contribution to SDGs concerns the sustainability of resources, energy and other factors affecting the environment and people; a positive example would be a sector that is CO₂-neutral and does not have a lasting adverse impact on the environment, while at the same time reducing social inequalities. Contribution to the economy refers to the current value generated within the sector compared to the maximum potential if the available resources were exploited as effectively as possible. Finally, governance and regulation measure the quality of the regulatory framework and adherence to it – a vital indicator as it establishes the framework conditions for all the others.

FUTURE READINESS ASSESSMENT

Global champions (country focus: Kazakhstan)

Kazakhstan is typical of the Global Champions cluster of countries in that it has vast mineral resources that it can exploit to become a global leader in 2030. The main challenges for the country over the coming decade will be improving its processing and manufacturing capabilities and fostering innovation.

Kazakhstan dominates Central Asia economically, generating around 60 percent of the region's GDP. Mining is a key pillar of the economy, representing more than ten percent of the country's gross value added. The country accounts for more than two percent of global output or reserves of more than ten key minerals, including copper, gold, silver, manganese and aluminum.

At present, Kazakhstan's main focus is on the extraction and primary processing of resources, an emphasis that owes in part due to its Soviet legacy. Significant progress is needed in developing secondary processing, improving competitiveness and reducing the sector's environmental footprint.

ACCESS TO FINANCE

Kazakhstan enjoys relatively good access to financing. Numerous global companies are present in the mining industry, including Rio Tinto, Glencore, Russian Copper, Polymetal, Rusal and ArcelorMittal. Earlier problems in attracting foreign capital were largely resolved by the creation of a national investment agency – Kazakh Invest – which acts as a single point of contact on behalf of the government. In 2018, the year after Kazakh Invest was set up, the country attracted USD 3.8 billion in foreign investor participation across all industries.

The local banking system also functions well, although the level of maturity is not particularly high. Thus, non-financial corporate debt, loans and debt securities accounted

for around 31 percent of GDP in 2018, while corporate loans made up just 12 percent of GDP. These figures are likely to grow as the local market and banking system matures.

Concessionary finance also plays an important role. In the last years Kazakhstan managed to obtain support from international development banks/ institutes. However, there is potential to increase the support received for the mining industry.

SECTOR COMPETITIVENESS

Attracting additional foreign investment and grants will be particularly important for increasing the competitiveness of the mining sector. For example, the Chinese company Xiamen Tungsten is expected to invest USD 0.75 billion in building mining capabilities to extract tungsten reserves from 2023. At the same time, the quality of the ores found in the country, especially for non-ferrous metals such as zinc and lead, is starting to decrease. To address this issue, the national mining company Tau-Ken Samruk is actively involved in exploration, and the country is encouraging private companies to do the same.

Extraction currently relies mainly on long-established facilities, which limit the sector's competitiveness. To address this issue, Kazakhstan needs to introduce modern technology, allowing it to increase productivity and achieve better environmental standards. The country's facilities are also overly focused on primary processing, with limited engagement in secondary processing. For example, Kazakhstan sends more than three-quarters of the bauxite extracted at the Pavlodar mining plant to Russia for further processing.

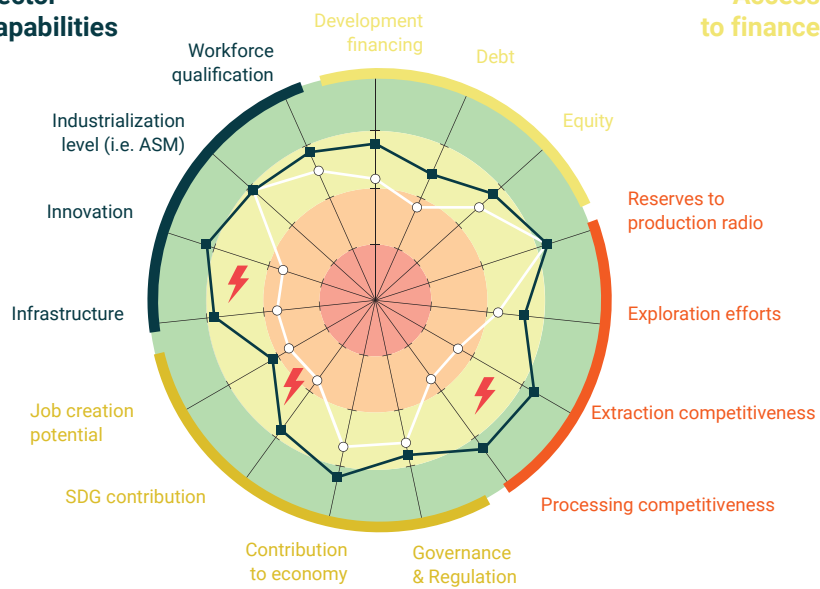
SECTOR CAPABILITIES

Despite recent progress in the area of infrastructure,

Future readiness assessment: Kazakhstan



Sector capabilities



Framework conditions

including using the National Sovereign Fund to improve the country's rail network, Kazakhstan still faces problems in the area of transportation and cross-border connectivity. The power supply is also far from perfect, ranked 82nd worldwide in terms of reliability by the World Bank.

Innovation plays a central role in modernizing infrastructure, and "Industry 4.0" forms a key part of the country's digital strategy. Some progress is already being seen here, such as the innovative "smart mine" in Kachar, where sensors enable real-time monitoring and automatic adjustments to enhance productivity. However, further progress on the national level is required here.

Overall, the level of industrialization in Kazakhstan is high, with artisanal and small-scale mining (ASM) making up just two percent of the sector. Workforce qualification is also relatively good, with dedicated higher education institutions and centers of competence working in partnership with industry incumbents.

FRAMEWORK CONDITIONS

Kazakhstan enjoys good framework conditions in terms of political stability, governance and regulation. The World Bank ranked the country among the top 30 in 2018 for ease of doing business. Kazakhstan adopted a new mining code in 2018, based on best practice in Australia, further increasing the attractiveness of the sector for investors. However, room for improvement remains on the Sustainable Development Goals (SDGs), where problems include environmental concerns, such as the high level of CO₂ emissions and radioactive pollution from nuclear testing carried out during Soviet times. Social inequality is also an issue in Kazakhstan, including regional poverty correlated with limited workforce mobility.

FUTURE READINESS ASSESSMENT

Global champions - 2030 scenario

The countries in the Global Champions cluster have vast and generally easily accessible reserves of several minerals, such as copper, gold, nickel, zinc, tin and tungsten. They enjoy a strong international foothold in these markets. For these countries, the 2030 Scenario will involve increasing their global footprint by consolidating and maximizing their core competitive advantages. Over the next decade, they are expected to achieve at least the industry average in terms of workforce qualification, infrastructure or key Sustainable Development Goals. At the same time, they could become top performers with regard to enablers such as innovation.

Global Champions are expected to make significant progress toward fully leveraging their natural mineral reserves in the period to 2030. This will mean ramping up their mining production and further developing processing facilities. Investment will be needed to overhaul existing facilities and to build new capacity. The aim should be to improve processing operations in terms of both efficiency and volume.

To derive additional value from minerals, Global Champions will likely increase their focus on downstream activities over the next decade, moving more strongly into manufacturing. Partnerships with key players in other industries will help here, such as automotive or consumer goods, depending on which particular metals the country mines. Collaborating with established manufacturing facilities will make it possible to leverage reserves and exploit other advantages such as low-cost labor and large domestic or regional demand.

By 2030, the governments of Global Champions will have developed regulations that foster sustainable development and stability. There will be stronger focus on environmental impact, with players encouraged to

adopt more environmentally friendly mining practices. Corresponding incentives will be put in place.

If Global Champions successfully develop their strategic competences and improve their international competitiveness, their economic situation will have significantly improved by 2030. This will provide the key to fully exploiting the industry's potential, and at the same time act as a basis for diversification.

RECOMMENDATIONS

To maintain their current position, Global Champions must focus on expanding and fully leveraging their processing capabilities, developing further downstream into manufacturing and ensuring economic and environmental sustainability. To achieve success in this ambitious undertaking, they will need to direct their national efforts toward key enablers such as innovation, regulation, workforce qualification and infrastructure. They will also need to attract significant investment in these areas.

Innovation is a key enabler, particularly for countries aiming to improve their processing capabilities. Adopting new technology and implementing breakthrough discoveries improves global competitiveness. But fostering innovation is a long-term process that requires commitment from a strong partner. In most cases, this is a role for government. In fact, becoming a technological hub and establishing the necessary R&D institutions to drive innovation is only possible with the full engagement of all key stakeholders, ideally backed up with international collaboration.

Another critical enabler is **education**. Without the necessary knowledge and access to a skilled workforce with appropriate technical qualifications, industry cannot develop as it should. The result is difficulties attracting FDI, higher operating costs for companies (which are forced

to employ foreign workers), and an absence of disruptive innovations. To avoid these problems, Global Champions must invest in their higher education system and at the same time develop industry-specific institutions. For example, Kazakhstan has established dedicated mining institutes. Similarly, in the Regional Players cluster, Saudi Arabia has created mining technology simulators. Steps such as these can help overcome barriers and at the same time increase countries' international appeal.

Global Champions need to establish a predictable and investor-friendly **regulatory framework**. This should be based on international best practices, such as those found in Australia, for example. Regulations should also take into account the long-term development of the mining industry, ensuring that minerals are extracted using sustainable methods (avoiding environmentally damaging mining techniques) and in appropriate volumes (implementing sustainable reserves-to-production ratios).

In terms of **infrastructure**, Global Champions should continue to invest in both transportation and energy. Kazakhstan, for example, lacks access to water – currently the world's cheapest means of long-distance transportation. It must therefore embrace rail as the next best alternative. Indonesia, with its 17,000 or so islands, is at the other extreme. Its objective must be to ensure the necessary port infrastructure. Initiatives such as the joint venture with UEA-based DP World – an investment of approximately USD 1.2 billion – will add additional capacity and should be prioritized.

To achieve both economic and environmental **sustainability**, Global Champions need a clear focus on renewable energy going forward. This can take various forms, such as hydroelectric power in Kazakhstan, or geothermal or solar power in Indonesia. Strategic

investments in renewable energy and the introduction of attractive financing schemes, such as power purchase agreements, can help provide market players with cheaper energy while also delivering substantial environmental benefits.

The above-mentioned enablers all require good **access to finance**. Global Champions must ensure an attractive environment for FDI and, at the same time, the necessary instruments for financing SMEs and startups, all underpinned by a clear regulatory framework. Countries can facilitate market entry for investors by means of initiatives such as Kazakhstan's mineral investment agency. The existence of such bodies can make a strong contribution to a country's overall ease of doing business score.

By focusing on these key enablers, Global Champions can secure their competitive position in the dynamic global mining market – and improve that position going forward. Global Champions currently find themselves at a crossroads. They can act now and flourish, becoming highly competitive leaders in the global value chain, or they can remain passive and potentially see themselves gradually losing ground to the competition.

FUTURE READINESS ASSESSMENT

Regional players (country focus: Saudi Arabia)

Regional Players make an important economic contribution in either the mining or the construction sectors. This section takes a closer look at Saudi Arabia, which has a relatively well developed construction materials industry. The country's main challenges lie in meeting local and regional demand, fostering innovation and improving sustainability. These issues are characteristic of several countries in the Regional Players cluster – Turkey and Nigeria, for example – which serve regional markets and have managed to gradually improve their processing footprint over time.

Saudi Arabia is the second-largest economy in the IsDB and the 18th largest in the world, with nominal GDP of USD 782 million (2018) and expected annual growth through 2030 of around two percent a year. The country has the world's third-largest reserves of natural resources, valued at USD 34 trillion, including the world's second-largest petroleum reserves and fifth-largest natural gas reserves.

The construction industry is of key importance for Saudi Arabia. The country plans to make significant investments in industrialization and in diversifying its economy, as reflected in the government's "Vision 2030".

ACCESS TO FINANCE

Saudi Arabia performs well in terms of access to financing. International bodies such as the IsDB and the World Bank support the country's industry, as do local institutions. The cement, ceramics, glass and steel industries in particular are well covered in the government's Vision 2030.

The banking system in Saudi Arabia is also relatively well developed. The country's financial system is ranked 38th in the world (2019), with a very low share of non-performing loans and a moderate level of credit provided to the private sector. Saudi Arabia also enjoys significant FDI and aims

to attract an additional USD 430 billion of local and foreign investments by 2030.

SECTOR COMPETITIVENESS

Local production facilities vary significantly across segments in terms of their level of development. Saudi Arabia is one of the top ten cement producers worldwide, for example, and the flat glass industry is a strong regional player, exporting more than half of production. In steel, by contrast, Saudi producers do not cover local demand and there was a trade deficit of around USD 3 billion for steel and iron products in 2018.

In the primary processing segment, Saudi Arabia's abundant natural reserves of limestone, granite, silica sand and other materials lend it a strong competitive advantage. But the industry is not fulfilling its potential and the overall trade balance is modest.

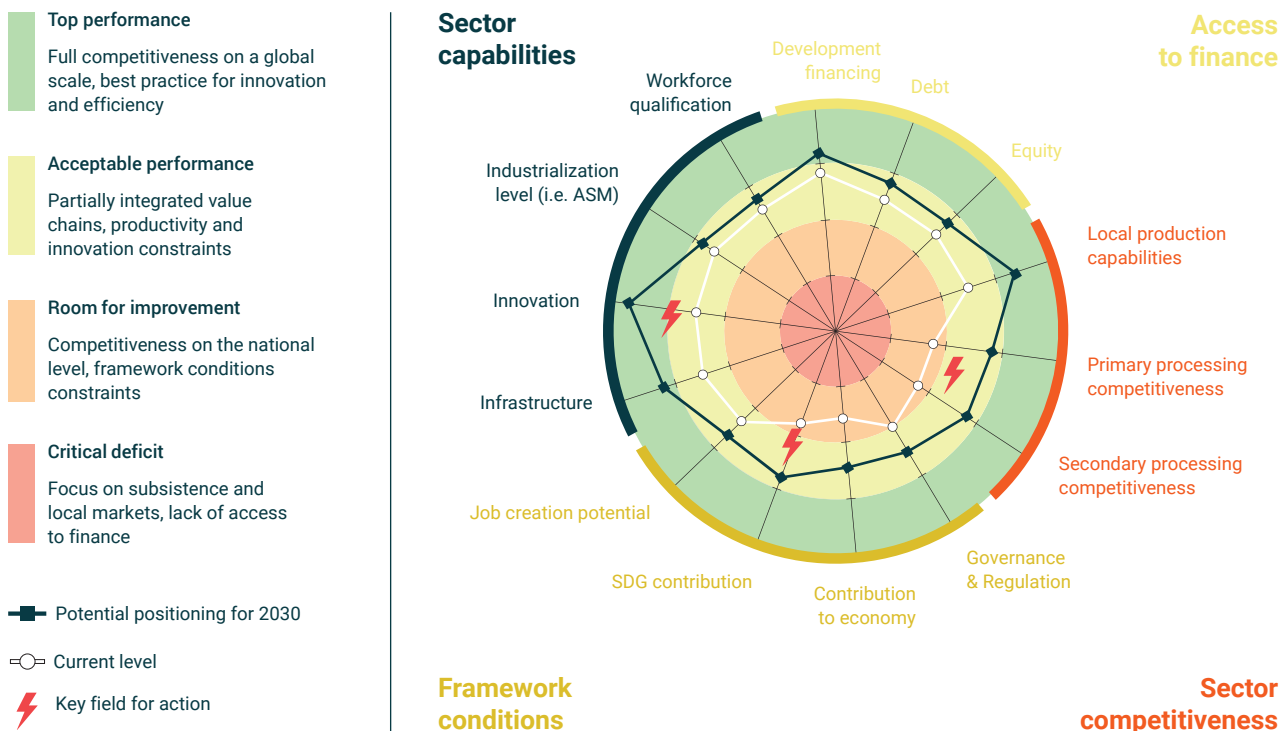
Local production facilities tend to be inefficient in terms of their energy use, relying on low energy prices. In cement clinker production, for example, over half the country's producers consume more energy per ton than the global average. Furthermore, local producers rely strongly on heavy fuel oils and gas.

In the cement sector, producers easily meet local demand. In fact, the sector is currently experiencing overcapacity, and opportunities for export are largely already exploited.

SECTOR CAPABILITIES

In 2019 the World Economic Forum ranked Saudi Arabia 34th in terms of overall infrastructure quality, up six places on the previous year. Vision 2030 foresees further major investments in infrastructure. The construction materials sector is well industrialized, despite its relatively low energy efficiency, and industrialization is expected to continue over

Future readiness assessment: Saudi Arabia



the next decade. The government is actively supporting the shift away from this reliance on low energy prices by providing funding through the Saudi Energy Efficiency Program. Through the Building Technology Stimulus Initiative it also supports the development of advanced building materials production.

Overall, the innovation capability of the Saudi economy has improved significantly in recent years. Thus, the country was ranked 36th for innovation in the 2019 global competitiveness index, with an upward trend, putting it almost at the level of the global leaders. In addition, the education system is well financed, although some scope remains for improvement in terms of overall quality.

FRAMEWORK CONDITIONS

Saudi Arabia performs well in terms of political and economic stability. However, governance and the

regulatory framework for the private sector show room for improvement. The World Bank ranks Saudi Arabia 62nd for ease of doing business (2019).

The construction materials industry has strong potential to increase its contribution to GDP. This is likely to take place over the coming decade as the government invests in infrastructure, manufacturing and residential buildings under Vision 2030. Growth in the construction sector also means new jobs, especially for engineers and other highly skilled workers.

Sustainability remains a challenge for the industry, particularly with regard to energy efficiency and pollution. The United Nations ranked the country 98th out of 162 countries in its global sustainable development goals report for 2019 – a position well behind the majority of developed countries.

FUTURE READINESS ASSESSMENT

Regional players - 2030 scenario

The Regional Players cluster consists of six countries that, although geographically dispersed, display similarities in terms of their populations and growth dynamics. They are also comparable with regard to their mining and construction industries: for example, they export excess supply of certain minerals or construction materials like cement, creating a positive trade balance, and have potential to do the same with other materials in the future.

The mining and construction industries of Regional Players are developing positively, albeit with a high degree of variation between individual countries. Economically, Saudi Arabia is a high-income country and Turkey a medium-income country. Other countries in the cluster can be categorized as low to medium income, with an average GDP per capita of around USD 5,000.

Turkey can be considered a global leader in the construction market, but in terms of mining it only has global scale for lead and zinc. Uzbekistan, on the other hand, is almost entirely focused on its mining industry, while countries such as Saudi Arabia and Morocco demonstrate a relatively balanced split between the two sectors.

Given that the construction sector is important for all Regional Players but at the same time differences exist between individual countries, it is useful to split the cluster into two groups. These two groups reflect the current status and future development path envisaged for the construction sector in the period to 2030. The first group comprises countries whose construction industry has already achieved global status or is close to doing so; the second, countries that need to consolidate their current regional position over the coming decade.

Saudi Arabia and Turkey make up the first group. Their construction materials industry either already enjoys global

status or is close to achieving it. Over the next decade they are expected to increase their global competitiveness and expand into emerging technologies, such as advanced construction materials. Additionally, they are likely to increase their presence in related sectors, such as construction services and engineering. This makes them a model for other countries in this cluster to follow. As these two countries make significant investments in developing their competitive advantages, they are expected to gradually shift into the Global Champions cluster.

The second group comprises Malaysia, Morocco, Nigeria and Uzbekistan. These nations need to consolidate their current regional position. They are expected to focus on strengthening their existing competitive advantages in order to stay competitive within their regions. It is likely that they will focus on securing key structural elements, such as infrastructure and regulation, while at the same time investing in their emerging innovation capability. They are also expected to consolidate their position in processing, which will lead to an increase in the level of their exports.

Although the overarching aims of the two groups in this cluster differ, the efforts they need to make in order to achieve these aims are very similar. The recommendations below therefore apply to all countries in the cluster, except where specifically stated otherwise.

RECOMMENDATIONS

To achieve the 2030 Scenario, Regional Players will need to expand into processing, meeting regional demand and producing high-value materials while leveraging their competitive advantages. As part of this effort, they should incorporate the fundamental economic enablers outlined below into their strategic development plans and set themselves clear, attainable targets.

Ensuring **affordable energy** will be essential to maintaining or raising the level of industrialization in Regional Players' construction industries. Affordable energy is vital for developing materials such as cement and steel, whose production is highly energy-intensive. Affordable – and accessible – energy will also give these countries a local competitive advantage. Nations such as Saudi Arabia, which is still heavily dependent on oil for power, could benefit particularly from tapping their potential for renewable energy, such as solar. Doing so would ensure sustainable access to a cost-effective power supply while also reducing the sector's environmental footprint. The increased use of alternative fuels is expected to facilitate this transition.

In terms of **transportation**, Regional Players should maintain their infrastructure and direct investment toward strategic locations for exports, such as ports. This will translate into lower costs for companies looking to engage in export activities. However, the low-income countries Nigeria or Uzbekistan must also ensure the development of road and rail infrastructure. Besides facilitating the development of industry, investing in transportation infrastructure will help alleviate the upcoming challenge of population growth in countries such as Nigeria.

Regional Players should also strive to improve the **quality of education** in their countries. Developing higher education in fields such as architecture and civil engineering, for example, increases the level of technical qualification among the workforce. Creating incentives for public-private partnerships ensures that all relevant stakeholders are investing in education, not just government.

The countries' **innovation** capabilities must also grow. Regional Players should establish "innovation hubs" for technologies in areas where they excel, such as 3D printing in Saudi Arabia. Focusing on this expertise will ensure that

cutting-edge technology is adopted by local industry. It may also result in disruptive discoveries.

The development of local industry should be closely tied to investments in **sustainability**. Here, a strong regulatory framework is needed to support investments in modern production facilities for construction materials. Regional Players, given their large size and expected economic growth, must pay careful attention to waste management and energy efficiency as they move toward a sustainable future. The private sector in these countries has in many cases already recognized sustainability as a key area for investment. Saudi-based Yamama Cement Co, for instance, is currently building a new cement plant that prioritizes product quality, energy efficiency and environmental protection. This can serve as an example for other projects in the sector.

Another key enabler for local construction industries is improving **access to finance**. Countries such as Turkey and Nigeria need to attract more foreign capital into their construction materials industry. This task will be easier if they are able to improve their macroeconomic situation. Several Regional Players, in particular Nigeria, Morocco and Uzbekistan, need to improve their local banking systems and increase access to corporate debt, loans and debt securities, thereby providing the private sector with greater financial liquidity.

By taking these actions, Regional Players can maximize their competitive advantages and boost their attractiveness for investment. This will enable them to strengthen their position in regional markets and continue along the path to becoming Global Champions.

FUTURE READINESS ASSESSMENT

National contributors (country focus: Guinea)

The countries in the National Contributors cluster show a clear focus on the mining sector, with the construction industry playing a much weaker role in their economies. Key areas where these nations face challenges include transportation and energy infrastructure, working conditions and impact on the environment.

Guinea is typical of the National Contributors. It enjoys remarkable mineral riches, including roughly a quarter of proven global bauxite reserves, as well as iron, gold and diamonds. Unsurprisingly, its economy is centered around the mining industry, which represents 20 percent of the country's gross value added.

However, Guinea's mining sector is far from reaching its full potential. The industry focuses mainly on extraction, with very limited processing taking place within the country. Guinea has not yet fully explored its resources, which may be even greater than suspected. Financing is plagued with difficulties, and the transportation and energy infrastructure leave much to be desired. Nor are the country's rich mineral resources reflected in the wellbeing of its people.

ACCESS TO FINANCE

Financing represents a significant challenge for Guinea. The country's banking system, which should provide "debt" financing in the form of loans, is somewhat dysfunctional. As a result, local people find it difficult to access capital. Liquidity is in short supply and inflation high. The situation with regard to FDI, or "equity" financing, is not much better. Most investments in the past have come through partnerships with the government, although some global players such as Rio Tinto, Vale, Bellzone, BPH and Aluminum Corporation of China are present in the country.

These issues make development financing provided from international institutions highly important as a key

motor for driving the country's economy. The IsDB has invested around USD 1 billion in Guinea. However, focus on the mining sector has been relatively limited to date.

SECTOR COMPETITIVENESS

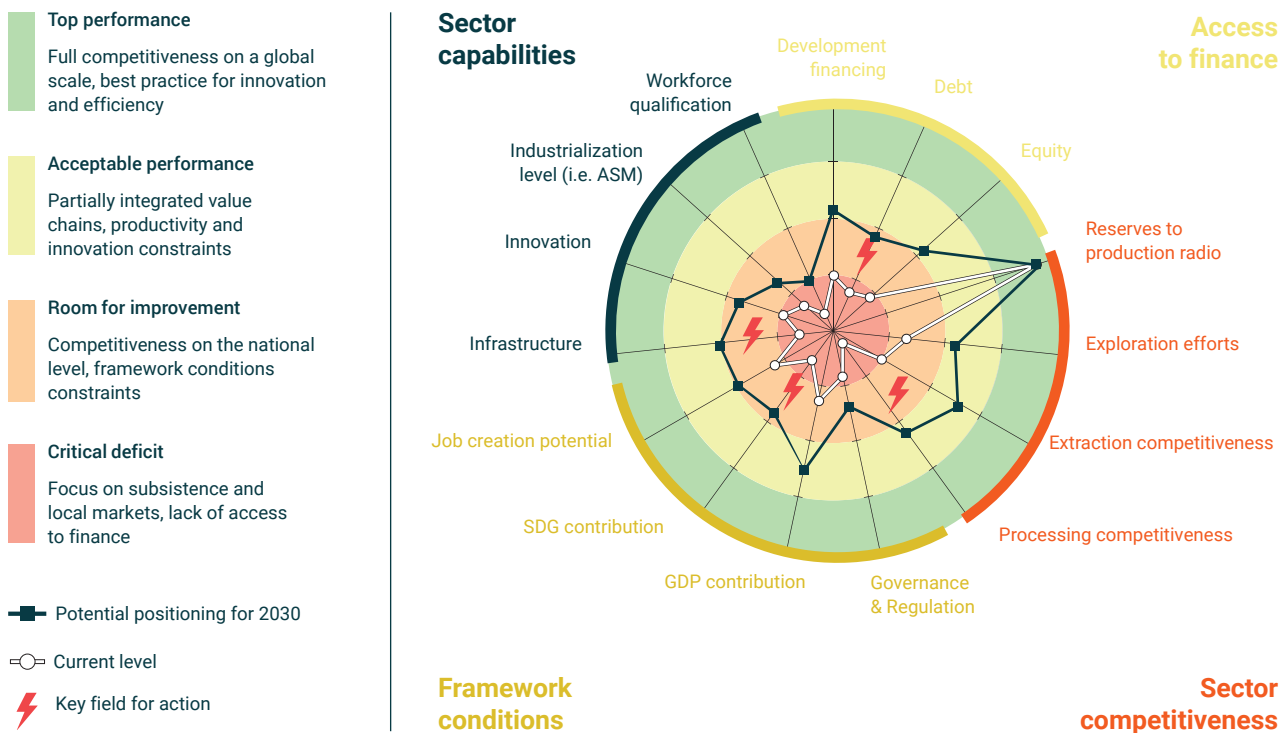
Guinea ranks high in terms of global reserves of minerals, with approximately 25 percent of proven global reserves of bauxite and more than two percent of proven global reserves of iron, most of it high grade. The country's actual reserves may be even greater, but as yet no comprehensive exploration of the country's resources has taken place.

Activities are focused on extraction, with very limited primary processing and no high-value-adding processing occurring in the country, despite the huge potential. Moreover, current production is not aligned with reserves: Guinea accounts for just 15 percent of global bauxite production, and its production-to-reserves ratio is even lower for iron and other minerals.

SECTOR CAPABILITIES

In 2019 the World Economic Forum ranked Guinea 125th out of 141 countries for infrastructure. Transportation infrastructure is weak, although one positive development here was the decision to make the awarding of the Simandou iron ore project conditional on the construction of 650 kilometers of Trans-Guinean railroad from the remote southeastern part of the country to the coast, and the building of a deep-water port. Energy infrastructure is also weak, with much of the country having no access to electricity and even Conakry, the capital, experiencing frequent blackouts. A positive initiative here is the 450 MW Souapiti hydroelectric project.

Future readiness assessment: Guinea



Mining has a low level of industrialization in Guinea, and innovation is weak as a result. Around 90 percent of the labor force employed in mining still uses ASM methods. Workforce qualification is poor; Guinea was ranked 180th in the world in terms of quality and access to education in 2019 in the United Nations' Human Development Index.

FRAMEWORK CONDITIONS

More generally, Guinea is adversely affected by political instability, corruption and also increasing tension between ethnic groups. The country ranks 131st out of 162 in terms of United Nations' sustainable development goals, as the environmental footprint of current mining methods, epidemics and poverty are challenges still to be tackled with the help of its vast resources. These elements, combined with cumbersome mining regulations, have until now

hampered the country's ability to attract investment from abroad. The World Bank ranks Guinea 156th out of 190 countries in terms of "ease of doing business".

FUTURE READINESS ASSESSMENT

National contributors - 2030 scenario

The challenges faced by Guinea are typical for countries in the National Contributors cluster. Nevertheless, these countries have enormous potential and are worth investing in. This optimism is reflected in our 2030 Scenario for national contributors – a picture of what these countries can realistically achieve over the coming decade if they follow our recommendations.

National Contributors are generally low to medium-income countries with average annual per capita GDP of under USD 3,000, with a few outliers such as Suriname, Gabon and Guyana significantly above the average. Mining represents a key economic pillar of the economy and has the potential to drive socio-economic development over the coming decade. This will require improvements in key areas – infrastructure, education, regulation and so on – which will in turn make the countries more attractive targets for investment.

In this 2030 Scenario, National Contributors will have made significant improvements in their mining sectors. This will be particularly visible in the area of competitiveness, where they will have become not only better at extracting minerals but also more skilled at utilizing existing reserves. It is assumed that these countries will have improved in terms of their processing capabilities, driven in part by the larger volumes mined, making investing further up the value chain economically feasible. Moreover, they will no longer be reliant on a single mineral, having diversified their extraction activities to include other resources. These improvements will mean that National Contributors no longer demonstrate critical or below industry standard performance, but are close to industry standard.

The improvements predicted for the next ten years extend beyond mining, too. We expect to see National Contributors are expected to diversify into other industries.

Many of the countries in this cluster have competitive advantages, such as low-cost labor or an internationally recognized official language – English or French. In many cases they can leverage these advantages to attract investments in areas other than mining, such as services or manufacturing.

RECOMMENDATIONS

For countries in the National Contributors cluster, achieving the 2030 Scenario means deriving significantly more value from the mineral sector. This, in turn, will stimulate the creation of new jobs and boost their overall economy.

National Contributors should focus on a number of key strategic objectives going forward. They will need to create incentives for investment both from inside the country and, even more importantly, from outside in the form of FDI. To do this, they must target a range of factors that act as "enablers" for investment, below.

Infrastructure represents both a critical bottleneck and an enabler of investment. Countries should address shortcomings in transportation infrastructure by building or extending railroads, highways and deep-water ports. To improve energy infrastructure they must create incentives for renewable energy, stabilize their power grid and extend coverage. Investing in these areas can have positive cross-industry effects. In the Sabodala gold mine in Senegal, for example, solar energy is used to power not just mining operations but also crop irrigation, leading to yields all year round rather than just in the rainy season. Different types of renewable energy exist in different countries – for example, solar power in Burkina Faso, Mali and Senegal, and hydroelectric power in Kyrgyzstan and Guyana.

Regulation is another key enabler of investment. National Contributors must ensure transparent, stable legislation

that is easy to apply and inspired by international best practice. A strong regulatory framework facilitates market entry for firms and creates incentives for consolidation by incumbents. It also boosts countries' overall scores for ease of doing business. To take an example, Togo's revision of its mining code in 2017 incorporated the area of corporate social responsibility (CSR) and closed the previous gap to international best practice.

Education forms the backbone of a nation's development. If countries invest in educational institutions and ensure a certain level of skill among the local workforce, investors will no longer be reliant on professionals from other countries, which will cut their operating costs. Collaboration between government and the private sector is possible, as in Zambia, where investment in mining education has led to the founding of institutions such as the School of Mines and Mineral Sciences and the creation of scholarships at top universities.

The mining sector will also benefit from greater **industrialization** over the coming decade. Again, government and the private sector can work together, overcoming the negative aspects of ASM by teaching local communities about alternative approaches and offering productivity-boosting solutions. In Senegal, for example, miners were told about the negative impact of using mercury for separation and provided with alternative tools – an initiative that delivered significant benefits for both the local communities and the environment.

Access to **financing** is an overarching enabler, encompassing all the strategic pillars mentioned above and capable of significantly accelerating growth. Many National Contributors face challenges in this area, with small and medium-sized enterprises (SMEs) finding it particularly difficult to secure financing. To overcome this barrier,

national and international institutions should be encouraged to provide loans with longer payback periods to companies, and potentially even targeted grants to countries to develop sectors as a whole.

Attracting investment, particularly FDI, will bring several benefits. Large industry incumbents generally use more modern technology, positively contributing to both innovation and industrialization. National Contributors should place particular emphasis on **innovation**, as directly adopting highly efficient and sustainable technology can be a means to accelerated development.

Overall, it is vital that National Contributors – but also all other clusters – focus on sustainability as they develop toward our 2030 Scenario. This entails **sustainability** with regard to both the environment and local communities. One way to do this, for example, is to build SDGs into all new legislation.



3.3

WHAT HAPPENS IF WE DO NOT CHANGE?

IsDB Member countries must stand ready to undertake forward-looking industrial policies as the COVID pandemic is expected to shape the path of the future of mining and construction industry. The pandemic shock will boost positive trends in the mining and construction industries. Automation, green technologies, and other smart technologies will increasingly dominate the industry. IsDB member countries gain to benefit from: (1) investing in their workforce, upgrading skills complementary to new technologies; (2) leapfrogging with new technologies to improve environmental sustainability and boost industry long-term competitiveness.

The IsDB countries present a world of opportunity for investors. Having looked in detail at sample countries and the chances that they present, it is worth taking a moment to look at the flip side of the picture. What might happen in the do-nothing scenario, if IsDB member countries fail to take action in the face of the challenges along the road to development in the period through 2030 and beyond?

Six undesirable consequences of inaction were identified: stagnating poverty levels and limited economic growth, increasing social inequality and unemployment, poor quality of education and inadequate skills, general insecurity, uncontrolled pollution, and exposure to disaster.

STAGNATING POVERTY LEVELS AND LIMITED ECONOMIC GROWTH

Many IsDB member countries are fortunate enough to have significant natural resources. Often, they have already made

great strides in developing their mining sectors, but they now need to diversify both vertically (for example, into processing and other value-adding areas) and horizontally (reinvesting profits into the sustainable development of other sectors). If they fail to do this, they will halt the economic growth required to support their growing populations. Failing to meet demand for construction materials will also mean continued reliance on imports – a recipe for slow economic growth.

INCREASING SOCIAL INEQUALITY AND UNEMPLOYMENT

Despite a growing middle class, the returns to already wealthy equity holders clearly outweigh the income provided to the local workforce in many ISDB countries. This social inequality is exacerbated by automation, which brings immediate benefits to owners rather than workers. If countries fail to take action to fairly distribute wealth, reinvesting part of the economic gains into maintaining or enhancing industry competitiveness, the gap between rich and poor will increase, potentially accompanied by mass unemployment across sectors.

POOR QUALITY OF EDUCATION AND INADEQUATE SKILLS

Poor technical education and inadequate skills can lead to long-term structural unemployment within the mining and construction industries. Substandard education translates into fewer opportunities to re-specialize – essential in an environment of frequent business fluctuations and growing levels of automation – and can hinder self-sufficiency, leading to a dependence on social aid. Failure to cater to modern industry needs and guarantee the necessary educational infrastructure will result in increasing levels of

unemployment and decreased levels of FDI, given a lower industry attractiveness.

GENERAL INSECURITY

Mining and construction are often key economic pillars, both contributing positively to services such as healthcare, law and order. Conversely, health problems, epidemics, social turmoil, poor basic living standards and criminality lead to a general feeling of insecurity and unrest. If not addressed, these issues can become detrimental to a country's economic growth, negatively impacting industry productivity as well as reducing the availability of human and financial capital. The end result will reflect in an increasing difficulty of doing business.

UNCONTROLLED POLLUTION

The environmental impact of mining and construction is usually evident to local communities, in the form of red mud, cyanide contamination, landslides, ever-growing mountains of municipal and industrial waste, and the like. Unless action is taken here, these adverse phenomena can easily become the norm rather than the exception.

EXPOSURE TO DISASTER

Inadequate infrastructure can lead to severe exposure to environmental disasters. For example, wooden buildings are highly vulnerable to coastal tsunamis, while clay brick buildings offer little protection from earthquakes. Action is needed not only to improve infrastructure but also to ensure adequate emergency services and basic healthcare during crises. Failings here can deter investors due to uncertainty over asset lifetimes. Expatriates are also less likely to be interested in supporting mining and construction operations in countries that they consider "risky".



Engineer piloting drone on construction site in order to perform video inspection



4

HOW TO UNLOCK THE POTENTIAL OF IsDB COUNTRIES?

Competitive advantages are a prerequisite for value chain expansion

IsDB member countries hold vast mineral reserves, but moving into processing generally requires low-priced energy and critical mass; primary processing is more accessible to mineral holders given raw material proximity

Renewable energy generation is a cost-effective and sustainable solution

IsDB member countries display vast potential in renewable energy, such as solar, hydro and even geothermal

Alternative financing models such as BOOT or PPA could bridge the investment gap

Investments in innovation hubs are a key facilitator

Groundbreaking innovations lead to more efficient solutions and often create additional competitive advantages

Providing the platform and incentives (e.g. investment programs) for SMEs and startups to operate will provide the necessary ecosystem for technological innovation

Adopting alternative fuels will decrease fossil fuel dependence

Alternative fuels can decrease CO₂ emissions by up to 40% in energy-intensive materials (i.e. cement), reduce costs and drive the circular economy

Private sector involvement is critical to the development of the mining & construction sectors

IsDB offers project financing and risk sharing, access to promising future markets and a network of high-level decision makers

KEY FIELDS FOR ACTION

Strengthening and broadening processing capabilities

Many IsDB member countries are blessed with extensive mineral resources. However, they generally focus their activities on extraction, with few expanding into processing. This is particularly true in West Africa. By extending their activities downstream, IsDB member countries can put themselves in a position to derive substantial additional value from the minerals they possess.

LEVERAGING COMPETITIVE ADVANTAGES AND ESTABLISHING PARTNERSHIPS

Expanding across the value chain by building processing capabilities – factories, smelters and refineries – delivers a number of benefits, outlined below. The process of industrialization also contributes to the overall economic development of a country. IsDB member countries must therefore consider carefully how they can best leverage their competitive advantages.

The steel industry in the European Union offers a good example of the sort of value that can be derived from processing. The industry's gross value added (GVA) was around EUR 128 billion in 2016, with only EUR 10 billion of that attributable to mining, including utilities and energy. Processing also creates jobs, as workers are required to operate processing plants. If investments also entail educating local workforces in the relevant technical skills, economies stand to benefit from pairing high-skilled employment opportunities with qualified laborers.

Of course, expanding along the value chain is not necessarily limited to moving downstream from raw materials. Some countries can also move upstream, that is, from consumption towards processing. Individual countries should carefully analyze their resources, the level of domestic demand, their competitive advantages and the total market size in order to determine the most

beneficial direction to move in.

Collaborating with other countries presents further opportunities. Where a country has rich mineral resources but limited or non-existent processing capabilities, cooperating with a country that has such facilities can bring benefits for both partners – a win-win situation. Thus, the mining country benefits from the processing country's technology, while the processing country benefits from increased access to the resources it needs to feed into its facilities.

HIGH CAPEX AND OPEX AS CONSTRAINTS

Although the prospect of value chain expansion is clearly appealing, it also presents challenges. Smelters and refineries are large, complex facilities that require a major initial investment, or capital expenditure (CAPEX). In Indonesia, for example, USD 850 million was recently invested in aluminum refining, which is expected to add an additional one million tons of alumina processing capacity, or almost one percent of global production (2018). Investments of this type require a long-term perspective and an environment of political and regulatory stability.

And the investment required goes beyond the initial CAPEX: operating expenditure – OPEX – can be high, too, as running facilities is often energy-intensive. For example, an aluminum smelter consumes up to 15,000 kWh of power per ton of aluminum produced; for comparison, the average energy consumption in Albania, for instance, is around 2,500 kWh per person a year. Carbon taxes, rising energy costs and fluctuations in the price of metals can create severe problems for industry. The European Union, for example, has lost more than one-third of aluminum production since 2002 due to higher energy costs, and now meets more than 70 percent of its total demand with imports.

CASE STUDY: ALUMINUM INDUSTRY IN AUSTRALIA

Australia's aluminum industry offers a good example of how countries can benefit from expanding across the value chain – otherwise known as "vertical integration". Fueled by cheap power from coal, Australia developed both its primary and secondary processing capabilities over a period of several decades, reaping the benefits. More recently, with increasing emphasis on environmental policy and consequent rises in energy prices, it has shifted its focus towards primary processing. In 2016 the country was the global leader in extraction, number two in primary processing (refining) and number five in secondary processing (smelting). Australia keeps most of the bauxite it extracts, exporting just a quarter of the total volume. This is crucial, as it provides the country with resources for its many refineries. Around 15 percent of the alumina produced is further processed within the country, while 85 percent is exported.

Australia's vertical integration of aluminum generates billions of dollars in trade revenues. It also creates many jobs within the country: an estimated 4,000 in bauxite mining, 6,200 in refining and 4,300 in smelting (2016). The decade-long process has been driven by state subsidies for both the industry and the new coal plants required to power facilities. This came at a cost, of course: for every dollar in export revenue, the cost of production, including subsidies and pollution costs, was an estimated USD 1.24, a difference absorbed by the Australian government.

Today, Australia is shifting its focus away from secondary processing and more towards primary processing. This is due in part to the introduction of carbon taxes and the replacement of large coal plants with renewable alternatives, which has led to increased electricity costs. Coupled with variable aluminum prices, this has put pressure on the

bottom line for smelters – and created an opportunity for countries that enjoy cheaper energy sources.

OPPORTUNITIES FOR ISDB COUNTRIES

While several regions around the globe are currently struggling to maintain competitiveness, the Middle East, for example, tells a different story. The aluminum industry in the UAE, driven mainly by Emirates Global Aluminium (EGA), has developed significantly over the past decades, growing from marginal levels of production to the number five position globally. This achievement owes mainly to cheap energy and an advantageous geographical position – closer than Australia to the Asian and European markets – which means lower transportation costs. However, the UAE does not enjoy extensive reserves itself, sourcing much of its bauxite from West African countries, such as Guinea. It has also established a partnership with Indonesia, where EGA is transferring its state-of-the-art technology. Such synergies benefit all the countries involved.

Other IsDB member countries, such as Uzbekistan, Kazakhstan and Saudi Arabia, can also leverage their cheaper energy and advantageous location. When considering whether to develop processing capabilities, they should carefully examine both the feasibility of entering the target market and the attractiveness of doing so. For example, they will need to weigh up the potential advantages of processing aluminum as compared to copper or zinc, and develop an appropriate long-term strategy.

KEY FIELDS FOR ACTION

Bridging the infrastructure gap

Energy and transportation infrastructure are vital to the mining and construction industries. Companies must be able to move raw materials and intermediate products efficiently from place to place and draw on a constant supply of energy. Some IsDB member countries lack such infrastructure – for instance, they experience prolonged periods of power instability. By tackling these issues head on, governments could enable mining and construction to grow and at the same time create spillover effects for the rest of the economy.

RENEWABLE ENERGY GENERATION

Renewable energy is an increasingly attractive solution to the challenges of underdeveloped energy infrastructure. Particularly relevant for the mining industry is photovoltaic energy generation – in other words, solar power.

In 2016 the global mining industry had a total installed renewable energy capacity of around 1 GW, with an additional 0.4 GW expected by 2021. Solar power offers a wide range of benefits. First, it gives companies full control of their energy costs, which has a major impact on their bottom line. Relying on the country's national grid or buying in diesel fuel puts mining companies at the mercy of price variations. Given that energy accounts for between 15 and 40 percent of mining costs, the benefits of owning a solar power plant are evident. It also ensures a stable power supply, which is particularly advantageous in countries with suboptimal national grids. Innovative financing schemes make building a solar power plant even more attractive. The BOOT model – build, own, operate, transfer – and power purchase agreements with energy service companies (ESCOs) reduce capital expenditure and running costs for mining companies. And, of course, solar power is also good for the environment, cutting CO₂ and other emissions significantly.

BARRIERS TO INFRASTRUCTURE INVESTMENTS

One of the main barriers to investing in infrastructure is that it is generally very capital intensive. This factor can put off investors. Alternative financing schemes can be beneficial in this respect, offering mining companies substantial savings the moment the plant starts operating. However, the mining companies must be prepared to make a long-term commitment, often in the region of ten to 15 years. In politically unstable countries, where the prospects for investors may be uncertain, mining companies may be unwilling to make lengthy commitments of this sort.

Ensuring the constant operability of mines also creates issues for solar power. Mines operate around the clock, whereas solar power is only generated during daylight hours. Consequently, mining companies may have to invest in battery storage for the power that generate, which is often a costly solution. Alternatively, they can combine solar power with energy from other sources, such as the national power grid – which, however, makes them subject once again to unreliability in areas where the national or local power infrastructure is suboptimal.

CASE STUDY: BURKINA FASO, AN UPCOMING HUB FOR SOLAR POWER

Power generation is a strategic issue for Burkina Faso. In 2017 the country had one of the highest power production costs of the region, at around 24 USD/kWh. It generated 70 to 80 percent of its power from fossil fuels that were not only costly but also negatively impacted the environment. Moreover, the national power grid was severely underdeveloped, serving just about one-fifth of the population.

To improve this situation, the government set itself a number of strategic targets for 2030. Goals included increasing access to electricity to 65 percent and generating half of the country's power from renewable sources. By making the energy sector a strategic priority in this way, Burkina Faso was able to obtain institutional funding for public projects. In 2019, for example, it signed agreements with independent power producers (IPPs) to develop six new solar power plants, adding total capacity of more than 200 MW. Approximately one-third of the costs were covered by a loan from the African Development Bank.

The government initiative also had a positive impact on the private sector. At the Essakane gold mine, for example, the construction of a new solar plant adding 15 MW capacity to the existing 57 MW oil plant is expected to reduce the mine's annual CO₂ emissions substantially. The project, which will cost around USD 25 million in total, is financed under a BOOT model, whereby the company building the plant will own and operate it for 15 years before transferring ownership to the mine.

The Bissa and Bouly gold mines have adopted a similar initiative, jointly signing an agreement for the construction of a 13 MW solar project including a battery storage system. Financing is again via a BOOT model, with the energy service company (ESCO) covering the capital cost of the investment. The local community also benefits in the form of the new jobs required for operating the plant on a day-to-day basis.

Thanks to its strategic thinking, Burkina Faso is now well positioned to achieve its ambitious plans for 2030. In fact, it could soon shift from being a power importer to a regional power exporter.

OPPORTUNITIES FOR IsDB COUNTRIES

Many IsDB member countries face challenges in the area of infrastructure, but these challenges are also investment opportunities.

For instance, almost all IsDB member countries have potential for developing one form of renewable power or another, be it solar power in the Middle East and North Africa, hydroelectric power in Kazakhstan, Sierra Leone and Guinea, or geothermal power in Indonesia. Investments aimed at exploiting this potential will provide these countries with many benefits. Moreover, those benefits may also extend regionally. Guinea, for instance, offers potential for harnessing hydroelectric power in volumes that could well exceed national demand. To maximize this potential, it will be necessary to develop networks capable of transporting power not just to previously neglected parts of the country but also to the wider region.

Governments can act as catalysts for investments by creating incentives for renewable power. A stable regulatory framework is fundamental to the development of the sector. Energy infrastructure must also form a key strategic pillar in the government's plans. Countries should also try to create an attractive environment for investment across different areas of infrastructure, such as, power generation, transmission and distribution.

KEY FIELDS FOR ACTION

Driving innovation and technology

Innovation stands at the forefront of progress: without the ability to look for and embrace new solutions, development comes to a standstill. In the mining and construction industries, many novel technologies and innovations have emerged in recent years, such as the Internet of Things (IoT), virtual and augmented reality, and drones. ISDB countries with established sectors and a global presence must now boost their ability to drive innovation, while those that have yet to secure a foothold in world markets should adopt new technology fast and reap the associated benefits.

BUILDING AN INNOVATION-CENTRIC ECOSYSTEM

Adopting a development strategy based on innovation generates benefits for the whole of society. Ultimately, this approach translates into economic growth. Countries looking to develop their mining or construction industries should therefore foster an ecosystem that is centered around a long-term vision. Ideally this will be based on a collaborative approach between the public and private sectors, and involve significant investment in research and development (R&D).

Why is investing in R&D so important? The benefits of breakthrough discoveries are not limited to the companies that make and exploit them: they spill over into the countries where those companies operate. Increased tax revenues, new jobs and environmental benefits are just some of the positive effects regularly observed. South Korea, for example, is rated number one globally in terms of innovation, with more than four percent of its GDP invested in R&D (2019). This strategy has transformed South Korea into one of the world's top exporters in recent years, with exports representing around 44 percent of the country's GDP in 2018, compared to 33 percent in 2003. The country also now ranks fourth best in the world for ease of doing business (2018).

STRONG COMMITMENT AND DELAYED REWARDS

Although the benefits of innovation are clear, establishing the necessary framework for maximizing impact is not always a simple matter. Developing the right ecosystem takes time and generally requires the long-term involvement of a significant enabler, such as government.

Large companies normally have sufficient resources to invest in R&D, but they are not always the main drivers of innovation. In Canada, for example, a significant portion of mining innovation stems from startups or small and medium-sized enterprises (SMEs). For these players, access to financing is key: many smaller companies do not have the necessary resources to invest in R&D, particularly in the early stages of their development.

Governments need to foster innovation in relevant sectors. Besides short-term solutions, nations hoping to establish themselves as technology hubs require long-term policies geared towards improving ease of doing business. Countries rarely become technology hubs overnight, so support from government must be consistent over many years and rooted in a properly thought-through strategy.

CASE STUDY: CANADA, A MINING INNOVATION HUB

Canada's minerals and metals industry plays a significant role in the country's economy, providing direct employment for more than 420,000 people and generating a nominal value of around USD 72 billion (2017). Canada has vast resources, with over 60 different minerals and metals produced annually. By exploiting this richness, the country has managed to secure a global position in the production of strategic metals such as aluminum, nickel and cobalt, to name but a few.

Canada's overall economic environment, with its highly skilled workforce and state-of-the-art infrastructure, has stimulated expansion across the entire value chain – from mining to manufacturing. To maintain this progress, the country has invested heavily and is widely recognized in the mining industry as a hub for innovation. Many projects start their life in one of the country's innovation centers. The NORCAT Underground Center in Onaping, Ontario, for example, supports over 60 projects a year. Established companies and startups are given the opportunity to develop, test and pilot their innovations within the compounds of an operational mine. This has led to several technological breakthroughs in areas such as robotics, the IoT and equipment automation, many of which have become industry standards around the globe.

Collaboration between the Canadian government and industry players is a key part of this success. For example, the Canada Mining Innovation Council (CMIC), made up of representatives from mining companies, universities and service providers, works towards the long-term vision of "zero waste mining". Similarly, the International Minerals Innovation Institute (IMII) coordinates and provides financial support for the educational development of the workforce, with the goal of improving operational safety.

The Canadian government takes care to foster development across all regions of the country. For instance it has budgeted more than USD 700 million for the north of the country over the next decade, in an attempt to deal with issues such as underdeveloped infrastructure (at present, it costs firms 70 percent more to establish operations in the north than in the south). This comprehensive approach, based on partnerships between key stakeholders, consistent governmental support and a long-term strategic vision, underpins Canada's success.

OPPORTUNITIES FOR ISDB COUNTRIES

Some IsDB member countries are rich in mineral resources, while others have few reserves to exploit. The challenge is to devise an appropriate policy depending on the country's particular situation.

Countries such as Burkina Faso, Mali and Togo could employ a strategy of adopting new technology while developing their own innovation skills. They can draw on existing innovations to address pressing challenges, such as unregulated ASM. Burkina Faso, for example, is already starting to digitalize its supply chain for gold, adopting a virtual currency to reduce cash payments and increase transparency. Similarly, Senegal is embracing an innovation-based approach for its SMEs in the mining sector and elsewhere. Thanks to collaboration between government and foreign investors, entrepreneurs are set to enjoy improved access to funding. The country is also building a center for innovation in Dakar in collaboration with the UAE with the aim of fostering innovations in construction and adapting them for the local situation.

Countries with developed economies and good access to capital, such as Saudi Arabia and the UAE, and countries with significant resources, such as Kazakhstan and Indonesia, should aim to develop their competitive advantage by making innovation part of their national strategy. Another IsDB country, Malaysia, is to a vibrant hub where more than 40 multinationals and 500 SMEs develop and test revolutionary technology. Saudi Arabia and Dubai are also known for their advances in construction technology, such as BIM and 3D printing.

KEY FIELDS FOR ACTION

Achieving sustainability

The cement industry is currently responsible for around a quarter of total industrial energy consumption. Cement production requires large quantities of both electrical and thermal power due to very high temperatures reached during the production process. It is also responsible for a high level of direct emissions of carbon dioxide (CO₂). At present, global production relies heavily on fossil fuels: coal accounts for nearly 70 percent of energy used in the production of the intermediate product clinker, and oil and gas for a further 25 percent. Improving energy efficiency and reducing environmental impact are therefore key challenges for the cement sector.

TRANSITIONING TO ALTERNATIVE FUELS

Transitioning from fossil fuels to less carbon-intensive alternatives is essential if the industry is to achieve sustainable growth. It has long been established that using waste resources to produce energy for the cement industry – known as "co-processing" – can be economically viable; in fact, the first commercial use of alternative fuels began in the mid-1980s.

Initially, alternative fuels were seen primarily as a way to improve the industry's competitiveness, due to the fact that fuel accounts for nearly one-third of the cost of producing clinker. But alternative fuels are also an environmentally sound option for reducing greenhouse gases (GHG) and cutting the volume of waste that goes to landfill. Today, the emphasis is on minimizing the industry's environmental impact, with alternative fuels reducing direct CO₂ emissions by up to 40 percent. Depending on the type of kiln used, alternative fuels can also reduce NO_x emissions.

Many types of waste have sufficient calorific value and are suitable for cement production. Used tires, non-recyclable plastics, textiles and paper residues, and

industrial and municipal waste are all in common use.

In addition to substituting fossil fuels, up to five percent of the primary material used for clinker production can be replaced by the mineral ashes contained in waste-derived fuels.

WASTE COLLECTION AND SORTING INFRASTRUCTURE

Cement kilns could potentially use 100 percent alternative fuels. However, practical considerations limit their use. For instance, most alternative fuels differ significantly from fossil fuels in terms of their characteristics, especially calorific value. Large-scale substitution also requires substantial capital investments: costs per kiln vary significantly depending on the type of alternative fuel, ranging from USD 2 million for coarse refuse derived fuels (RDF) to USD 15 million for whole tires.

Other limitations relate to the quality of the waste used. Low-calorific materials with a high moisture content, as is the case for most unsorted municipal waste, are not suitable for co-processing. Metals such as mercury, cadmium and thallium can also be hazardous if not removed beforehand. The use of waste as a fuel therefore requires a well-developed waste collection and sorting infrastructure.

Waste management legislation is vital for ensuring the availability of alternative fuels. Local legislation must also permit energy recovery in cement production plants. Social acceptance is important, too, with local communities often concerned about potential harmful emissions – although in reality well-managed cement plants using alternative fuels have lower GHG emissions and do not pose any specific health or environmental hazard.

CASE STUDY: GERMANY, A GLOBAL LEADER IN ALTERNATIVE FUELS

As a result of strict legislation, alternative fuels are now widely used within the European Union: In 2017, alternative fuels accounted for around 46 percent of the fuel mix. One of the most advanced countries in terms of legislation is Germany, which has banned landfill for any waste that could be reused in the circular economy. Waste generators pay a "gate fee" to dispose of their waste, which cement producers can use to cover the capital investments required to process the materials. Germany also has a well-developed waste collection and sorting infrastructure, providing the industry with high-quality materials.

The German cement industry uses these resources to reduce its environmental impact. The use of coal – the traditional fuel for cement production – fell from 87 percent of the fuel mix in 1987 to 62 percent in 2000, and to just 28 percent in 2018. Alternative fuels now represent 65 percent of the fuel mix (2018). The commonest types of waste used here are tire scraps, waste oils, solvents, and other sorted or pre-processed commercial and residential waste, such as plastics and packaging.

Thanks to these efforts, Germany is now a global leader in terms of the use of alternative fuels in cement production. Substituting fossil fuels is a key part of the country's plans to reduce CO₂ emissions, as alternative fuels have a significantly lower carbon content than coal. Moreover, some alternative fuels of plant or animal origin do not increase the levels of CO₂ in the atmosphere at all: they are completely carbon neutral. Substitution with waste-derived fuels has enabled Germany to achieve a reduction in CO₂ emissions of more than 20 percent compared to using only fossil fuels.

OPPORTUNITIES FOR ISDB COUNTRIES

Alternative fuels represent an exciting opportunity for IsDB member countries to reduce their environmental footprint. Saudi Arabia, for example, has developed a mandatory energy efficiency program that limits the supply of fossil fuels at below global market prices, creating an incentive for local industry to make itself more energy efficient.

Alternative fuels can also have economic advantages for countries where fossil fuels are not abundant, such as Egypt, Turkey or Senegal, even taking into account the capital investment required. In 2012, in response to frequent power outages, Egypt diverted most of the natural gas supply to energy generation. The shortage of gas forced the cement industry to diversify its fuel mix, switching to coal and alternative fuels. Substitution with alternative fuels proved to be an economically viable option for the Egyptian cement industry, and could be an option for other IsDB member countries as well. The costs of importing coal can be significantly higher than the costs for waste-based alternative fuels, which can be up to 40 percent cheaper than coal when processing on a large scale.

Indirect benefits also arise from the use of alternative fuels, such as a reduction in the total amount of waste that ends up in the environment. Landfills are one of the oldest methods of waste disposal. Today however, they are gradually being phased out due to the risk of contamination of groundwater and soil. European countries such as Germany, Sweden, Switzerland and the Netherlands have banned the disposal of untreated waste in landfill, and this is considered the future industry standard. Co-processing could therefore represent a good solution for IsDB member countries with large numbers of hazardous landfills, such as Bangladesh, Nigeria or Pakistan.

Civil engineers shaking hands within a
operating construction site



4.2

AN INVITATION TO COLLABORATE *Advantages of working with IsDB*

The Islamic Development Bank supports people to build a sustainable future for themselves, their communities and their countries by putting the infrastructure in place to enable them to reach their full potential. Together with the private sector, IsDB sustainably drives modernization and growth within its Member Countries.

IsDB ...

- **builds partnerships**, creating collaborative relationships between communities and nations by bringing together the public and private sector through public-private partnerships and joint project development
- **provides Islamic finance**, granting long-term sustainable and ethical financing structures as the global leader in Islamic finance to underpin project investments by issuing Sukuk (5-year Trust Certificates)
- **fosters innovation and sustainable solutions**, championing science, technology and innovation led solutions to meet the UN Sustainable Development Goals by boosting skills, sourcing ideas and transforming visions into real solutions through two main vehicles: The Engage Platform and the Transform Fund
- **develops high-potential markets**, investing in training, skill building and research and development so that Member Countries can generate and retain greater economic prosperity at home, raising the quality of their products and further integrating their value chains
- **fosters collaboration** and contributes to enhancing the participating of Member Countries to Global Value Chains

IsDB Member Countries include many of the fastest growing economies worldwide. Jointly, IsDB Member Countries represent the purchasing power of almost one quarter of the world's population. The joint GDP of IsDB Member Countries amounts to roughly USD 7 trillion. With GDP growth rates of up to 8% per year, they have considerable potential to further increase their market share in the global economy.

IsDB INVITES ITS PARTNERS TO COLLABORATE ON FURTHER DEVELOPING THE MINING AND CONSTRUCTION SECTORS, ...

- **providing them with access to IsDB's extensive network** of public and private sector representatives and **high-level decision-makers**
- jointly building up **skills and capacities** within IsDB Member Countries, granting partners long-term and sustainable **access to promising future markets**
- offering joint **project financing** as well as future **risk sharing schemes** to mitigate investment-associated risks

4.2

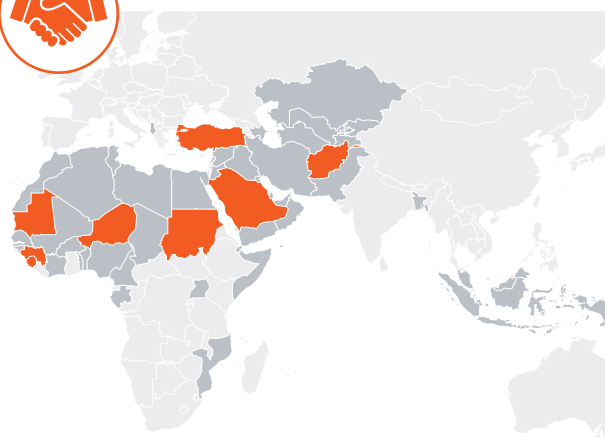
AN INVITATION TO COLLABORATE *Opportunity examples*

To drive socio-economic growth by fully leveraging country-specific competences and resources, but also overcome inherent development barriers, IsDB members should look to identify opportunities for collaboration and capitalize the potential synergies stemming from cross-country partnerships. This section explores key areas for future collaboration between IsDB member countries that are likely to result in win-win scenarios.

IsDB countries are generally recognized for their vast resources, yet in many cases their existence remains theoretical. To unlock their potential, countries must explore resources and turn them into proven reserves which are appealing to investors. Often individually lacking the necessary capital and technical know-how, many IsDB countries can collectively engage in exploratory activities.

The benefits from value chain expansion are evident – increased revenues, job creation and overall economic growth. IsDB countries pose significant potential for downstream expansion across minerals like bauxite, nickel or iron, but often lack the resources, know-how or the infrastructure enablers. Leveraging the diversity of IsDB members countries via collaborations can therefore create the necessary competitive advantages and the critical mass for development.

Moving further upstream, beyond extraction or processing, vertically integrated IsDB member countries should look to derive further value from the established industries. Entering the manufacturing segment can prove a viable solution to create additional value and decrease reliance on mineral resources. To compensate for the initial knowledge barrier or domestic absence of complementary resources, countries could leverage IsDB strengths across several industries.

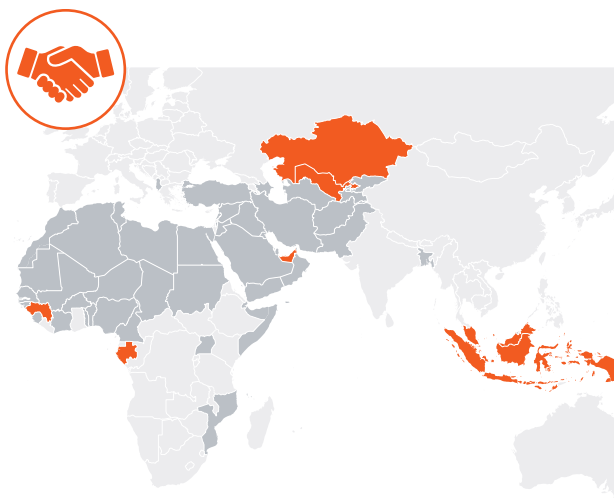


Access untapped opportunities

IsDB member states such as **Niger** and **Afghanistan** are known to host mineral resources i.e. gold, iron or copper, yet little investment has been made into discovering the magnitude and location of these deposits. Partnerships with countries that have mining competences and are looking to expand their industry i.e. **Saudi Arabia** or Indonesia could prove beneficial. By financing exploration activities, subsequent mineral discoveries could result in significant payouts for all parties involved – The host will benefit from increased mineral rents while the investor will have secured access to a new source of raw materials. Spillover effects can also result from providing geological transparency, further incentivizing FDI.

Turkey displays a vibrant steel industry as the 8th largest global steel producer and hosts several strong players, while also expecting additional developments. However, the country is also a major importer of iron ore given a lack of national reserves. **Sierra Leone, Mauritania** and **Guinea** on the other hand are known for significant iron ore reserves that are still incipient in terms of large-scale extraction. Engaging in a partnership to extend and modernize local mining capabilities could boost their national industries. Turkey's investment in **Sudan's** first copper mine showcases the country's precedent for such collaboration.

**IsDB can actively contribute to foster
collaboration between member countries**



Develop processing

The **UAE's** (EGA) USD 1.4 billion investment in **Guinea** to develop additional bauxite mining capabilities is a good starting point. Several benefits are still attainable from further exploring this partnership by expanding into alumina refining capabilities. Infrastructurally, Guinea has both sea access and significant hydro potential, capable of providing cost-effective operations. Building refining capabilities in Guinea would offer EGA additional importance on the global arena while further developing Guinea's national economy. EGA's joint venture smelter in **Indonesia** is proof of the advantages such a collaboration brings. Other opportunities are also evident in CIS countries such as **Kazakhstan** or **Uzbekistan**, which that have a strong mining production but lack the necessary processing competences.

Gabon hosts one of the largest reserves of manganese and has already established its first processing plant. **Malaysia** on the other hand has significant processing capabilities but, if no new domestic resources will be discovered soon, is likely to run out of raw material. By transferring know-how into Gabon to establish new mines processing plants, Malaysia will ensure continued access to raw materials while developing Gabon's industry. To add to the appeal of the partnership, Gabon has already ensured several success factors by investing in renewable power (solar) and hosting Central Africa's first school of mining.



Shift to manufacturing

The automotive industry, among many others, is heavily reliant on metals such as iron, aluminum or copper, with higher demand for battery metals (i.e. nickel or cobalt) expected going forward.

Indonesia is already investing in factories to produce EV batteries by 2023, capitalizing on the country's compatible mineral reserves – nickel and aluminum. Similarly, **Morocco** has significant cobalt resources and already hosts a developed automotive industry. An evident collaboration for the two countries could entail leveraging Indonesia's acquired knowledge into a joint battery factory in Morocco, complementing two crucial metals.

Further extending the partnership into the automotive sector could be done by leveraging Turkey's global position as a production hub and **UAE's** EGA as market leader in aluminum manufacturing. The latter already supplies leading OEMs and could provide raw material for several components (e.g. chassis, battery, etc.) internally, from member countries. Accounting for an extended time frame, several other countries such as **Kazakhstan** or **Uzbekistan** could enter the mix, leveraging their copper resources and developing wiring capabilities, appealing to the automotive sector but also expanding into the growing electronics segment.

Act as a **facilitator**, provide information and advise on potential opportunities
Provide a **platform for communication** and foster interaction (e.g. events, meetings)
Use existing and innovative tools to **provide financing** for identified projects

4.2

AN INVITATION TO COLLABORATE Advantages of collaboration with IsDB

Description

Implementation of advanced, energy efficient technologies is crucial for the sustainable development of the construction and mining sectors, but there are significant costs associated to the modernization of processing plants and extraction facilities. Public funding allows to prioritize environmental societal objectives and bridge the potential financing gap.

Potential for the private sector

- Provides access to financing for projects that might not be funded by commercial banks (if the economic benefit is not clear)
- Decreases the environmental impact
- Supports innovation e.g. transition to alternative fuels

Description

Developing a new mine requires significant investments. Off-taker financing is a type of investment in which the future purchaser, or off-taker, of the output of the mine is financing the project at its inception. The debt is later amortized against deliveries of goods once the mine starts operating.

Potential for the private sector

- Offers financing at the launch of new projects, using future production as a collateral
- Ensures marketability for the output of the mine
- Provides predictability for the processor/ manufacturer

Debt instruments

MDB-led syndicated debt for large capital investments

Environmental protection and energy efficiency financing schemes

Equipment financing (leasing) for exploration and new developments

Trade financing facilitating export transactions and providing advance payments

Royalty and streaming financing

Crowdfunding for exploration activities and new, small-scale mine developments

Off-taker financing for new developments

Tax incentives by means of flow-through shares for mining companies

Innovative financing approaches



Equity instruments

Public-private partnerships with established players in the mining and construction industries

Public co-financing of private equity funds investing in innovative companies and start-ups

Equity sharing for exploration activities or mine redevelopment

Description

Partnering with strategic investors which have the necessary expertise and resources to develop and commercialize a project is an important tool for enabling foreign investment in high capital-intensive industries. Financial involvement from public authorities is usually limited with governments participating as land, premise or resource owners.

Potential for the private sector

- Increased security of the investment (especially when international institutions are involved)
- Potential government support for infrastructure development and workforce supply
- Risk sharing for high risk projects

Public or MDB-backed entity providing management expertise and capital for large-scale projects

Public investments in organizations fostering R&D, community building and expert support in mining and construction

Joint public-private financing for mining educational institutes and vocational centers

Machinery and technology lending pools for ASM

Description

Developing an industry requires swift adoption of new technologies, fostering innovation and know-how generation as well as sufficient skilled workforce. Public investments in research institutes and industrial organizations support the development of the local sector and bring together the relevant stakeholders.

Potential for the private sector

- Supports the accumulation of knowledge and promotes innovation
- Facilitates communication between the key stakeholders in the industry
- Provides an expert pool supporting the industry

Expertise-linked instruments



Worker using digital technology to survey the surface and easily inspect the mining area





GLOSSARY

3D printing

The process of building/ manufacturing three-dimensional objects from a digital design by successively building the material, layer by layer

Alternative fuels (AF)

Materials or substances other than conventional fossil fuels that can be also be used as fuels e.g. hydrogen, waste and residual materials

Artisanal and small-scale mining (ASM)

Subsistence mining without official employment by a mining company, consisting of workers extracting minerals generally with the use of rudimentary tools

Augmented reality (AR)

An interactive experience of a real-world environment where the objects are enhanced by computer-generated perceptual information

Blast furnace

A type of metallurgical furnace used for smelting metals, running on coke fuel

Blockchain

A ledger that is resistant to data modification, can record transactions in a highly efficient and verifiable manner, often used to record digital transactions of crypto currencies

BOOT model (in energy)

Build-own-operate-transfer model – A form of financing where the service provider builds, owns and operates a facility e.g. solar plant for a prolonged period, selling the proceedings (in this case power) to the client and transferring ownership at the end of the contractual period

Building Information Modeling (BIM)

A digital platform based on 3D modeling of objects and places, enabling knowledge sharing between all major stakeholders involved, from a project's inception to its demolition

Calorific value

The energy contained in a fuel, determined by measuring the heat produced by the complete combustion of a specified quantity of it

Clay

Finely-grained natural rock or soil material that combines one or more natural minerals

Clinker

An intermediate product in the cement industry, made of limestone and aluminosilicate materials

Co-processing

The use of waste as a raw material, source of energy, or both, replacing natural mineral resources and fossil fuels

Concentrate

Processed raw ore, removing the major impurities by means of crushing or milling for example, thus concentrating the metal component of the output

Cyanidation

Hydrometallurgical technique for gold extraction from low-grade ores

Digital twins

Digital replica of specific assets, processes, people, places, systems and devices that can be used for simulating operations or other various purposes

Downstream

The final activity of a given value chain (in context referring to manufacturing) – An expansion downstream can start from mineral extraction and move towards processing or even final product manufacturing

E-mobility

General term used to reflect the development of vehicles not reliant solely on fossil fuels, that can be powered from several alternative sources i.e. batteries or hydrogen fuel cells

Electric vehicles (EVs)

Vehicles that rely solely on electric power for propulsion

Electric furnace

A type of metallurgical furnace used for secondary steel making, reliant on electricity as input to produce heat

Electrolysis

A technique that uses electric current to separate elements from naturally occurring sources such as ores

Exo-skeleton

An external skeleton that supports, protects and enhances the human body

Global value chain

An overview of the key steps, extending across different nations, that input factors must pass through to create finished products

Gravity concentration

The separation of two or more minerals (preferably of the same size) by their relative response to the force of gravity

Greenhouse gases

Gases that prevent heat resulting from solar radiation to escape the earth's atmosphere, causing greenhouse effects i.e. increasing the planet's surface temperature



GLOSSARY

Modular construction

Construction method that involves construction sections being built away from the building location, and then delivered and assembled on site

Municipal solid waste

The non-hazardous disposable waste materials generated by households, institutions, industries, agriculture, and sewage

Large-scale mining (LSM)

The extraction of minerals using industrial technologies, machinery and equipment

Leaching

The process of ore treatment with chemicals to convert the valuable materials into soluble salts (impurities remain insoluble)

Open hearth furnace

A type of metallurgical furnace that uses combustion of gaseous or liquid fuels to convert steel scrap and liquid iron into steel

Open-pit mine

Large, open depression in the ground used for extracting rock or minerals from the earth's surface

Power Purchasing Agreements (PPA)

Legal contract between an electricity provider and a power purchaser for a long period of time, usually between five and 20 years

Prefabrication

The practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located

Proven reserves

The volume of resources estimated with reasonable certainty, from the analysis of geologic and engineering data, to be recoverable from well-established or known reservoirs with the existing equipment and under existing operating conditions

Red mud

A highly alkaline waste product composed mainly of iron oxide that is generated in the industrial production of aluminum

Refinery

Processing facility where metals/ores are purified, without making any chemical changes to the input

Scrap

Recyclable materials left over from product

manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials

Smelter

A processing facility where metals/ores are purified, via heating and chemical processing

Sustainable Development Goals (SDGs)

A global agenda of 17 goals developed by the United Nations General Assembly in 2015, with a vision of protecting the planet and ending poverty

Upstream

The starting activity of a given value chain (in context relating to mineral extraction) – An expansion upstream can start from the final consumption and move towards processing or even mineral extraction

Virtual lab

A virtual environment used for training or experiments which in reality may cause harmful effects to human beings

Virtual reality (VR)

Interactive experience of real-world or non-real-world environment, often implying complete immersion in the virtual location and insulation from the immediate physical environment

Flow-through shares for mining companies

A tax-based financing incentive which allows the buyer of shares of a mining company to claim certain expenditures for exploration and development costs incurred by the mining company as expenses of the buyer himself, therefore benefiting from the tax reductions related to them

Royalty and streaming financing

A form of financing where royalty/streaming company provides funding in exchange for future payoffs, allowing mining companies to invest in new developments or expansions. Royalties are linked with receiving a percentage of future revenue, while in streaming the payment is made in physical metals



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