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Africa's green manufacturing crossroads

Choices for a low-carbon industrial future

September 2021

Climate change is fueling conflict, food insecurity, and impacting livelihoods across Africa. As the continent's manufacturing sector grows, it is vital to ensure that it does not add to climate change. A green approach to manufacturing could drive broader economic development by providing new investment and job opportunities across the continent. This report, supported by UK Aid, makes a timely and powerful case for green investment.

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Executive summary

Africa is at a crossroads. The window of opportunity to avoid irreversible climate change is closing, and urgent action is needed to keep temperature increases below 1.5°C from pre-industrial levels—an international benchmark inscribed in the Paris Climate Agreement of 2015.[1] At the same time, African governments have said that they are committed to industrializing and growing their economies to create jobs and wealth. The choices the continent makes now about its future development trajectory, especially in the manufacturing sector, will be critical in ensuring that it can do both.

As a leading emitter of greenhouse gases (GHGs), the manufacturing sector and the power it consumes is a crucial focus of decarbonization efforts to limit rising temperatures.[2] Globally, manufacturing would need to reduce its emissions by about 90 percent relative to 2018 levels as part of the international effort to reach net-zero emissions by 2050.[3] The remaining 10 percent could be compensated for by using additional technologies and tactics such as carbon capture and storage and reforestation.

Africa is one of the most vulnerable continents to climate change and climate variability and therefore has a strong incentive to join this global effort and bolster its adaptive capacity.[4] Rising temperatures are likely to aggravate water stress, increase food insecurity, and increase disruptions due to extreme weather events across the continent, compromising human health and economic systems.[5] However, there are concerns that decarbonization cannot come at the expense of manufacturing growth and jobs. The African Union's Agenda 2063 reiterates the importance of building competitive productive capacity in manufacturing and the industrialization of African economies.[6]

In this report, our analysis seeks to demonstrate that decarbonization and growth are not mutually exclusive, and the path to net-zero manufacturing emissions in Africa has significant economic potential. Because Africa's manufacturing sector is underdeveloped, generating just 2 percent of global Manufacturing Value Added (MVA), almost half of the continent's potential GHG-producing industries have not yet been built.[7] The sector therefore has a significant opportunity to leapfrog more developed nations and build a thriving low-carbon manufacturing sector from the ground up. By so doing, Africa could avoid future costs by sidestepping the expensive transition from fossil fuels to renewables that the developed world is having to navigate and create a competitive and resilient economy that does not rely on resources that are likely to become increasingly more costly.

Decarbonization matters because if Africa's manufacturing sector follows the growth trajectory of developed markets over the past 20 to 30 years, it will likely double in size, and

1 "Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge University Press, August 2021, ipcc.ch.
2 For the purpose of this report, greenhouse gas emissions (unless otherwise specified) are the sum of the basket of greenhouse gases listed in Annex A to the Kyoto Protocol, expressed as CO_2e.
3 For more information, see "The Paris Agreement", United Nations Framework Convention on Climate Change, April 2016, unfcc.int.
4 M. Boko, I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda. "Climate Change 2007: Impacts, Adaptation and Vulnerability" *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* 2007, Africa. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.
5 Ibid.
6 "Agenda 2063 The Africa we want in 2063", African Union, April 2015. au.int.
7 "African industrial competitiveness report: An overview of the manufacturing industry in the region", United Nations Industrial Development Organization (UNIDO), November 2020, unido.org

without any abatement efforts its emissions would nearly double as well. Not only would this set the world back significantly on its overall emissions reduction targets, but the continent could also put itself at a disadvantage; as the rest of the world pulls ahead in the race to net zero, Africa's manufacturing sector could become uncompetitive and find itself unable to export globally, since many countries outside Africa have committed to ambitious abatement goals and are starting to pass laws and taxes on GHG emissions of imported goods.[8] As a result, the continent could risk increasing its dependence on global development support, leaving its people struggling to find formal jobs.

African manufacturing is a major contributor to the continent's emissions, with five sectors dominating

Our analysis shows that African manufacturing currently emits about 440 megatons of carbon dioxide equivalent ($MtCO_2e$)—about 30 to 40 percent of total African emissions. This report measures both the emissions generated by manufacturing facilities and vehicles used in production processes (scope 1 emissions) and the power these industries use to drive their operations (scope 2 emissions) (see Box 1).

About 80 percent of scope 1 emissions are concentrated in just five high-emitting industries: cement (contributing 32 percent to total African manufacturing emissions); coal-to-liquids, a technology that produces liquid fuels and petrochemicals from coal (13 percent); petroleum refining (5 percent); iron and steel (6 percent); and ammonia, which is primarily used in the production of fertilizers (4 percent). Scope 2 emissions from all sectors contribute about 27 percent to total manufacturing emissions. Furthermore, the bulk of Africa's manufacturing emissions—75 percent—comes from just four economies: South Africa (37 percent); Egypt (20 percent); Algeria (10 percent); and Nigeria (7 percent), driven by factors including their level of development, population size, high concentration of high-emitting sectors such as cement and refining, and share of manufacturing in GDP.

Without any decarbonization commitments, the continent's manufacturing scope 1 and 2 emissions could grow to about 830 $MtCO_2e$ by 2050 as the sector grows in line with GDP. To change this trajectory, decisive action would be needed across the sector. This report models three possible scenarios that reflect varying degrees of abatement efforts, from limited abatement (base-case scenario) to all-out abatement to achieve net-zero emissions by 2050 (net-zero scenario). The latter is the focus of this report and can serve as a useful guide to policy makers, investors, and manufacturers who are committed to working towards net zero by 2050.

Without any decarbonization commitments, the continent's manufacturing scope 1 and 2 emissions could grow to about 830 MtCO2e by 2050 as the sector grows in line with GDP.

[8] Carbon Border Adjustment Mechanism: Questions and Answers, European Commission website, ec.europa.eu.

An all-out abatement effort could see the manufacturing sector cut emissions by 90 percent to reach net zero by 2050

The base-case scenario assumes that the continent meets its current global nationally determined contributions (NDC) as part of the Paris Agreement, but takes no further action to decarbonize.[9] This would see African manufacturing increase its emissions by about 70 percent relative to 2018 levels by 2050, leaving the sector less competitive as the rest of the world drives a steeper decline in emissions.

In the second scenario, our analysis assumes that the continent aligns itself with global, more ambitious decarbonization commitments. By so doing, it could reduce emissions by about 25 percent relative to 2018 levels and by about 55 percent relative to the 2050 base case. While this global NDC-aligned scenario is achievable, a more aggressive decarbonization path that targets net-zero emissions by the middle of the century may yield greater benefits for the continent.

The net-zero scenario assumes that an all-out abatement effort is embraced across manufacturing to reduce emissions by 90 percent relative to 2018 levels (about 94 percent compared to the base case). This will be very difficult to achieve. To reach net zero by 2050, all available decarbonization levers would need to be pulled, especially in the five highest-emitting sectors. For example, in the cement industry, the highest-emitting sector on the continent because of the key role it plays in infrastructure development, abatement efforts would need to target energy-intensive production processes—notably the production of clinkers—and embrace technologies such as carbon capture and storage to reduce emissions. Additionally, a demand switch towards greener alternatives such as cross-laminated timber would be required.

There is additional potential for African manufacturing to contribute to global decarbonization by localizing supply chains and producing green goods to supply the African market, as well as sourcing sustainable inputs for its manufacturing sectors.

Decarbonizing the power sector would also be an important focus to reach net zero. There are two potential enablers here: an acceleration of the transition to renewable power sources and away from fossil fuels to enable zero-carbon electrification of manufacturing processes, and the uptake of new technologies that are not yet mature, notably battery storage and hydrogen.

Africa's emissions in the next 30 years are expected to come from future growth, hence there could be clear economic and environmental benefits to 'grow green', especially in the power sector and traditionally high-emitting manufacturing sectors. However, strong, coordinated action would be needed from all stakeholders to incentivize and finance this transition, especially as many of the required technologies are not yet mature. Investing in new and unfamiliar sectors and technologies may carry some risk and may also depend on the appetite of innovative entrepreneurs to seize these new opportunities to drive green growth.

Decarbonization-fueled growth could create 3.8 million net new jobs in Africa over the next 30 years

To achieve net-zero emissions, our analysis shows Africa would likely require $2 trillion of additional investments over the next 30 years, the bulk of which would be to reshape the power sector. Of this, about $600 billion would be needed to decarbonize existing manufacturing industries and power networks—both through investments to retrofit brownfield manufacturing facilities and into new greenfield facilities that are zero-carbon by design. The remaining $1.4 trillion would be needed to create new, low-emitting substitution businesses that replace or supplement high-emitting legacy sectors, specifically coal-to-liquids, petroleum refining, and cement. For example, cross-laminated timber is a sustainable replacement for traditional cement and could be used in the manufacturing of new green buildings, while charging stations and other infrastructure to power the growing electric vehicles market could supplant the need for coal-to-liquids technology and reduce the need for petroleum refining by up to 70 percent.

[9] The Paris Agreement requests each country to outline and communicate its post-2020 climate actions, known as their Nationally Determined Contributions (NDCs), which embody efforts to reduce national emissions and adapt to the impacts of climate change. Individual country NDCs are not necessarily aligned with the 1.5°C temperature goal and are generally considered by the UNFCCC to be not ambitious enough. NDCs are submitted every five years to the UNFCCC secretariat.

To fully decarbonize, the continent would likely need to invest beyond these two new green businesses in other key industries; however, these investments are not factored into this report.

To finance the power sector's green growth, strengthening grid infrastructure, diversifying supply, and improving storage capacity (notably batteries) so that renewable power can be dispatched when required rather than only when it is produced are all critical. Existing transmission and distribution networks would need to be upgraded to absorb a higher share of intermittent (renewable) power. A macro shift towards renewable energy sources, of which the continent has an abundance, could also be a focus. While existing fossil-fuel infrastructure means that this technology remains competitive in the short term, a longer-term lens shows renewables to be the most cost-effective technology to build and run in all regions within the next 10 years.[10] Thus, to achieve net zero, the early transition away from fossil-fuel assets, including some that are still under construction or approved but not built, may be an area for policy makers to explore.

Assuming a carbon price of zero, our analysis indicates that about 50 percent of all net-zero investments would be net present value (NPV) positive without additional supporting mechanisms by 2030. However, if a functioning carbon market could be built across Africa enabling African manufacturers to buy and sell carbon credits linked to carbon prices in export markets, the proportion of NPV-positive investments could rise.[11] Our analysis indicates that a carbon price of $50 per ton of CO_2e would ensure 60 percent of investments would be NPV positive by 2030.

Furthermore, decarbonization-fueled growth could create about four million net new jobs. While about two million jobs may be lost in legacy industries in both the manufacturing and power sectors as consumers switch to greener alternatives, six million new jobs are likely to be created in emerging green businesses by 2050, chiefly in electric vehicle charging infrastructure and cross-laminated timber, and with strong growth in the wind and solar industries.

Assuming a carbon price of zero, our analysis indicates that about 50 percent of all net-zero investments would be net present value (NPV) positive without additional supporting mechanisms by 2030.

[10] "The Sky's the Limit: Solar and wind energy potential is 100 times as much as global energy demand", April 2021, Carbon Tracker Initiative, carbontracker.com.

[11] The Report of the High-Level Commission on Carbon Prices (2017) published by the International Bank for Reconstruction and Development and International Development Association / The World Bank, estimated that the appropriate carbon price across the world would need to be US$40–80/$tCO_2e$ by 2020, and US$50–100/$tCO_2e$ by 2030, to be consistent with meeting the goals of the Paris Agreement.


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New green opportunities could deliver revenues of up to $2 billion per year by 2030

To build a competitive, low-carbon manufacturing sector from the ground up, urgent investment in new green manufacturing businesses would be required, thus opening up new prospects that historically may not have been viable. We have identified eight high-potential opportunities that could deliver revenues of between $200 million and $2 billion per year while collectively helping to reduce the continent's GHG emissions across the supply chain by up to 60 $MtCO_2e$ annually by 2030 (see Exhibit 19).

Our analysis shows that these new green businesses also have the potential to create about 700,000 direct and indirect jobs by 2030, with even stronger job growth in the decades beyond.

These new businesses were assessed on three key dimensions: their market potential for 2030; their probable environmental impacts, both in terms of GHG emissions abatement and other sustainability factors such as water use and pollution; and their near-term feasibility for uptake on the African continent, particularly with regards to technology readiness. Examples include businesses manufacturing new products that could displace existing carbon-intensive products such as plant-based proteins that reduce the reliance on meat farming, and businesses that either support green transportation or enable the energy transition. Examples here would include manufacturing wind turbine components to supply the fast-growing wind sector on the continent and manufacturing electric two-wheelers and electric vehicles.

Other opportunities we've identified include producing biofuels such as bioethanol, assembling micro-grids for local markets and off-grid solar systems, and the manufacture of cross-laminated timber as a substitute for carbon-intensive cement.

While not considered in our analysis, businesses that target the circular economy, such as recycling cotton-rich fiber and manufacturing fertilizers and other products from waste, also hold significant potential. Extending the life of a product is an important way to reduce manufacturing emissions.[12]

Investing in these new businesses and technologies may inevitably carry some risk. Still, an abundance of natural resources on the continent, including solar and wind power, minerals, and agricultural land, mean that—with the right support and incentives in place—the continent is well-positioned to support new green growth.

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[12] "Towards the circular economy: Economic and business rationale for an accelerated transition", Ellen MacArthur Foundation, 2013, ellenmacarthurfoundation.org

Five potential areas of action to help reach net zero by 2050

Decarbonizing Africa's manufacturing sector by 2050 is a significant and difficult undertaking that would require a cohesive effort from stakeholders, including governments, businesses, international organizations, development finance institutions, investors, and civil society. Our analysis has identified five important areas of action to consider:

1. Shift to a net-zero mindset and policy environment

To put climate change at the top of every agenda, all stakeholders could work together to change the prevailing mindset to a 'net-zero new normal'. Three things would be essential to drive this mindset change, starting with raising public awareness through public debates and education campaigns at all levels. A strong correlation exists between countries where the population is highly aware of climate risk and those with strong decarbonization commitments.[13]

Second, countries could develop green growth strategies to ensure that they capture the full opportunity emerging from green businesses while adapting and improving the resilience of their manufacturing sector (e.g., promoting electric vehicles manufacturing).

Third, an explicit focus on a 'just transition' would be required to ensure that both the poverty crisis and the environmental crisis are addressed concurrently.[14]

These efforts would need to be complemented by strong green policies to ensure that change happens. African governments can drive this by setting ambitious targets and NDCs, and by putting in place the enabling regulatory environment and direct support mechanisms for a green manufacturing ecosystem. Sector-specific regulations and incentives could help to drive decarbonization, especially in high-emitting or hard-to-shift industries (e.g., iron and steel, and cement).

To track and monitor this transition, transparency on current carbon emissions and decarbonization progress would likely be required from individual high-emitting companies and industries. Such a framework could enable standards to be enforced by respective governments.

2. Unlock green financing

With an estimated $2 trillion investment over 30 years required to achieve net zero in Africa, significant efforts would be needed to mobilize green financing on the continent. In approaching this challenge, stakeholders can consider three points.

First, a strong pipeline of investable green projects focusing on the decarbonization of existing industries (e.g., green steel) and new high-potential green businesses—starting with the eight businesses identified in this report—would help establish the continent as an investment destination. To facilitate this, both governments and Development Finance Institutions could consider how best to assist with project preparation and transaction facilitation.

Second, new green financing instruments that match the different risk and return profiles for green investments would need to be put in place. These could include early-stage project development finance, carbon credits, green insurance, green bonds, green guarantee mechanisms, and payments for performance. The latter could be effective in attracting increased official development assistance that is linked to green outcomes.

Third, a strong baseline and verification system for GHG emissions could be established to give financiers confidence that their investments are yielding the expected carbon savings, thus making them *de-facto* enforcers of companies' committed decarbonization efforts.

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13 UNDP and Oxford-Peoples' Climate Vote.

14 The Paris Agreement (2015) explicitly calls for countries to pursue a just transition that ensures environmental sustainability as well as decent work, social inclusion, and poverty eradication.

3. Upgrade green infrastructure
Africa's infrastructure lags behind that of the rest of the world and this is a major roadblock for development on the continent.[15] Our analysis suggests that important precursors for green manufacturing growth include renewable energy, transport, recycling, an enabling business ecosystem (e.g., green financing apps), and data infrastructure (e.g., online databases). The latter is needed to aggregate usable knowledge that can help to monitor and track decarbonization progress. In meeting this backlog, public-private partnerships could play a role in helping to speed up new builds and investments in critical green infrastructure.

4. Upskill and reskill the workforce
The drive to decarbonize will likely require major changes in industries, and skills needs would change too. Stakeholders can approach this challenge methodically.

We expect large private companies would drive much of the change by hiring and training workers in new skills, but governments and development partners can help too, particularly in offering support to small and medium enterprises, for example, by developing skills certifications for new green jobs to support skills mobility and developing shared infrastructure such as training institutes.

Interventions would have to be tailored for specific localized situations. For example, in countries with high potential for forestry and thus cross-laminated timber, such as Angola and Zambia, a direct reskilling initiative may be most effective to help people transition away from cement into the new industry. In countries with low forestry potential, the situation is different, and stakeholders may need to apply the just transition principles in any cement-transition discussions.

5. Accelerate R&D
Developing viable new green sectors, technologies, and products specific to Africa's needs could boost the uptake of sustainable opportunities. Investors and the public and private sectors could support significant R&D efforts to drive this.

On the one hand, local research could focus on projects relevant to Africa, but not a priority globally, such as local circular economy solutions and processes to reduce emissions. On the other hand, Africa could take steps to ensure the fast development of new green businesses. One action to facilitate this could be to set up dedicated green manufacturing accelerators to spur innovation and enable the scaling-up of new green manufacturing businesses and technologies (notably through research partnerships). These accelerators could enable the sharing of best practices and provide entrepreneurs with access to critical support and assistance in navigating complex administrative and legal environments, and facilitate matchmaking between venture capitalists and high-potential entrepreneurs.

An opportunity to reimagine Africa's growth path

An early transition to a low-carbon economy could help mitigate dangerous climate impact and enable the continent to avoid locking itself into large-scale investments that would require a more painful—and expensive—transition down the line. Across multiple sectors, the technology is readily available today, with additional low-carbon technologies expected to reach maturity and economic viability from 2030 to close the gap to full decarbonization by 2050. Meanwhile, investors and businesses have an opportunity to position themselves ahead of the curve by moving fast and seizing new green manufacturing business opportunities. Those willing to take a risk and establish new green businesses early could benefit from Africa's transition.

While this may not be an easy path, the benefits of decarbonization are likely to be significant. We believe that as countries seek to chart a path to recovery after the COVID-19 pandemic, there is an opportunity now to step back and reimagine Africa's growth with a more sustainable mindset. A transition to net zero by 2050 is likely to offer the best prospect for securing the prosperity of the continent and the livelihoods of its people in the long term.

[15] "African Industrial Competitiveness Report: An overview of the manufacturing industry in the region", United Nations Industrial Development Organization (UNIDO), November 2020, Unido.org.

The path to net-zero manufacturing in Africa

African manufacturing would have to reduce its emissions by around

90%

relative to 2018 levels by 2050

Africa's manufacturing sector:

Contributes just

3% to global

manufacturing CO_2 emissions

Currently emits

440 $MtCO_2e$

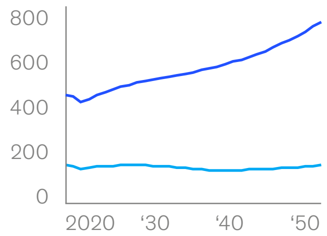
around 30%-40% of total African emissions

Three scenarios for African decarbonisation vs 2018 levels

Emissions, $MtCO_2e$ — Scope 1 — Scope 2

+70%

Base Case



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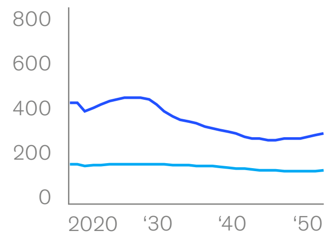
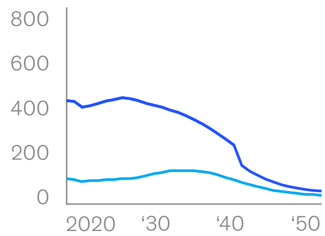
Global NDC Guided



-90%

Net Zero



Net zero will be hard to achieve but offers significant benefits

$2 Tr additional investment needed for net zero

50% of investments NPV-positive by 2030

3.8 million net new jobs created

8 high potential new green business opportunities identified

Five potential actions to get things moving

1. Shift to a **net-zero mindset** and **policy environment**
2. Unlock **green financing**
3. Upgrade **green infrastructure**
4. Upskill and reskill **the workforce**
5. Accelerate **R&D**

BOX 1

Snapshot of our scope and methodology

In this report, we are using the term manufacturing as defined by the International Standard Industrial Classification, which includes 23 sub-sectors across Africa (see the full list in Appendix 2). The primary focus of our analysis is on greenhouse gas (GHG) emissions, measured as tons of carbon dioxide equivalent (CO_2e), a metric that compares the emissions from various GHGs based on their global warming potential. This is in line with the Paris Agreement.

We also recognize that the environmental impacts of the manufacturing sector are far broader than just GHG emissions, ranging from pollution, waste, and the impact on water to biodiversity loss. While we have not been able to do full justice to the range of effects in this report, some of these are considered in the case studies presented and are noted as areas for further research.

The GHG emissions released by manufacturing are part of an intricate ecosystem and need to be treated carefully to avoid multi-counting. The manufacturing lifecycle results in three classifications of emissions:

— **Scope 1:** Emissions resulting directly from industrial processes, including fuels used within company facilities;

— **Scope 2:** Indirect emissions from supplied electricity/energy used by the industry;

— **Scope 3:** Indirect emissions that occur upstream or downstream, including upstream emissions that result from raw materials and imports used by the industry, and downstream emissions from transportation, product usage, disposal, and waste.

This report focuses on scope 1 and 2 emissions, as these fall within the control of manufacturers. With roughly the same output as scope 1 and 2 combined, scope 3 emissions are significant but not included in this analysis as they lie outside the manufacturing sector's control.

This report explores Africa's green manufacturing opportunity at two levels:

1. **Africa's manufacturing emissions and outlook at a macro level**

   - **First,** we estimated the 2018 baseline of CO_2e emissions from manufacturing sector activities in Africa, based on a combination of bottom-up analysis for the highest-emitting sectors and a top-down estimate for the lowest-emitting sectors.

   - **Second,** we projected these emissions in a business-as-usual or 'do nothing' scenario to understand how manufacturing emissions are likely to grow.

   - **Third,** we developed three green manufacturing scenarios to estimate the potential of emission reduction in existing manufacturing activities by implementing green manufacturing levers.

   - **Fourth,** we estimated the implications of the net-zero pathway in terms of investment requirements and jobs using multiple assumptions, including that labor productivity is fixed at 2018 levels, and emissions intensity by technology is fixed at 2018 levels for low-emitting sectors.

2. **Green manufacturing business opportunities in Africa at a micro level**
   Given the above context, we then explored the potential for developing specific green businesses on the continent, corresponding to manufacturing activities that do not currently exist and their impact in terms of CO_2e emissions reduction. This section is not intended to be an exhaustive outlook for green manufacturing opportunities on the continent. Rather, it is a preliminary view of the leading green business opportunities that are being discussed today, with a high-level assessment of their economic and CO_2e-saving potential for Africa.

CHAPTER 1

Defining Africa's decarbonization path: A choice to 'grow green'

570Gt
global carbon budget may be exceeded **by 2030**

30%
of global emissions come **from the industrial sector**, including manufacturing, mining, and oil and gas

3%
of global manufacturing emissions are **from Africa = 440 MtCO$_2$e**

2x
African manufacturing could **double in size by 2050**

In Africa and around the world there is an increased understanding that action to prevent further climate change is needed. Scientists from the Intergovernmental Panel on Climate Change (IPCC) have warned that global warming of 2°C will be exceeded during the 21st century unless rapid and deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades.[16] "The alarm bells are deafening, and the evidence is irrefutable," says UN Secretary-General António Guterres.[17]

Already, the consequences of a global average rise of approximately 1°C above pre-industrial temperatures are playing out worldwide in ways that pose an existential threat to humanity.[18] These include an increase in the intensity and number of storms, floods, droughts, and catastrophic fires, and rising sea levels, all of which will affect the manufacturing value chain. Of the 17 warmest years ever recorded, 16 have occurred in the 21st Century, with the past five years the warmest on record.[19] And in Africa, where most people rely on rainfall to grow their food, the planet's two most extensive land-based end-of-century projected decreases in rainfall will occur; one over North Africa and the other over southern Africa.[20]

As GHG emissions are directly correlated with temperature increases, they are one of the

[16] "IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge University Press, August 20201, ipcc.chi.
[17] "IPCC report: 'Code red' for human driven global heating, warns UN chief", UN News, August 2021, news.un.org.
[18] "Special Report on Global Warming of 1.5°C", Intergovernmental Panel on Climate Change (IPCC), 2019, ipcc.ch.
[19] Global Land-Ocean Temperature Index, NASA's Goddard Institution for Space Studies (GISS), climate.nasa.gov.
[20] R. Washington, "How Africa will be affected by climate change", December 2019, bbc.com.

most important factors to control to limit global warming.[21] In 2015, 196 countries committed to doing just this as signatories of the landmark Paris Agreement. This legally binding international treaty on climate change came into force in 2016, with an ambitious goal of limiting global warming to below 2°C from pre-industrial levels while pursuing efforts to keep it below 1.5°C to avoid unpredictable climate consequences. To achieve this, the world would have to reduce its GHG emissions dramatically to stay within a 'carbon budget' of 570 Gigatons (Gt).[22]

The Paris Agreement calls for countries to aim to reach their peak of GHG emissions as soon as possible and arrive at net zero by 2050, where an overall balance is achieved between emissions produced and emissions taken out of the atmosphere. To put this into perspective, the world would need to abate roughly 90 percent of emissions by 2050 relative to 2018 levels. However, previous McKinsey analysis shows that as things stand, the world is on track to exceed the 570 Gt carbon budget by 2030.[23] This means that even a rapid and accelerating energy transition across multiple sectors may not succeed in bending the curve sufficiently to avert an unsustainable temperature increase.

African industrialization and the decarbonization of the manufacturing sector can go hand-in-hand

Globally, the industrial sector, including manufacturing, mining, and oil and gas, is one of the largest contributors to total GHG emissions—contributing about 30 percent—and, as such, has a significant role in achieving the 1.5°C pathway.[24] Industry would need to reduce 40 percent of scope 1 and 2 emissions (direct process and fuel emissions, and indirect emissions in the form of purchased electricity or heating used by the industry) by 2030 and 90 percent by 2050 to achieve net-zero emissions.[25] As part of this, the switch to renewable energy will be crucial, having significant knock-on benefits for abatement in all sectors, including manufacturing, chiefly by unlocking savings through electrification.

Africa is currently a relatively low emitter of GHGs—contributing about 3 percent to global emissions—largely because its manufacturing sector is underdeveloped; Africa's share of global MVA is just 2 percent.[26] In 2018, GHG emissions from Africa's manufacturing sector stood at about 440 $MtCO_2e$ (see Box 1). Most of these emissions—about 80 percent—are concentrated in just five industries: cement, coal-to-liquids (a technology that produces liquid fuels and petrochemicals from coal), petroleum refinery, ammonia production (a key component of fertilizers), and iron and steel. Furthermore, just four African countries (South Africa, Egypt, Algeria, and Nigeria) are responsible for 75 percent of manufacturing-sector emissions, owing to their level of development, population size, and share of manufacturing in GDP (Exhibit 1).

The highest emitter by far is the cement industry, which is ubiquitous across the continent and was responsible for 142 $MtCO_2e$—roughly 32 percent of total manufacturing scope 1 emissions—in 2018. Coal-to-liquids accounted for about 58 $MtCO_2e$, of which almost two-thirds were caused by just one coal-to-liquids plant complex in South Africa. About 42 $MtCO_2e$ of the manufacturing sector's scope 1 emissions come from low- and medium-temperature heating (LMTH) industries such as wood and wood products, textiles, and leather.

Scope 2 emissions from power consumed by the entire manufacturing sector produced 121 $MtCO_2e$ emissions in 2018, which at 27 percent of total manufacturing emissions makes it the second largest emitter category after cement. Most of these power emissions are fuel emissions from heat processes such as gas or oil burners.

21 *AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability,* Intergovernmental Panel on Climate Change (IPCC), 2014; *Global warming of 1.5°C,* IPCC Special Report 15, 2018.
22 *Global warming of 1.5°C; Key aspects of the Paris Agreement,* United Nations Climate Change, 2021.
23 "Global Energy Perspective 2021", McKinsey & Company, January 2021, McKinsey.com.
24 Climate Watch – The world Resources Institute (2020), wri.org.
25 "Global Energy Perspective 2021", McKinsey & Company, January 2021, McKinsey.com.
26 "African industrial competitiveness report: An overview of the manufacturing industry in the region", United Nations Industrial Development Organization (UNIDO), November 2020, Unido.org.

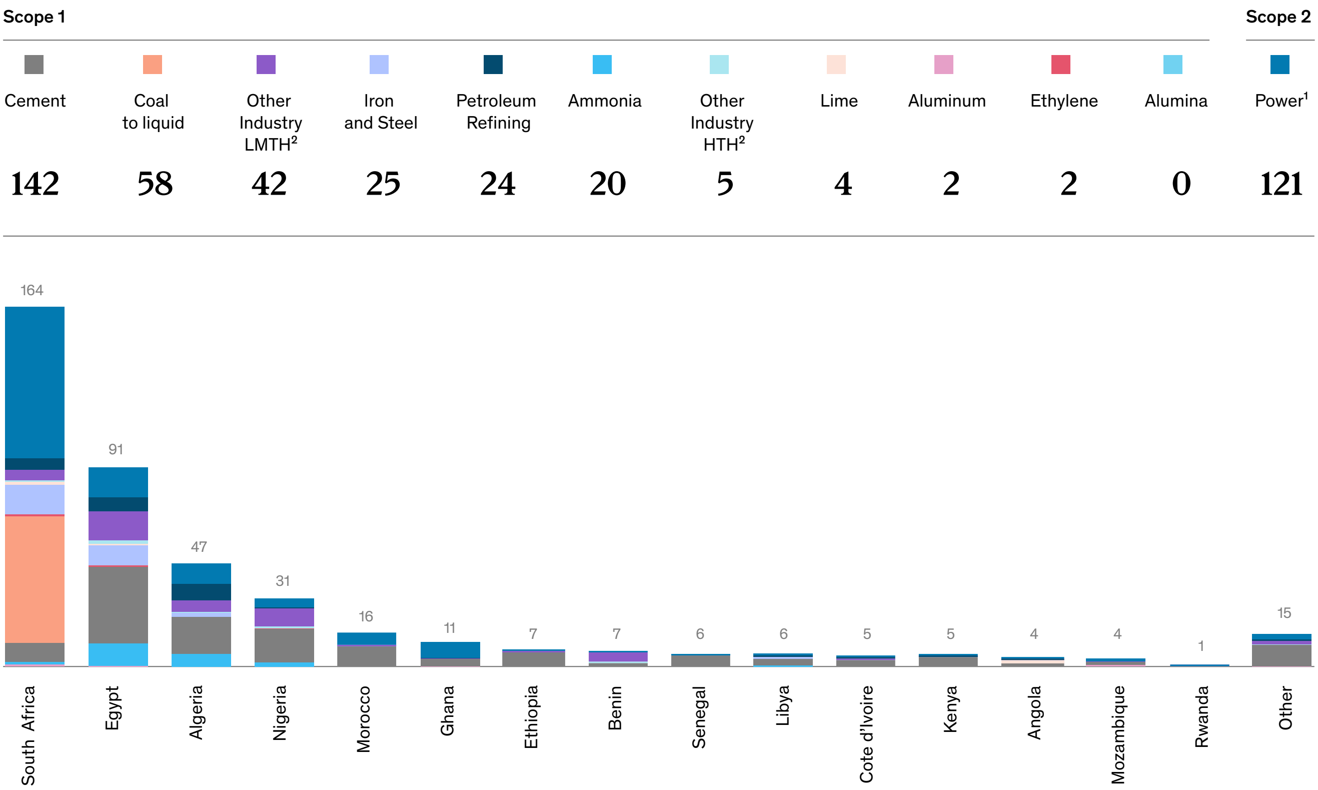
In the next 20 to 30 years, Africa's manufacturing sector is expected to double in size, following in the footsteps of developed markets. The continent's emissions are therefore likely to come from future growth. We estimate that about half of the sector's GHG emitting assets have not yet been built, hence there is a significant opportunity to 'grow green', especially in traditionally high-emitting sectors. In this, the continent has two things in its favor. First, it has high renewable power potential combined with a low asset base that would need new builds to drive growth, regardless of climate change; second, because it is coming off such a low emissions base, the continent does not have a significant 'legacy burden' holding it back. Making the right technology choices now could help Africa sidestep the expensive transition from fossil fuels to renewables that the developed world has to navigate and set the continent up for future success and prosperity.

Experts we spoke to agree that the potential for economic growth in Africa cannot be separated from its decarbonization trajectory. Dr Arkebe Oqubay, Senior Minister and Special Adviser to the Prime Minister of Ethiopia, says: "Economic development that destroys the environment is no longer a viable option. As latecomers to industrialization, African countries have the opportunity to develop environmentally sound manufacturing sectors by leapfrogging historic greenhouse gas emitting technologies and adopting green industrial policies."

Exhibit 1

Africa's manufacturing emissions are low at 440 $MtCO_2e$, concentrated in just five sectors

Manufacturing sector scope 1 and 2 emissions[1] 2018, $MtCO_2e$



1 Power shown corresponds to power consumed by the manufacturing sector, not the continent as a whole
2 Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors

Source: IEA CO_2 Emissions from Fuel Combustion 2020 Edition with bottom up allocation from McKinsey DLL and Expert estimates, Worldsteel, IHS, the Global Cement Report, Tradeship Publications Ltd (UK), USGS; top down allocation from IHS, DIM, World Bank and UNIDO

Economic development that destroys the environment is no longer a viable option. As latecomers to industrialization, African countries have the opportunity to develop environmentally sound manufacturing sectors by leapfrogging historic greenhouse gas emitting technologies and adopting green industrial policies.

Dr Arkebe Oqubay, Senior Minister and Special Adviser to the Prime Minister of Ethiopia

CHAPTER 2

Three pathways to achieve green growth

By 2050, without any abatement efforts African manufacturing emissions could **almost double**:

440 MtCO2e to 830 MtCO2e

3 alternative scenarios for Africa:

Base Case:	755 $MtCO_2e$
Global NDC Case:	330$MtCO_2e$
Net Zero Case:	47 $MtCO_2e$

If Africa's manufacturing sector keeps on its current growth path, without any efforts to decarbonize, it is likely to nearly double its emissions by 2050. The African Union's Agenda 2063 makes it clear that the continent has to focus on growth, industrialization, and jobs in the next three decades, and it also has a window of opportunity to choose a low-carbon path to achieve this. In this chapter, we model three scenarios to show what could be possible for green growth on the continent.

Business as usual would take Africa down an unsustainable path. While all African countries have made intended NDC commitments, just 12 have ratified these, and the vast majority lack clarity regarding the concreteness of targets and the quantification of costs.[27] Additionally, most African NDCs do not make an adequate distinction between conditional and unconditional targets.[28] This suggests that as things stand, the continent is heading down an unsustainable path; if Africa's manufacturing sector grows unfettered, without regard for the climate, scope 1 and 2 emissions from industrial processes and the use of fuel are likely to grow from 440 $MtCO_2e$ to about 830 $MtCO_2e$ between 2018 and 2050, in line with economic growth (see Box 2).

[27] "Analysis of Adaptation Components of Africa's Nationally Determined Contributions (NDCs)", African Development Bank, 2019, afdb.org.

[28] An "unconditional contribution" is what countries could implement without any conditions and based on their own resources and capabilities. A "conditional contribution" is one that countries would undertake if international means of support are provided, or other conditions are met. Conditional targets are usually more ambitious, but harder to achieve. For example, Morocco's unconditional contribution is 17% reduction below BAU emissions by 2030, and its conditional contribution is an additional 25% reduction below BAU by 2030. Ghana has an unconditional emission reduction goal of 15% relative to a BAU scenario, and an additional 30% emission reduction that is contingent on external support in the form of finance, technology transfer and capacity building. See "A pocket guide to NDCs under the UNFCCC", International Institute for Environment and Development, 2018, iied.org.

As African economies industrialize and energy demand increases, the availability of affordable green energy will be vital. Without green power, it will not be possible to realize Africa's green manufacturing potential.

Michael Turner, Director, Actis

When considering scope 1 emissions, the greatest proportion of manufacturing emissions is likely to come from cement production. Cement plays a central role in construction, and growth in this industry is typically correlated with GDP. As the African population grows and urbanization accelerates, cement emissions will likely rise disproportionately, increasing their share of scope 1 emissions from 44 percent in 2018 to 54 percent in 2050. Other industries that would be responsible for a significant proportion of scope 1 emissions over the next 30 years, if no efforts to decarbonize are made, are coal-to-liquids, iron and steel production, petroleum refining, ammonia production, alumina and aluminum processing, and other industries that use heat in their processes.

Scope 2 emissions from the electricity used in all manufacturing processes would also grow as the sector grows, making a major contribution to manufacturing emissions. However, cheaper renewable energy is expected to become available over time, which could help to keep power emissions in check. Michael Turner, Director, Actis—a leading global growth markets investor—says: "As African economies industrialize and energy demand increases, the availability of affordable green energy will be vital. Without green power, it will not be possible to realize Africa's green manufacturing potential."

While the environmental consequences of this path are now well understood, what is less clear is the degree to which the economy could also suffer. Climate change and environmental breakdown have quantifiable economic and health costs, weighing on long-term growth and well-being.[29] If nothing is done, the continent's export competitiveness will likely be damaged as several global economies are starting to impose carbon taxes on imports. For example, the EU's Carbon Border Adjustment Mechanism seeks to prevent so-called 'carbon leakage' caused by EU companies moving carbon-intensive production abroad to take advantage of more lenient environmental standards by imposing taxes on GHG emissions of imported goods. Under these new regulations, importers are required to attain a CO_2 certificate corresponding to the carbon price that would have been paid had the goods been produced under the EU's carbon pricing rules.[30]

Investors, too, are increasingly moving away from GHG-intensive projects, making it more challenging to finance capital expansion projects in Africa.[31] Additionally, the continent may lose out on significant economic opportunities if it fails to act assertively. Although abatement efforts require additional investment in new technology and business models over the next 30 years, our analysis indicates that growth in new and emerging industries offers new opportunities from which Africa is well-placed to benefit.

29 "The State of the Climate in Africa 2019", World Meteorological Organization (WMO), 2020, wmo.int.
30 Carbon Border Adjustment Mechanism: Questions and Answers, European Commission website, ec.europa.eu.
31 Attracta Mooney and Stephen Morris, " Coalition of big investors pushes banks to defund carbon emitters", Financial Times, April 2021, ft.com.

BOX 2

Modelling how the energy mix and emissions could evolve

In this report, we have used McKinsey's Decarbonization Scenario Explorer (DSE) model to determine how manufacturing emissions and the energy mix could evolve. This model considers up to 100 technologies across 15 sectors, building forecasts on three dimensions: by country, industry, and technology.

It does this in three stages:
1. It forecasts the activity level in a given industry/country. For example, in the steel industry the activity level would be calculated as tons of steel, and in the transport sector, it could be passenger kilometers. This is based on available data sources such as the Global Cement Report, the World Steel Association, and Tradeship Publications. Data beyond 2030 and for all industries without explicit production forecasts are extrapolated by applying sector MVA growth to activity levels.

2. The model then forecasts how this activity level might grow and evolve based on the use of specific technologies. So, for example, in the transport sector, technologies may include an internal combustion engine and battery electric vehicles. The model assumes that most technology use grows according to a typical S curve—a relatively slow beginning followed by rapid growth, then maturity.

3. From there, the model calculates how much energy is needed in production and the scope 1 and 2 emissions this would generate. Scope 1 emissions are based on emissions by industry and include Africa-specific assumptions, and scope 2 emissions are based on estimated electricity consumption by industry, including energy mix forecasts in Africa combined with specific emissions forecasts by region.

The model draws on a variety of data sources, including an emissions baseline (IEA CO_2 emissions from fuel combustion 2020 edition, FCDO development impact model); economic data (from a variety of sources including IHM Markit, The World Bank World Development Indicators, and UNIDO); emission factors (including McKinsey decarbonization library, GaBi, and the FCDO development impact model, etc.); technology CAPEX (Fitch and McKinsey decarbonization lever library); technology fuel consumption and technology OPEX (Trademap and McKinsey decarbonization lever library).

Three decarbonization scenarios to build a greener Africa

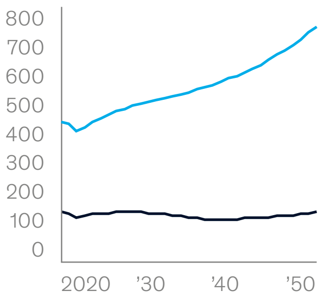
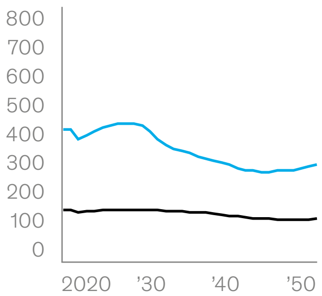
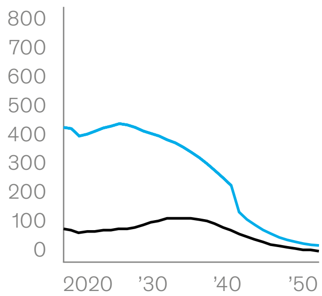
Building a green economy offers Africa a major opportunity to increase its prosperity sustainably, giving it the leverage it needs to address its long-standing social and economic challenges. This report considers three decarbonization scenarios to help illustrate the potential of green manufacturing in Africa (Exhibit 2). These are:

- A **base case** where African countries honor their current NDC commitments;
- A **global NDC-guided case** that aligns Africa's NDC with the global average; and
- A **net-zero case** that aspires to the ultimate goal of keeping temperature increases to 1.5°C.

Exhibit 2

Three scenarios are defined to understand the potential of green manufacturing in Africa

— Scope 1 — Scope 2

	Base Case	Global NDC Guided	Net Zero
Scenario description	Demand in line with predictions and abatement efforts in line with recent African commitments	Demand in line with predictions, and abatement efforts aligned with global NDC commitments, focusing on the highest emitting sectors and most realistic levers	Demand in line with predictions with abatement targets designed to achieve the 1.5°C scenario, using all possible levers to reach 90% emissions reduction
Industry actions and key levers	Industry does not make specific decarbonization efforts beyond requirements to meet unconditional NDC[1] commitments from African countries	Mainly relatively inexpensive brownfield improvements (e.g., use of biofuels) with some greenfield investment for new capacity (e.g., recycling EAFs)	Brownfield improvements (e.g., CCS) and large greenfield investment in existing industries (e.g., DRI H2 EAF, heat process electrification) including potential early retirement
Emissions, Mt CO_2e			

[1] Many African countries have not yet communicated Nationally Determined Contributions and of those that have, most are not absolute reduction targets, e.g., Egypt (20% absolute), Uganda (22% vs. Business as usual) Nigeria (20% vs. Business as usual), Ghana (15% vs. Business as usual)

Source: NDC commitments, https://unfccc.int

The scenarios range from the least interventionist to the most rigorous abatement strategy with extensive interventions to achieve a steep reduction in emissions relative to business-as-usual (BAU). Only the third scenario would drive a steep enough decline in emissions for Africa to keep pace with the commitments being made in the rest of the world, and which are necessary to keep global temperature rises below the 1.5°C target.

Each scenario explores a selected set of levers and industry actions to reduce scope 1 emissions and power decarbonization scenarios to reduce scope 2 emissions (Exhibit 3). An approximate 3 percent real GDP growth per annum is assumed, with manufacturing value added following a similar trajectory.[32] The costs for realizing these scenarios are looked at in the next chapter.

SCENARIO 1: BASE CASE

Demand in line with predictions and abatement efforts aligned with existing NDC commitments

Scope 1 and 2 manufacturing emissions increase by 70 percent by 2050 relative to 2018 levels

The base case expects emissions from African manufacturing to grow by about 70 percent by 2050, a marginal improvement on a BAU path. In this scenario, it is assumed that demand is in line with predictions for growth and that no additional abatement efforts are made, other than those that have already been committed to through the Paris Agreement NDCs.[33] More than half of the continent's absolute abatement efforts in terms of $MtCO_2e$ are likely to come from South Africa because that country is starting with a higher baseline of emissions and is the only country in Africa with 2050 NDC commitments. As a result, this scenario anticipates scope 1 and 2 emissions amounting to 755 $MtCO_2e$ by 2050 (Exhibit 4).

Exhibit 3

Four main categories of levers to decarbonize Africa's manufacturing sector

Use low-emitting energy sources	Use low-carbon electricity (e.g., renewables, nuclear) Use low-carbon fuels (e.g., biogas, hydrogen)
Implement new production technologies	Reduce electricity use (e.g., better equipment efficiency, low power lighting) Reduce fuel use (e.g., thermal isolation, heat recovery systems) Reduce material use (e.g., reduce losses, implement lower material intensity designs)
Improve existing technologies' efficiency	Increase products' useful life (e.g., reuse products, improve product designs) Recycle products Remanufacture products Use low-carbon feedstock (e.g., vegetable fats and oils for bioplastics)
Use recycled low-carbon feedstock	Capture process emissions (e.g., CCS) Implement low-carbon production technologies (e.g., direct reduction of iron – electric arc furnace)

32 In line with the latest IHS forecast extrapolated to Africa.
33 In Africa, only Morocco and the Gambia's NDC commitments are aligned with the 1.5°C target, climateactiontracker.org.

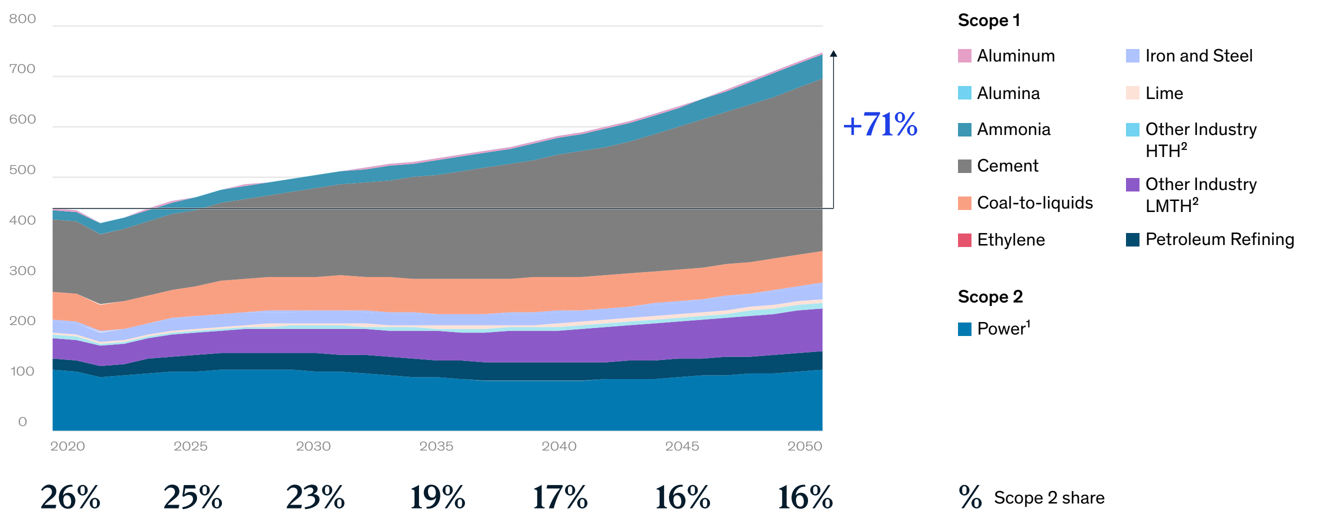
In this scenario, cement would be the major driver of scope 1 emissions growth while scope 2 emissions remain stable. Power demand would grow in line with manufacturing growth, but a significant uptake of renewable power—reaching about 60 percent by 2050—would keep emissions flat as wind and solar sources become more competitive.

Africa would need to implement decarbonization technologies at only a relatively small scale to meet its current NDC decarbonization targets. With cement accounting for the lion's share of Africa's manufacturing emissions, it offers the widest scope for abatement efforts. Key technologies to abate emissions in this industry are also relatively mature. The base-case scenario assumes that less cement would be produced with conventional firing, with about 25 percent of cement kilns being fired by biomass by 2050, reducing GHG emissions by about 28 $MtCO_2e$.[34] Additionally, introducing low-carbon clinker replacements in cement production, even at a small scale, could result in a 15 $MtCO_2e$ reduction by 2050. Clinkers, typically a blend of calcareous rock, such as chalk or limestone, and argillaceous rock, such as clay or shale, are formed as an intermediary product in traditional cement production and are extremely energy-intensive to produce. In Africa, about 80 percent of cement emissions result from calcination. This chemical reaction occurs when raw materials such as limestone are exposed to fuel-intensive high temperatures in the production of clinkers.[35]

Exhibit 4

Base Case: Existing African NDC commitments do not lead to significant $MtCO_2e$ abatement by 2050

Manufacturing sector scope 1 and 2 emissions[1] in Base Case, $MtCO_2e$



1 Power shown corresponds to scope 2 from the manufacturing sector, not power emissions of the continent as a whole
2 Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors

Source: DSE, IEA, Global Carbon Atlas

34 Biomass is material that comes from living organisms, such as plants and animals. The most common biomass feedstocks used for energy are plants, wood, and waste, which can be burned directly for heating buildings and water, industrial heat and reduction processes, and generating electricity in steam turbines.
35 Getting the Numbers Right (GNR), Global Cement and Concrete Association, 2017.

Exhibit 5

In the base-case scenario, Africa would need to implement decarbonization technologies at a relatively small scale to meet its current targets

Sector	Key levers	2030 abatement	2050 abatement	Assumptions
Cement	**Biomass**	-13 $MtCO_2e$	-28 $MtCO_2e$	Switching cement kiln fuel from 100% conventional fuel sources (mainly coal) to 25% biomass based
	Clinker replacements	-6 $MtCO_2e$	-15 $MtCO_2e$	Introducing some clinker replacement in cement production at small scale allows for NDC targets to be achieved
Low- and medium-temperature heat sectors	**Natural gas**	-3 $MtCO_2e$	-7 $MtCO_2e$	Increasing the natural-gas portion to 25% to displace oil as an energy source provides a cheap and mature option that contributes to the abatement target
Total of selected levers		**-22 $MtCO_2e$**	**-50 $MtCO_2e$**	**Selected levers account for 85% of total scope 1 emission reductions in 2030 and 63% of total scope 1 emission reductions in 2050[1]**

[1] Of the reported countries, actual targets vs. 2017 correspond to +0.5% in 2025 and -2.1% in 2030. The only country with 2050 timeline is South Africa, which has communicated a 34% reduction commitment vs. Business as Usual in 2050

Source: DSE, IEA, Global Carbon Atlas

In this scenario, a third key lever includes moving to natural gas as an energy source as an interim solution in the low- and medium-heat temperature sectors. Increasing the natural-gas portion to 25 percent to displace oil heating could lead to a 7 $MtCO_2e$ reduction by 2050 (Exhibit 5).

SCENARIO 2: GLOBAL NDC GUIDED

Demand in line with predictions and abatement effort in line with global average targets

Scope 1 and 2 manufacturing emissions are about 55 percent lower than the 2050 base case and 25 percent lower than 2018 levels

The global NDC-guided scenario assumes that Africa's NDC commitments are aligned with more ambitious global commitments until 2030.[36] This pathway could see emissions peak around 2025 and drop back to 2018 levels in 2030. By 2050, overall emissions would be expected to fall by about 25 percent relative to 2018 levels to 330 $MTCO_2e$ (Exhibit 6). This is equivalent to a 56 percent reduction compared to the base case of 755 $MtCO_2e$.

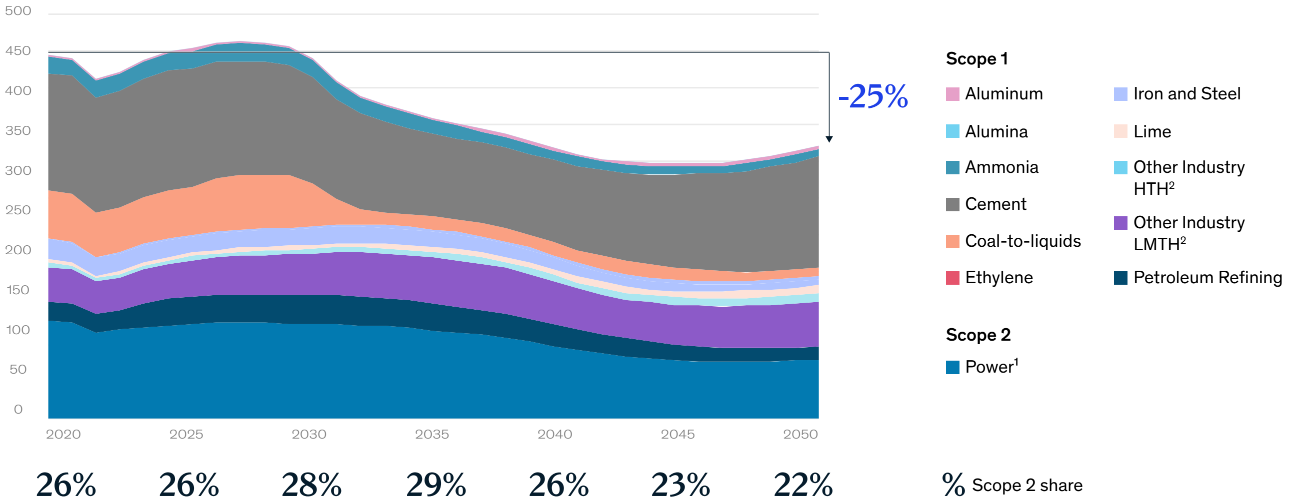
A continued reduction of scope 1 manufacturing emissions would be driven by rapid technology adoption, including a switch to biomass and the use of green hydrogen. Scope 2 emissions would be kept in check by a higher share of renewable energy sources—reaching 75 percent by 2050—even though power demand grows faster in this scenario than in the base case owing to increased electrification.

[36] While global NDC targets are more ambitious than current African commitments, they still fall far short of the required commitments to limit global temperature increases to 1.5°C.

Exhibit 6

Africa's manufacturing emissions could decrease by around 25% if the continent aligns on global-NDC ambitions

Manufacturing sector scope 1 and 2 emissions in Global NDC Guided, $MtCO_2e$



1 Power shown corresponds to scope 2 from the manufacturing sector, not power emissions of the continent as a whole
2 Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors

Source: DSE, IEA, Global Carbon Atlas

In this scenario, most of the actions available to industry, especially in high-emitting sectors, would involve relatively inexpensive brownfield improvements with some greenfield investment for new capacity using technologies that are already available or likely to become available at an industrial scale in the short to medium term. Two key abatement technologies with significant breadth of application are green hydrogen and carbon capture and storage (see Box 3).

Green hydrogen could contribute to abatement in the production of both ammonia, and iron and steel. For example, replacing half of conventional steel production with hydrogen direct reduced iron (DRI) processes that use green hydrogen from 2030 could result in a reduction of about 19 $MtCO_2e$ by 2050, while the introduction of carbon capture and storage for South African coal-to-liquids plants in the late 2020s could cut emissions by around 85 percent to 55 $MtCO_2e$ by 2050.

The large-scale adoption of biomass and clinker alternatives in cement from 2025 would also be necessary. For example, replacing about 50 percent of traditional clinkers with energetically modified cement—typically made from natural pozzolans (naturally occurring volcanic rock), silica sand, and other materials and not requiring clinkers in its production process—or calcined clay (industrially produced pozzolans) could achieve a 182 $MtCO_2e$ reduction by 2050.

In other industries, a move from 100 percent use of oil in heating in the low-and medium-temperature heat sectors to include 80 percent natural gas (not including carbon capture and storage) from 2025 to 2050 could contribute to an approximate 21 $MtCO_2e$ abatement (Exhibit 7).

Exhibit 7

Considerable abatement efforts across high-emitting sectors would be required under the global NDC-guided scenario

Sector	Key levers	2030 abatement	2050 abatement	Assumptions
Cement	**Biomass**	-31 $MtCO_2e$	-60 $MtCO_2e$	Moving to 40% biomass-fired kilns over the next decade aggressively decreases carbon emissions
	Clinker replacements	-47 $MtCO_2e$	-182 $MtCO_2e$	Introducing some clinker replacement in cement production at small scale allows for NDC targets to be achieved
Coal-to-liquids	**Carbon capture and storage**	-38 $MtCO_2e$	-58 $MtCO_2e$	Moving from 0% to 100% CCS, with installation of CCS in South Africa around 2030 and Francistown around 2045
Ammonia	**Carbon capture and storage**	-6 $MtCO_2e$	-19 $MtCO_2e$	Implementing a 40% share of CCS in ammonia from 2023 to 2038 is key early driver for reduced carbon emissions
	Hydrogen	-1 $MtCO_2e$	-23 $MtCO_2e$	Reaching a 45% share of green hydrogen in ammonia production by 2050 allows for a further reduction in carbon emissions
Iron and steel[2]	**Recycling**	-2 $MtCO_2e$	-4 $MtCO_2e$	Increasing steel recycling to 44% of production in 2050
	Hydrogen	-1 $MtCO_2e$	-19 $MtCO_2e$	Switching to hydrogen direct reduction of iron production of virgin-quality steel from 2030 and reaching almost 50% of production in 2050
Low- and medium-temperature heat sectors	**Natural gas**	-1 $MtCO_2e$	-21 $MtCO_2e$	Moving from 100% heating with oil to 80% natural gas from 2025 to 2050 provides a cheap and mature option that contributes to a lower abatement target
Total of selected levers		**-127 $MtCO_2e$**	**-386 Mt CO_2e**	**Selected levers account for 67% of total scope 1 emission reductions in 2030 and 72% of total scope 1 reductions in 2050**[1]

[1] Of the reported countries, actual targets vs. 2017 correspond to +0.5% in 2025 and -2.1% in 2030. The only country with a 2050 timeline is South Africa, which has communicated a 34% reduction commitment vs. Business as Usual in 2050

[2] Subject to overall steel adjustments

Source: DSE, IEA, Global Carbon Atlas

BOX 3

Two key abatement technologies with application across all sectors

To reach net zero by 2050, all-out abatement across manufacturing would be required. Two key technologies, carbon capture and storage (sometimes also referred to as carbon capture utilization and storage) and green hydrogen, stand out as having significant potential to drive decarbonization across all sectors.

Carbon capture and storage (CCS)
CCS captures CO2 from large-point sources, including power generation or industrial facilities that use fossil fuels or biomass for fuel, or directly from the atmosphere. Once captured, CO2 can be compressed and transported to be used in a range of applications or stored. The ability to capture CO2 varies depending on the type of source and its characteristics. Importantly, CCS captures emissions rather than displacing carbon fuel sources. It also unlocks many low-carbon product outputs, including low-carbon biofuels, natural gas, green steel, and blue hydrogen.

CCS would compete against other abatement approaches within each industry based on the economics of emission reduction. This is likely to be highly region specific. Globally, more substantial investment incentives and climate targets are building new momentum behind CCS. Plans for at least 40 commercial facilities have been announced in recent years, including the Alberta Carbon Trunk Line in Canada, which started operating in 2020, and the planned Longship project in Norway.[1]

Green hydrogen
Hydrogen is a clean-burning molecule emerging as a leading decarbonization solution in hard-to-abate sectors such as iron and steel, and petroleum refining. A key factor in hydrogen is that when it burns, the only by-product is water, which makes it an appealing zero-emissions energy source—but only if it is produced using renewable energy.

Green hydrogen is produced using renewable energy and electrolysis to split water molecules to extract the hydrogen without producing emissions, and is therefore considered a renewable energy source. It is distinct from grey hydrogen, which is produced from methane and releases GHGs into the atmosphere, and blue hydrogen, which captures those emissions and stores them underground to prevent them from causing climate change. Brown hydrogen is hydrogen produced using coal.

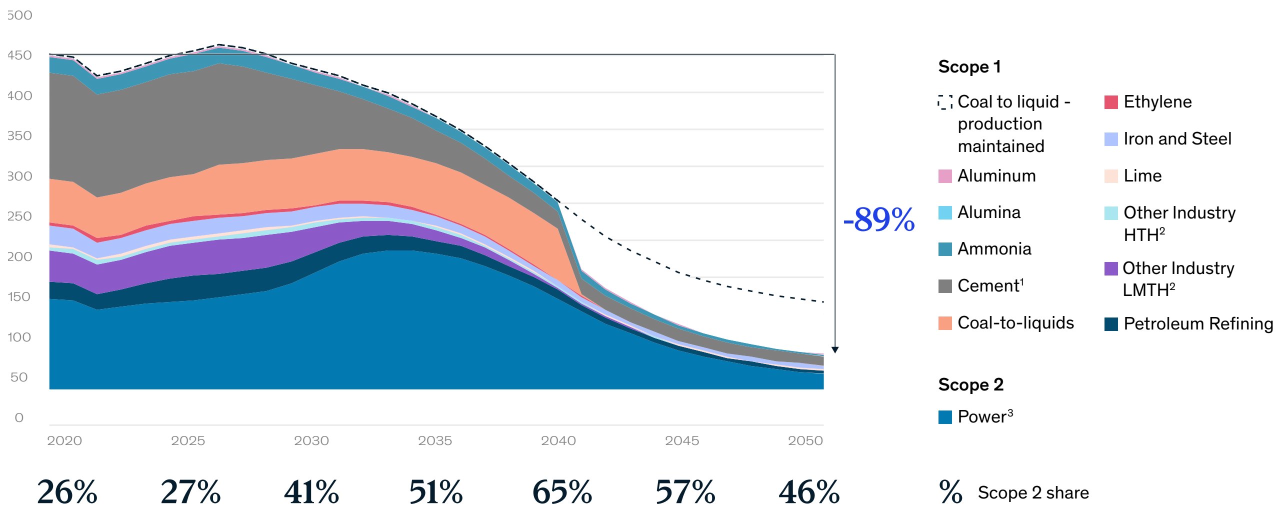
A major advantage of hydrogen technology is that, being a gas, hydrogen can be easily compressed, stored, and transported and, depending on the availability of renewable energy and water, it can also be relatively cost effective to produce. The cost of producing green hydrogen is primed to fall to around $2 per kilogram by 2030, driven by the global market.[2] To take advantage of this, African manufacturing could have an opportunity to invest in delivery infrastructure and stimulate local demand in the short term.

1 International Energy Association website, iea.org.
2 Hydrogen Economy Outlook, BloombergNEF, March 2020, Bloomberg.com.

Exhibit 8

A steep decline in emissions starting in 2030 is needed to reach the net-zero target by 2050

Manufacturing sector scope 1 and 2 emissions in Net Zero, $MtCO_2e$



1 Traditional cement production in commercial and residential buildings would largely be replaced by cross-laminated timber
2 Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors
3 Power shown corresponds to power consumed by the manufacturing sector, not the continent as a whole

Source: DSE

SCENARIO 3: NET ZERO

Demand in line with predictions, with abatement targets aiming for a 1.5°C pathway

About 94 percent abatement of scope 1 and 2 manufacturing emissions relative to the base case and 90 percent from 2018 levels

The net-zero scenario assumes that abatement targets are designed to keep rising temperatures within 1.5°C and that African manufacturing would be using all available levers to cut its scope 1 and 2 emissions by 90 percent by 2050 relative to 2018 emissions. This is equivalent to a 94 percent reduction versus the base case. Residual emissions could be offset by carbon-sequestering actions such as planting trees. These gains would be driven by the aggressive adoption of low-carbon technology and the large-scale electrification of the manufacturing sector, combined with a significant transition to renewables in the power sector on which manufacturing depends. This pathway anticipates emissions amounting to just 47 $MtCO_2e$ by 2050 (Exhibit 8).

In this scenario, an all-out abatement of scope 1 emissions would be required throughout manufacturing-sector industries, along with a significant reduction of demand in specific sectors as low-carbon alternatives become available (Exhibit 9).

Exhibit 9

All-out scope 1 abatement throughout manufacturing sector industries needed to achieve Net Zero

Sector	Key levers	2030 abatement	2050 abatement	Assumptions
Cement	Biomass and CCS	-30 $MtCO_2e$	-86 $MtCO_2e$	Moving from conventional cement production to biomass-fired kilns and CCS in 2050 aggressively decreases carbon emissions
	Clinker replacements	-93 $MtCO_2e$	-134 $MtCO_2e$	Maximally replacing clinkers in cement with low-carbon alternatives (70% energetically modified cement where available, 50% calcined clay elsewhere)
	Demand reduction	-0 $MtCO_2e$	-155 $MtCO_2e$	Reducing demand by 40% in 2050 due to uptake of cross-laminated timber in commercial and residential construction
Ammonia	Carbon capture and storage	-8 $MtCO_2e$	-19 $MtCO_2e$	A 40% share of CCS in ammonia in 2050 is a key driver for reduced carbon emissions
	Hydrogen	-1 $MtCO_2e$	-31 $MtCO_2e$	A 60% share of green hydrogen in ammonia in 2050 would allow further reduction of carbon emissions
Coal-to-liquids	Shutdown and cancellation	-61 $MtCO_2e$	-68 $MtCO_2e$	Shutdown of coal-to-liquids in 2040 (South Africa) and cancellation of new coal-to-liquids projects by 2040 (Botswana)
Refinery	Demand reduction	-3 $MtCO_2e$	-29 $MtCO_2e$	A ~70% reduction in refinery demand would lead to decrease in carbon emissions
Iron and steel[2]	Hydrogen	-2 $MtCO_2e$	-23 $MtCO_2e$	Strongly switching to hydrogen production of virgin-quality steel, reaching 60% of production in 2050
Low- and medium-temperature heat sectors	Electrification	-27 $MtCO_2e$	-66 $MtCO_2e$	Increase in use of electrified heat supply (up to 70% by 2050)
Total of selected levers		**-225 $MtCO_2e$**	**-611 $MtCO_2e$**	**Selected levers account for 91% of total scope 1 reduction in 2030 and 88% of total scope 1 reduction in 2050[1]**

1 Of the reported countries, actual targets vs. 2017 correspond to +0.5% in 2025 and -2.1% in 2030 vs. business as usual. The only country with a 2050 timeline is South Africa, which has communicated a 34% reduction commitment
2 Subject to overall steel adjustments

Source: DSE

The industry with the most significant impact, as in all scenarios, is cement. The move from conventional cement production to the use of biomass-fired kilns and carbon capture and storage could decrease emissions by 86 $MtCO_2e$ versus the base case by 2050, and completely replacing clinkers in cement with low-carbon alternatives such as energetically modified cement and calcined clay could result in a further 135 $MtCO_2e$ reduction in GHG emissions by 2050. Taken together, these abatement efforts in the cement industry could lead to a 91 percent reduction of GHG emissions by 2050 from 2018 levels. Additionally, a 40 percent reduction in demand for traditional cement due to the uptake of cross-laminated timber in commercial and residential construction could lead to a further 155 $MtCO_2e$ abated by 2050.[37]

In the net-zero scenario, several manufacturing industries could achieve a 100 percent reduction in GHG emission by 2050, including aluminum, coal-to-liquids (assuming a shutdown or cancellation of coal-to-liquid plants), and ethylene, along with high-temperature heat industries and low- and medium- temperature heat industries. Coal-to-liquids decarbonization is a key factor in getting to net zero. If production in this industry is maintained with the current technology and feedstock, Africa would reduce its total manufacturing emissions by about 75 percent versus the 90 percent needed to reach net zero.

Important decarbonization levers across the manufacturing sector would include a decisive switch to green hydrogen and biomass beyond 2030 to replace natural gas as a fuel and feedstock in certain chemical and industrial processes. For example, in South Africa, the production of virgin steel via hydrogen direct reduced iron (DRI) could reach 60 percent of production by 2050, saving around 23 $MtCO_2e$, while all other steel production could switch to the Tecnored (biofuel) process, leading to an 81 percent reduction of GHG emissions in that industry by 2050 relative to 2018 levels. A strong decline in refining capacity, specifically for transport fuel, from 2030, driven by a likely shift in demand to electric vehicles, could abate a further 29 $MtCO_2e$, an 84 percent reduction, by 2050.

[37] While cross-laminated timber replaces both cement and steel in the construction process, this report focuses only on its impact on cement emissions.

In this scenario, the power sector would also need to pursue aggressive decarbonization. The electrification of the manufacturing sector, coupled with a comprehensive switch to green sources of power generation, is central to reaching net zero. Scope 2 emissions would be massively reduced in the net-zero scenario compared with the base case, although they would still account for 45 percent of remaining industrial emissions, owing to the persistence of gas-based peak-load generation. It would be necessary to incorporate more flexible storage solutions and to switch from gas-fired generation to green hydrogen generation to reduce scope 2 emissions further.

Is Africa ready to raise its green manufacturing ambition?

Africa's manufacturing sector could reach net zero if certain tough conditions are met. However, this would require very aggressive abatement action, particularly in high-emitting industries. The reality is that a handful of manufacturing industries would determine the success or failure of achieving the required scope 1 reductions of 90 percent by 2050, namely cement, coal-to-liquids, refineries, ammonia, and steel.

We have provided an in-depth analysis of three high-emitting industries—cement, ammonia, and iron and steel—to understand the implications of each of our three scenarios better (see Appendix 4 and Box 4). Refinery and coal-to-liquids are excluded because in the net-zero scenario, demand for most refinery products like petroleum and diesel fuels would fall with the electrification of the transport and manufacturing sectors.[38]

A deep dive into the power sector is also included (Box 5) owing to the central role that this sector plays in a net-zero scenario. Many decarbonization levers rely on green electricity but, even in the net-zero scenario, the African power sector is likely to continue to rely on about 5 percent gas generation by 2050. This is not sufficient to ensure grid stability. New renewable and dispatchable power sources, including green hydrogen and flexible storage solutions, would need to be rolled out on a large scale, starting in 2030, to ensure a reliable power supply.

The fast adoption of low-carbon technologies is a key prerequisite for emissions abatement across the manufacturing sector. However, this is complicated because some of these technologies don't yet exist on an industrial scale. An abatement of about 30 percent is possible from mature technology which is currently available at a commercial and industrial scale. However, about half of the key technology levers for emissions abatement are only in the pilot stages, and 20 percent are still in the R&D stage.[39] The chemical industry, for example, relies heavily on levers that are not yet economically viable, including carbon capture and storage and green hydrogen. However, costs for these technologies are expected to decrease over the next decade.

Reaching abatement goals would therefore require considerable investment both in mature technologies and in R&D to drive the adoption of new technologies, notably in cement, steel, and heat technology. Much of this will happen internationally. Major changes in various dimensions of industry—including the replacement of legacy sectors with new, green sectors—would also be required, which would, in turn, require government and policy support to help incentivize the shift.

These changes will not be easy to navigate, but substantial economic benefits could accrue from Africa joining the clean economy. These are explored in the next chapter.

[38] Our analysis for the coal-to-liquids sector only addresses refined fuels replacement; there are other chemical by-products that would need to be replaced, but these are not addressed here.
[39] Expert interview.

BOX 4

How Africa's biggest emitter can help build a greener economy

Cement has been central to the development of the modern world and is estimated to be the second-most-consumed product globally after potable water.[1] As a result, it is also responsible for a significant portion of global GHG emissions.[2]

By 2030, emissions from cement on the fast-developing continent of Africa could contribute about 35 percent to total manufacturing sector emissions, increasing to 182 MtCO_2e in line with GDP growth in the 2050 base case.[3] Flagged as a major emitter, the cement industry is under more pressure than most to decarbonize, and major global cement companies are starting to commit to net-zero pathways.[4] To help them get there, a combination of technology levers across the entire cement manufacturing process would need to be pulled as soon as possible, along with aggressive promotion of switching to low-carbon alternatives (Exhibit 10). Our analysis has identified several key levers for GHG emissions abatement in the African cement industry over the next decade:

1. **Accelerating the switch to biofuels and driving carbon capture and storage: 86 MtCO_2e saving by 2050**
   Within factories, manufacturers have two main levers to pull to reduce emissions. First, they can replace coal with biomass fuel in heating processes, abating GHG emissions and potentially saving about $5 per ton of clinker. An additional upside is that reduced emissions opens the possibility for manufacturers to participate in carbon trading schemes to sell their remaining emissions share. While biomass technology is mature, with existing industrial-scale projects in operation, it could be challenging to implement because the continent may not be able to grow sufficient crops to produce biofuels sustainably.

   Second, manufacturers can implement industrial-scale carbon capture facilities to capture fuel and process emissions. This approach uses amine-solvent technology to remove CO_2 from flue gas. Typically the most expensive solution and implemented as a last resort, carbon capture and storage is a mature technology with several industrial-scale pilots operating today. It could be a game changer in enabling cement emissions to reach net zero even though this could result in an additional cost of $35 to $70 per ton of cement for at-scale projects.[5]

2. **Developing effective clinker substitutes to avoid emissions altogether: 134 MtCO_2e reduction by 2050**
   Our analysis shows that replacing energy-intensive clinkers with clinker substitutes, such as natural and artificial pozzolans including energetically modified cement and calcined clays, in the manufacture of cement, could achieve an estimated reduction in CO_2 emissions of up to 50 percent compared with the industry standard. Natural pozzolans, including rocks of volcanic origin and some sedimentary clays and shales, occur widely across the continent wherever there are volcanic structures or tectonic intersections

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[1] C.R. Gagg, "Cement and Concrete as an engineering material: an historic appraisal and case study analysis", May 2014, researchgate.net.
[2] Thomas Czigler, Sebastian Reiter, Patrick Schulze, and Ken Somers, "Laying the foundation for zero-carbon cement", McKinsey, May 2020, McKinsey.com.
[3] McKinsey Decarbonization Scenario Explorer (DSE) models.
[4] Science Based Targets initiative (SBTi), sciencebasedtargets.org.
[5] Ibid.

such as the Great Rift Valley, and have the potential to replace up to 70 percent of clinkers used in traditional cement mixtures. Although this technology has been piloted, it has not yet been widely adopted.

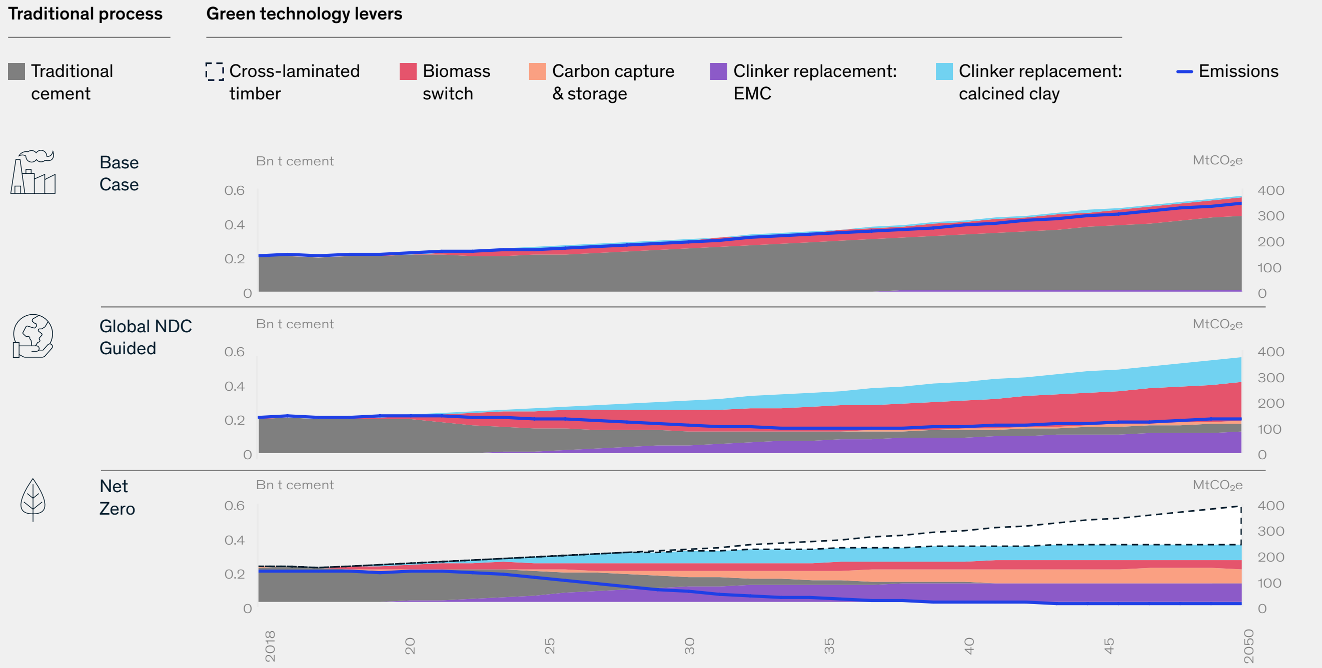
3. **Promoting the switch to cross-laminated timber: 155 $MtCO_2e$ reduction by 2050**
To reach net zero, at least 40 percent of cement demand would need to switch to the greener alternative of cross-laminated timber by 2050. This technology has also been piloted but has not yet been widely adopted. There are some feasibility challenges to consider in the African context, including the need to shift construction regulations and reskill the workforce (see appendix 5). For cross-laminated timber to be a better option for the environment, sufficient water access would also be required, along with a significant investment in sustainable forestry. However, the latter also creates further abatement opportunities through the creation of carbon sinks—natural reservoirs to absorb and store carbon from the atmosphere.

Additional innovative alternatives to cement can also be considered. For example, 14 Trees, an Africa-based initiative, is working to produce low-carbon alternatives to traditional burnt bricks including soil-stabilized bricks and green concrete blocks manufactured using fly ash waste products that would otherwise be discarded into the environment.[6]

Exhibit 10

Biomass and clinker substitutes are key levers with CCS needed to reach the 1.5°C goal

Technology share cement in Bn t p.a. and GHG scope 1 emissions in $MtCO_2e$



Source: DSE, FCDO Development Impact Model, McKinsey EU net zero report

[6] Company website, 14trees.com.

BOX 5

Green manufacturing would need green power

Our modelling suggests that power consumption in Africa's manufacturing sector is likely to double or even triple by 2050, reaching 515 TWh in the base case and 754 TWh in the net-zero scenario. This expansion would inevitably drive up scope 2 emissions, but if it is met with renewable energy, emissions could fall, rather than rise, in the long term.

Growth in power consumption would be driven primarily by the expansion of manufacturing in response to increased consumption by a growing African population. At the same time, a growing trend to replace the use of fossil fuels on site with electricity to drive energy-intensive processes such as smelting is also likely to drive higher demand for power; electrification of manufacturing processes offers the sector its fastest route to decarbonization.

If no decisive action is taken to decarbonize power generation and add significant flexible renewable capacity to the power mix, growth in demand could drive up scope 2 emissions by more than 40 percent relative to 2018 levels, and GHG emissions could reach 171 MtCO2e by 2050. However, if the power sector can shift most of its generation—95 percent—to flexible renewables by 2050, the picture could be vastly different, with emissions falling to just 22 MtCO2e (Exhibit 11). This would be challenging—only around 20 percent of power came from renewable energy sources in 2018—but it is feasible if challenges to grid stability and baseload power are addressed.

A key part of scaling up renewables, mainly solar and wind, to deliver clean energy in the future will depend on solving on-demand distribution challenges. In a growing economy, it is critical that electricity can be dispatched when needed, but wind and solar are intermittent and considered to be non-dispatchable power. To balance the grid, significant investments in additional technologies, including dispatchable renewables such as hydro and geothermal, battery storage solutions, and green hydrogen would be required.

Two principal actions could help ensure that Africa's power sector reaches these targets:

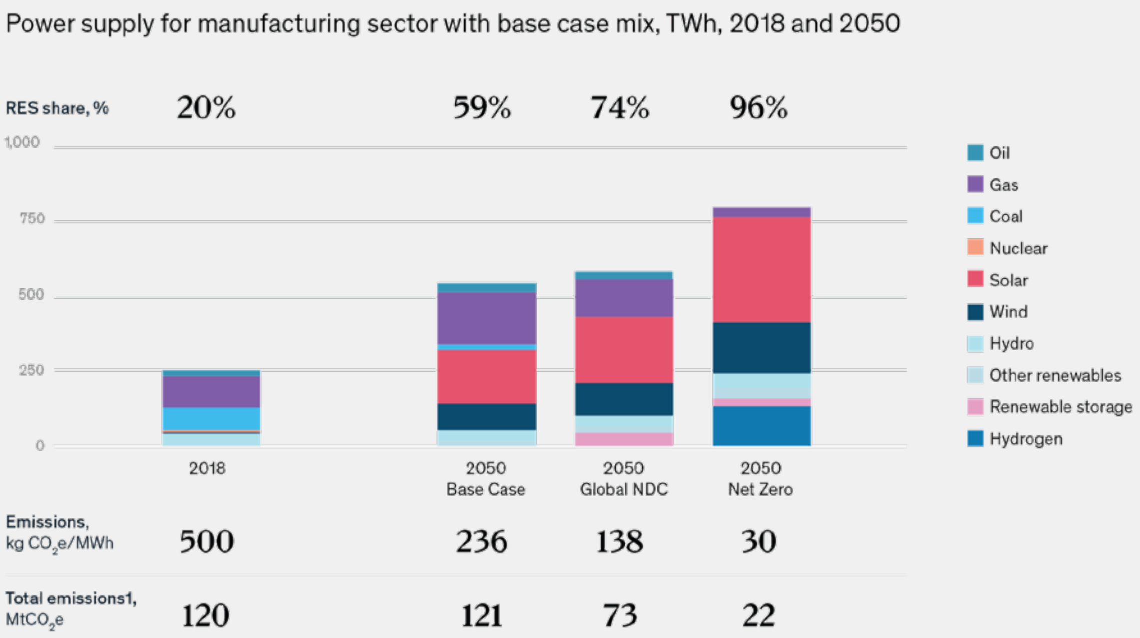
1. **Deploy mature renewables such as wind and solar at scale**
   The full cost of renewable energy sources is already below the marginal cost of gas generation in some regions and is dropping rapidly everywhere, even in countries where the cost of gas is still lower than renewables.[1] Significant financing would need to be mobilized to scale up renewable capacity installations by about 70 percent, in line with the net-zero scenario. Another important step is to engage in discussions with policy makers around developing appropriate incentives for implementing renewable solutions.

2. **Build flexible power**
   Additional clean dispatchable power generation would be needed to balance intermittent sources and R&D efforts to develop viable large-scale green hydrogen and battery storage technology could be intensified so that these technologies are ready to deploy as soon as possible. To achieve net zero, both technologies would need to become competitive by 2030 to 2035.

[1] "Renewable power generation costs", International Renewable Energy Agency (IRENA).

Exhibit 11

To reach net zero, 95% of generation would need to shift to renewables such as wind and solar



[1] Total manufacturing emissions from power

Source: DSE

However, until hydrogen and battery technologies are available at scale, it may be necessary to continue to build gas generation capacity. New gas plants may need to be constructed in the next 10 years to satisfy an increasing demand for dispatchable power. An unsolved question here is how to finance gas capacity that will run at much lower loads than previous plants and potentially have shorter time horizons, as new technologies emerge. To ease the transition, it could be important to ensure that new gas plants are planned to have fuel-switch flexibility built in so that they can be easily converted into hydrogen generation plants.

Additionally, it may be necessary to expand carbon-free dispatchable capacity where possible, notably hydro and geothermal energy sources, to help ensure power stability.

Chapter 3

The costs and economic implications of decarbonization in Africa

Decarbonizing Africa's manufacturing and power sectors and building new green assets are likely to have profound economic implications for the continent, not least of which is that a net-zero pathway would ensure that African manufacturing can grow and create jobs without adding emissions and remain globally competitive. However, this pathway has significant costs. Reaching net zero could require $2 trillion of additional investments in manufacturing and power over the next three decades to decarbonize the existing asset base and develop new assets as the sector grows in line with population growth.

Our analysis indicates that about $600 billion would be needed to decarbonize existing sectors and $1.4 trillion to invest in the development of new green businesses. In the process, shifting demand patterns could lead to job losses in legacy sectors such as coal-to-liquids and cement. However, new opportunities and industries also have the potential to create around six million new jobs while helping to build a more resilient and sustainable future for the continent (Exhibit 12).

Managing this transition to a low-carbon future may well be one of the continent's major challenges in the next 30 years and needs to be approached in a way that leaves no one behind. A 'just transition' of African manufacturing would need to ensure that environmental sustainability is achieved alongside the creation of quality jobs and living conditions for workers and their communities, with the goal of building a more inclusive economy and eradicating poverty.[40]

Investments in technology to decarbonize Africa's manufacturing and power sectors are likely to pay off over time

Large upfront investment is required to set Africa's manufacturing and power sectors on a path to net zero, but these are likely partially to pay off in reduced operational costs over time. African manufacturing is anticipated to double in size over the next three decades in line with population growth and increased demand for locally-produced goods, so the continent stands to accrue significant benefits from these investments. This contrasts with manufacturing in other regions, notably Europe, where growth was on a downward trend, even before the impact of COVID-19.[41]

Our analysis shows that capital expenditure (CAPEX) in manufacturing and power will likely double by 2050 in the net-zero scenario versus the base case, the majority of which would be needed in the power sector. While investments in renewable energy sources, notably hydrogen, wind, and solar, would be a priority, it would also be important to invest in carbon capture and storage at petroleum refineries that will not be closed in the electrification of boilers in the low- and mid-temperature heat industries, and in low-carbon steel and ammonia production (Exhibit 13).

Exhibit 12

A Net-Zero decarbonization path would require significant investments in manufacturing and power and will likely result in labor shifts to new businesses

	Required investment 2021-2050 in Base Case and Net Zero, $ Bn[1]			**2050 jobs, Mn**
	Base Case	**Additional investment**	**Net Zero**	
Manufacturing (legacy) and power[2]	2 150	+ 590	2 740	- 2.2
New substitution manufacturing sectors[3]	0	+ 1 400	1 400	+ 6
Total	2 150	+ 1 990	4 140	+ 3.8

1 Based on 2019 US dollar value
2 Power sector shown corresponds to share of power generation consumed by manufacturing sector
3 Cross-laminated timber to substitute cement and electric vehicle charging infrastructure to substitute refining and coal to liquids

Source: DSE, FCDO Development Impact Model, McKinsey EU Net-Zero report

40 "Just Transition, a report for the OECD", Just Transition Centre, 2017, oecd.org.
41 "World Manufacturing Production: Statistics for Quarter 1 2021", United Nations Development Organization, March 2021, unido.org.

Exhibit 13

Manufacturing and power investments would need to double by 2050 to reach net-zero targets, adding a $2 trillion capital need

Total CAPEX in the Base Case and in Net Zero by subsector 2021 – 2050, $ Bn[1]

Manufacturing

New substitution businesses

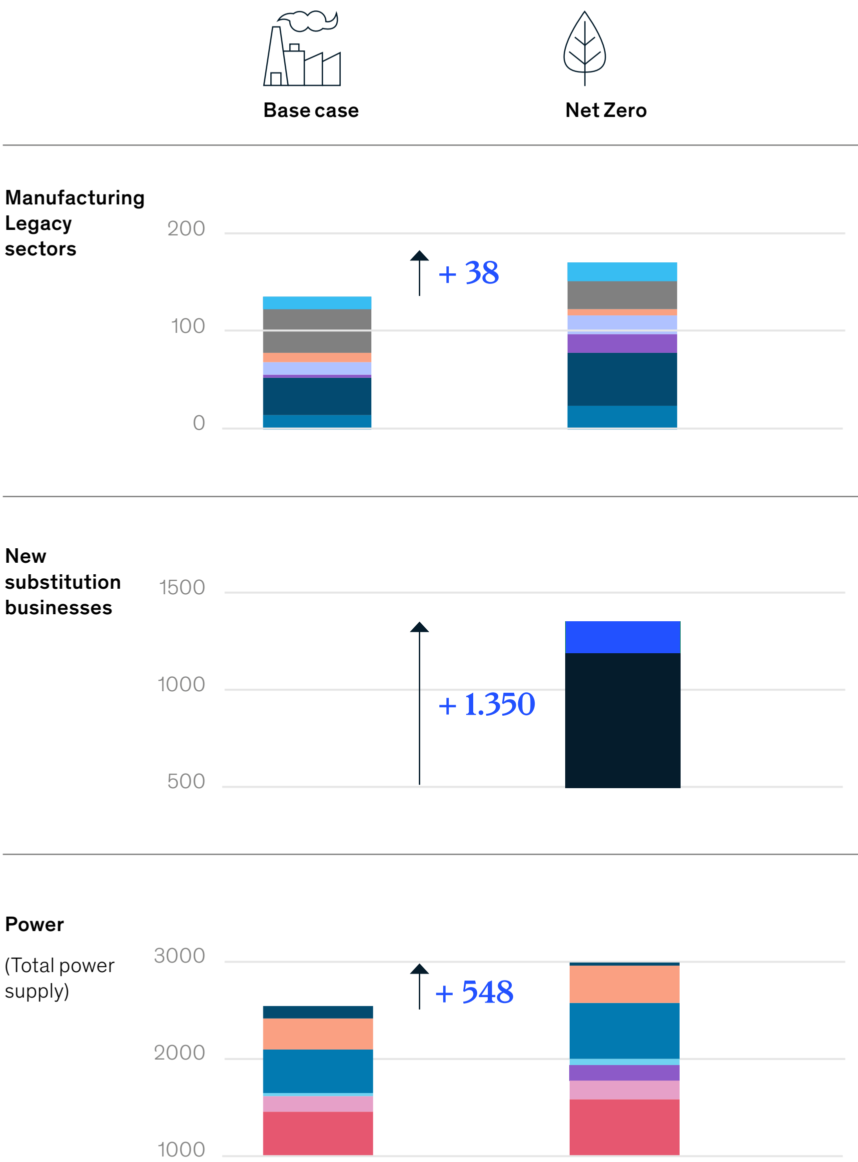
- EV charging infrastructure
- Cross laminated timber

Legacy sectors

- Ammonia
- Cement
- Coal-to-liquids
- Iron and Steel
- Other Industry, Low-Mid-Temperature Heat
- Petroleum Refining
- Other[2]

Power

- Fossil[3]
- Solar
- Distribution
- Wind
- Other RES[4]
- Hydrogen
- Transport



Main changes

Manufacturing Legacy sectors:

- Higher investment in carbon capture and storage for refineries that won't be later closed, electrification of boilers for LMTH, and low-carbon steel and ammonia production
- Lower CAPEX in cement (calcined clay and activated pozzolans) and coal-to-liquids (shutdown of plants)

Power:

- Higher investments in renewable energy sources: hydrogen, wind and solar
- Lower investments in fossil energy

~$2 Tn of additional CAPEX would be required across manufacturing and power to achieve the net-zero ambition

[1] Based on 2019 US dollar value
[2] Includes lime, ethylene, alumina, aluminum and high-temperature heat
[3] Includes gas and oil (majority of gas)
[4] Includes hydro, geothermal, renewable storage and other (Biomass, CSP)

Source: DSE

To assess the economic implications of abatement, we have compared the total cost of the new technologies required against the total cost of the base technology that would otherwise be used, anticipating that old assets would be retired as new ones are built and that newer technologies will become more efficient and less carbon-intensive over time. Assuming a carbon price of zero, around 50 percent of abatement levers would be NPV positive by 2030 without any additional supporting mechanisms, and in a high-emitting industry such as cement, this climbs to 75 percent (Exhibit 14). To capture the other 50 percent, significant shifts in consumer behavior to choose greener alternatives would be needed. This could be achieved through a combination of education and awareness campaigns to promote greener alternatives but would likely also require policy support, with regulations to incentivize switching. For example, government regulation has been shown to play a significant role in driving the uptake of electric two-wheelers in India (see Box 10).

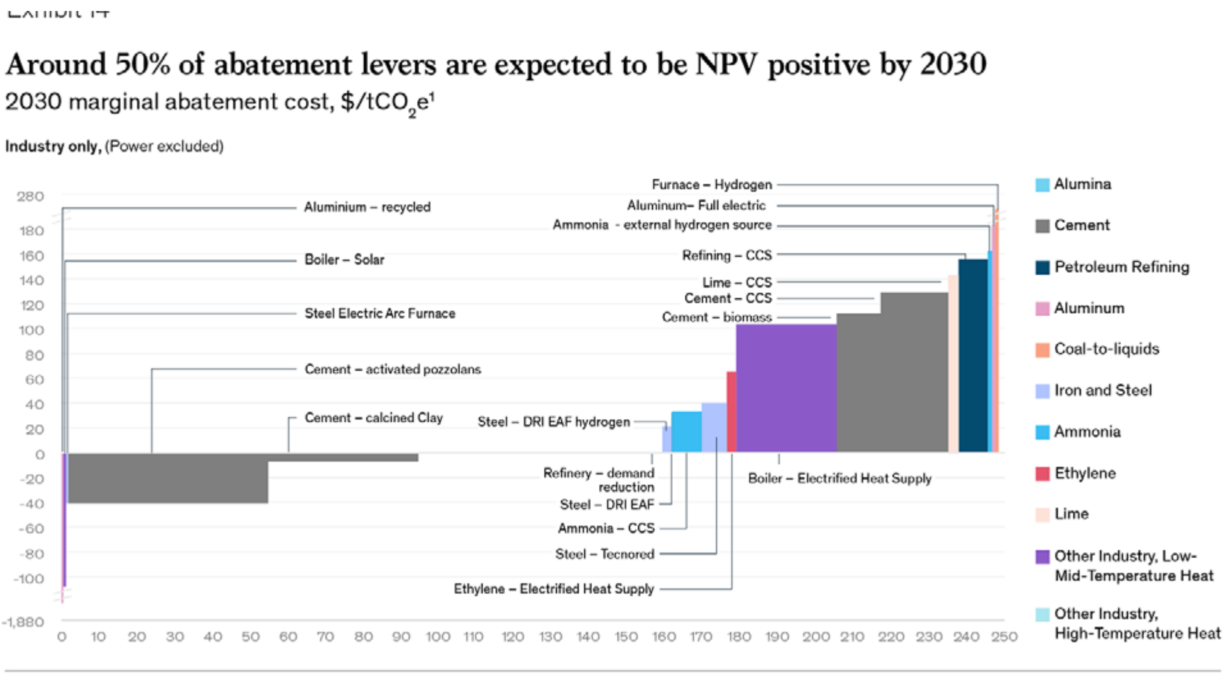
If the carbon price is increased in line with global projections for a carbon emissions trading system to \$50 per ton of CO_2e, then about 60 percent of investments would be NPV positive by 2030 without additional supporting mechanisms.[42] This is realistic because as global urgency to achieve emissions abatement mounts, the cost of carbon is likely to increase.[43]

In some sectors, notably cement and coal-to-liquids, CAPEX requirements are lower in the net-zero scenario than the base case owing to a demand switch from one industrial process to another. Thus, while industry-specific CAPEX may fall, the net CAPEX would rise.

[42] Many governments have adopted carbon pricing initiatives such as carbon taxes or emissions trading systems (ETS) as effective market-based instruments to reduce emissions. For carbon taxes, the regulator sets a fixed unit price per ton of CO_2e emitted (overall or for a sector). Polluters then simply have to pay for each ton emitted. For ETS, the regulator sets a fixed limit for the amount of CO_2e to be emitted, sometimes called a 'cap' (overall or for a sector). They then issue the respective number of emissions allowances (or certificates) to firms either directly or through auctions. One allowance typically grants the right to emit one ton of CO_2e.

[43] The Report of the High-Level Commission on Carbon Prices (2017) published by the International Bank for Reconstruction and Development and International Development Association / The World Bank, estimated that the appropriate carbon price across the world would need to be US\$40–80/tCO_2e by 2020, and US\$50–100/tCO_2e by 2030, to be consistent with meeting the goals of the Paris Agreement.

Exhibit 14



[1]Based on 2019 dollar value

Source: DSE, Ember Climate Energy Think Tank

For example, applying the technology shifts needed to decarbonize the cement industry would require a CAPEX of $12 billion between 2021 and 2030 under the base case and $15 billion under the net-zero case. Between 2030 and 2050, however, these costs rise to $37 billion for the base case but just $17 billion in the net-zero case. The lower investment in cement manufacturing by 2050 under the net-zero scenario would be driven by an expected demand switch to cross-laminated timber of 40 percent. However, these savings would be balanced by investments in alternative building materials and processes. For example, around $250 billion may need to be invested by 2050 in forestry and wood-products industries to support the emerging cross-laminated timber industry.

A similar pattern is likely to be seen in the electrification of mobility. As people shift towards using electric vehicles, there would be a slowdown in demand for refined products leading to the shutdown of coal-to-liquid complexes and reduced investment in refinery. However, an additional investment of around $1,100 billion would be required throughout the transportation sector by 2050 to support the transition to greener mobility, notably in electric vehicle charging infrastructure. Some of these investments would directly impact the manufacturing and power sectors, for example the installation of charging stations and the generation of additional power required by electric vehicles.

The high investment required to support industry switches is partially because these are not one-to-one replacements; cross-laminated timber replaces the concrete part of the value chain, and chargers displace gas stations.[44]

[44] The modelling in this report only considers the investment required for two new green businesses: cross-laminated timber and the manufacture of electric two-wheelers. To fully decarbonize, the continent would likely need to invest beyond these in other key industries such as infrastructure to transport green hydrogen.

A net-zero pathway could create about 6 million new jobs in Africa

If African manufacturing can take advantage of the opportunities presented by decarbonization, a significant upside is that this will likely lead to the creation of 6 million new jobs—both in the manufacturing and power sectors and beyond. While about 2.2 million jobs could be lost as old technology, such as cement and refinery, is displaced, overall job gains are substantial. In the net-zero scenario, a net gain of 3.8 million jobs is possible by 2050 (see Appendix 2 on methodology for detailed calculations). New jobs growth would be fueled predominantly by growth in new green businesses, increased complexity in certain processes, and investments in renewable power—mainly hydrogen, solar, and wind (Exhibit 15).

For example, 1.4 million jobs could be lost as cement demand falls, while 3 million new jobs in forestry and woodwork could be created in the cross-laminated timber industry. Electric vehicle charging stations and increased power demand could create up to 3 million jobs to replace an estimated 1.5 million jobs lost due to demand switching and shutdowns in coal-to-liquids and refinery.

Most job gains (just under 70 percent) and losses (just over 70 percent) would be in indirect or induced jobs and fall outside of the power and manufacturing sectors. A switch to green manufacturing would thus benefit the environment and create new jobs right along the supply chain.

Two caveats are crucial. First, a large share of new jobs would be coming from new businesses that do not yet exist in Africa; it is key to capture this value inside Africa rather than importing these products and risk a net loss of jobs. For example, East African electric motorcycle start-up, Ampersand, has grown into a leading electric vehicle operation in the region, with a team of almost 50 people in just three years. The business leases or sells purpose-built electric two-wheelers

Exhibit 15

Renewable power would be the major job-creating sector while demand reduction would result in job losses in refinery and cement

Total job gains or losses by sector, Base Case vs. Net Zero, Thousands

Manufacturing		2030	2050
New green business	EV Charging infrastructure		+3,000
	Cross laminated timber		+3,000
Legacy	Alumina	-	-
	Aluminium	+50	+20
	Ammonia	+10	+5
	Cement	+55	-1,500
	Coal to liquid	+30	-50
	Ethylene	+20	+70
	Iron and Steel	+15	+35
	Lime	+10	+35
	Petroleum Refining	-100	-1,500

Power		2030	2050
Renewables	Solar	-50	+350
	Wind	+125	+175
	Hydro	+20	+25
	Battery	-	+20
	Hydrogen	-	+35
	Other Renewables	+40	+10
Legacy	Nuclear power	+1	-1
	Gas power	-3	-30
	Coal power	-2,5	-5
	Diesel generators	-1	-13

Source: DSE, FCDO Development Impact Model, McKinsey EU Net-Zero report

to motorcycle taxi drivers in East Africa and all motorcycles and batteries are assembled on site.[45] This is helping to ensure that the next generation of African developers and engineers, who can lead the way with new technologies, are being nurtured in Africa. At the same time, the company has helped reduce emissions and increase incomes for drivers—as battery swaps are faster and more cost effective than refueling with petrol.[46]

Second, the job losses and gains would not be spread evenly across countries. For example, countries that are more cement intensive in their manufacturing could suffer disproportionately, while those that can plant trees and manufacture cross-laminated timber could benefit. In managing the transition, all stakeholders, starting with African governments, have a duty to safeguard workers and communities. The 'just transition' practices enshrined in the Paris Agreement, some of which are explored in Chapter 5, could be useful here (see Box 6 for case studies on how Kenya and Nigeria are approaching this issue).

[45] Company website, www.ampersand.solar.
[46] Ibid.

BOX 6: COUNTRY FOCUS

Kenya: A chance to capitalize on its green momentum

Kenya may have a head start in Africa's race to net zero. With existing commitments to reduce GHG emissions by 32 percent by 2030, and 90 percent of its energy already coming from renewable resources, the country has a significant opportunity to build on this momentum to become a leader in the green economy.[1]

In many respects, Kenya's path to decarbonization is tied to its cement industry and the technology choices it makes now. Cement production in Kenya has more than doubled over the past 12 years, helping to push its share of African manufacturing emissions to 5 $MtCO_2e$ in 2018—4.3 $MtCO_2e$ of which were from cement. And because cement is a key factor in developing economies, further growth in this sector is inevitable. In the base case, if Kenya sticks to its existing abatement commitments without implementing any additional measures, it could expect emissions to grow exponentially by 315 percent, taking Kenya's overall output to just over 20 $MtCO_2e$ by 2050. Most of this growth would come

1 "Renewables hit 90% of Kenyan power with new 50 MW solar plant", Reuters, December 13, 201, reuters.com.

from cement. By contrast, a net-zero path—involving decisive abatement efforts such as the implementation of carbon capture and storage and the use of activated pozzolans as a clinker replacement in the cement industry—could cut emissions by 77 percent, dropping Kenya's overall emissions to below 2 $MtCO_2e$ by 2050 (Exhibit 16).

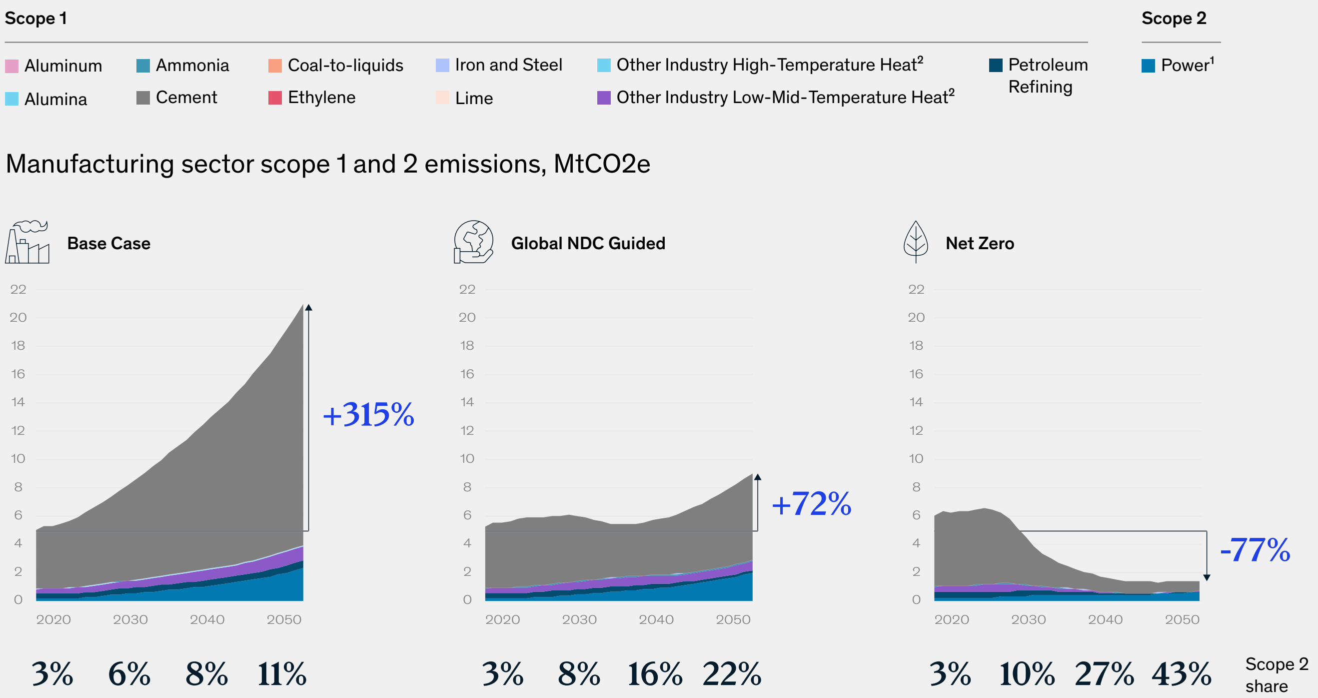
Electricity demand, and therefore scope 2 emissions, are also expected to grow by a factor of 10. The power demand for the manufacturing sector was just 3 TWh in 2018 but is expected to grow to around 25 TWh by 2050 as manufacturing activity booms. The bulk of this growth would be driven by growth in cement and the high-temperature heat and low- and medium-temperature heat sectors, but electrification and the use of green hydrogen and carbon capture and storage would add a further 3 TWh of demand by 2050.

Kenya's green power advantage would be decisive here. The country already has one of the highest shares of renewable energy sources in Africa, powered largely by geothermal development in the 2,000-mile-long volcanic Rift Valley. The levelized cost of energy for geothermal in the Rift Valley is three times lower than coal in Kenya, and in 2018, this energy source made up 43 percent of the total installed capacity in the country. Hydro (23 percent) and wind (12 percent) make up the balance of renewable energy sources, with oil and gas contributing just 13 percent to installed capacity.[2]

Kenya has a significant opportunity to capitalize on this advantage and grow its portion of renewable energy sources to 100 percent—with solar offering the most promise here. This would put it in a favorable position to build out its manufacturing sector around green opportunities

Exhibit 16

Kenya could expect high emission growth compared to other African countries in the base case



1 Power shown corresponds to power consumed by the manufacturing sector, not the continent as a whole
2 Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors

Source: DSE

2 "Africa 2030: Roadmap for a Renewable Energy Future", International Renewable Energy Agency, 2015, irena.org.

such as electric mobility, agricultural technology, clean energy, and the circular economy, with opportunities for recycling in plastics, textiles, and organic waste. "For example, reliable, affordable, high quality, and sustainable fertilizers can be locally produced from waste with a major positive ecological impact across the value chain," says Ani Vallabhaneni, Co-Founder of Kenyan sanitation start-up Sanergy. These high-potential opportunities could be worth between $2 to $4 billion in annual revenue by 2030, helping to attract new investment and creating new jobs.

Already, Kenya has a vibrant start-up culture and innovation ecosystem in the green space. For example, Ecodudu, an innovative waste-to-value company operating in Kenya's animal feed and agricultural inputs value chains, produces highly nutritious insect-based animal feeds and organic fertilizers.[3] Another start-up, Vuma Biofuels, is producing a clean biomass energy product made from discarded sugarcane husks.[4] Additionally, several significant green investments in recent years signal that Kenya is well placed to develop green financing mechanisms and attract green FDI to boost green growth.

Two noteworthy examples include Acorn, a property developer that raised Kenya's first green bond of $40 million on the Nairobi Stock Exchange in 2019, marking an important milestone for the capital markets in Kenya and the region,[5] and Komaza, a pioneer in smallholder tree plantation and wood processing. Komaza secured $28 million of the company's planned $33 million Series B equity financing in early 2020, taking it a step closer to reaching its goal of planting one billion trees by 2030, benefiting more than two million farmers in sub-Saharan Africa.[6]

To add further impetus to these initiatives, the Kenyan government could consider setting up a green steering committee to guide priority industries strategically and lay out the roadmap to help realize these opportunities. This could include assigning private sector sponsors for each sector and collaborating with relevant ministries to identify appropriate initiative owners. With a clear strategy and accompanying incentives, Kenya can be a leader in green manufacturing on the continent, setting the pace for others to follow.

Reliable, affordable, high quality, and sustainable fertilizers can be locally produced from waste with a major positive ecological impact across the value chain.

Ani Vallabhaneni, Co-Founder of Kenyan sanitation start-up Sanergy

3 Company website, ecodudu.com.
4 Company website, vumabiofuels.com.
5 "First Green Bond from Kenya: Acorn $40m - Climate Bonds Certified, financing green buildings", Climate Bonds Initiative, October 2, 2019, climatebonds.net.
6 "Komaza Raises $28M Series B to Capture Africa's $30B Wood Deficit While Restoring Degraded Lands", July 14, 2020, businesswire.com.

Nigeria: Building strength in new, high-potential green industries

As one of Africa's big four emitters and with some key resource disadvantages, Nigeria has a potentially challenging road ahead to reach net zero, but a focus on new green industries could help ensure an overall positive job balance from decarbonization.

Our analysis ranks Nigeria as Africa's fourth-biggest emitter with a manufacturing emissions baseline of 31 $MtCO_2e$ in 2018. Cement is the highest contributor to this, with just under half (15 $MtCO_2e$) of all emissions coming from this sector in 2018. Other key contributors are refinery (although all capacity is currently shut down for an overhaul), low- and medium-temperature heat sectors, and ammonia, Nigeria being one of only five significant ammonia producers in Africa.

Steady growth in these key sectors would continue to drive up emissions unless abatement actions are taken. In the refinery sector, the Dangote refinery is set to come back online in 2022, increasing African refinery capacity by 650,000 barrels a day. Meanwhile, ammonia production is set to ramp up as Moroccan fertilizer group OCP launches its new Nigerian ammonia fertilizer plant in 2023.[7] Without decisive abatement action, emissions will likely grow by 142 percent in the

[7] "Morocco's OCP sees Nigeria ammonia plant starting up in 2023", November 14, 2019, reuters.com.

base case, reaching 75 $MtCO_2e$ in 2050. A path that follows the NDC-guided scenario would see emissions grow by just 43 percent to around 45 $MtCO_2e$, while a net-zero path would succeed in cutting emissions by 77 percent to just under 10 $MtCO_2e$ (Exhibit 17).

A key abatement lever available to Nigeria, as in other countries, is carbon capture and storage; possibly used in combination with sustainable biomass or waste as fuel, this technology would be essential in reducing emissions in the cement industry. The use of calcined clay as a clinker replacement would also be key in that industry, although this only allows replacement up to 50 percent and requires some fuel in production. Nigeria does not have reserves of natural pozzolans, which are the most attractive abatement lever for cement.

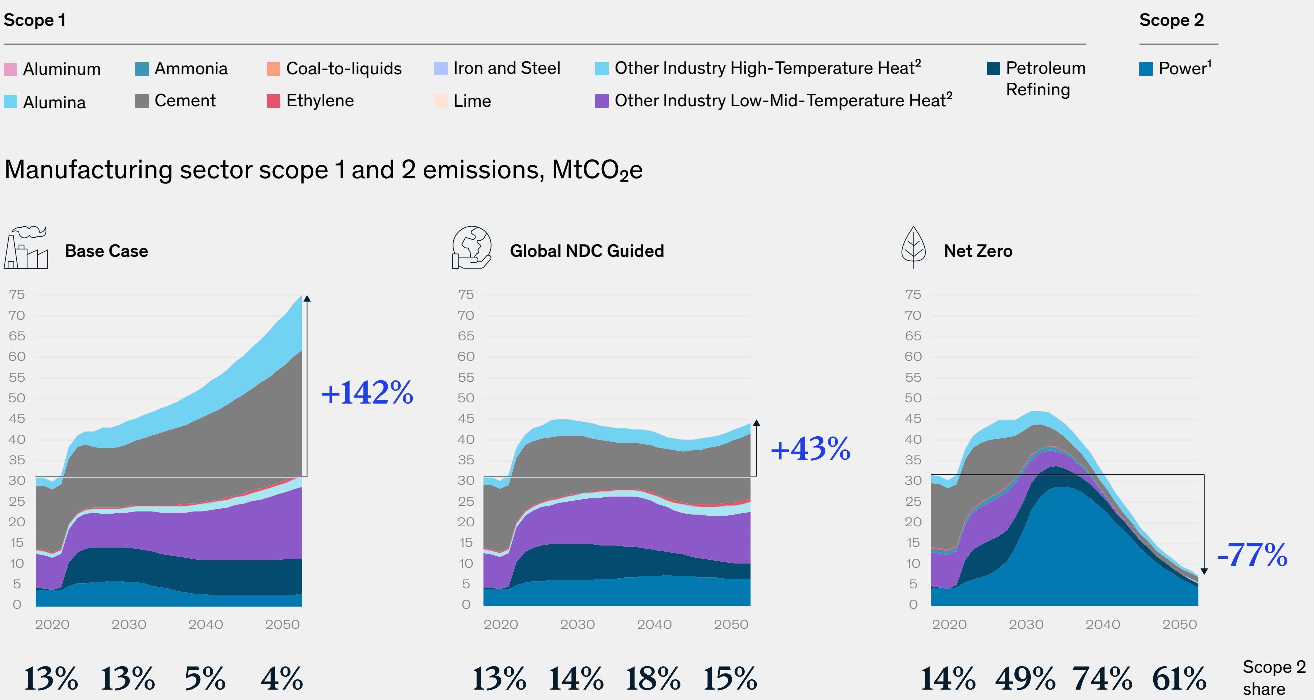
The ammonia industry would also rely on carbon capture and storage as one of two key decarbonization levers, while green hydrogen would be the second key lever in this sector. In refinery, aside from carbon capture and storage, a reduction in demand for refined products of around 75 percent by 2050 would be required to reach net zero.

It would be crucial, too, for Nigeria's power sector to make a decisive shift towards cleaner energy to support the green transition. As the sector grows and electrifies, the manufacturing sector's demand for power would grow considerably in a decarbonization scenario due to the growth of the economy, industrial electrification, green hydrogen use, and carbon capture and storage. Further demand would be added as home-based diesel generators—currently playing a large role in supplementing public generation in the country—are replaced with grid electricity.

Even without the added effort of decarbonization, Nigeria's transmission and distribution

Exhibit 17

Steady growth in key sectors could drive up emissions in Nigeria



[1] Power shown corresponds to power consumed by the manufacturing sector, not the continent as a whole

[2] Low- and medium- or high-temperature heat (LMTH) summarizes heat-related emissions from several sectors where heat production is the key source of scope 1 emissions including: Machinery, transport equipment, food and beverages, textiles and leather, and wood and wood products. High-temperature heat (HTH) includes paper, pulp and print, and part of other industry (including plastics) and is only used in the first five sectors

Source: DSE

infrastructure is facing challenges. About 80 percent of public power generation stems from gas, and a lack of access to electricity means that high-emission, oil-fired backup generators currently account for 35 percent of power generation in the country. Backup generators are expected to decrease to zero before 2050 as the country invests significantly in its power grid to bring down emissions. Still, gas would likely remain an important power source for the future, although there may also need to be a shift towards solar.

Here, too, Nigeria may be at a resource disadvantage. The conditions for key renewables, solar and wind, are not ideal, leading to higher prices for renewable energy sources compared with North Africa (60 percent higher) and South Africa (30 percent higher). Nevertheless, start-ups such as Auxano—the first privately owned solar photovoltaic manufacturing company in Nigeria—and Nayo Tropical Technology have been active for several years, providing solar inverter solutions and manufacturing solar panels and other components for mini-grids and solar home systems respectively.[8] The higher levelized cost of energy for renewables is also expected to drive up the hydrogen price in Nigeria. This would particularly impact ammonia production, where green hydrogen is a key abatement lever and which, at around $80 per ton of CO_2 to produce, would be more expensive than in other parts of Africa.

In traditional industries, any job gains from electrification would be balanced by large losses in the refinery and cement sectors. In Nigeria, where these sectors play a larger role than most other countries, net losses could amount to 90,000 jobs by 2050, with few options available to balance those losses with job gains in substitution businesses. A lack of forestry land makes it unlikely that Nigeria would gain jobs from new green business opportunities in cross-laminated timber, for example. However, there may be opportunities to grow new high-potential businesses such as assembling electric two-wheelers or bioethanol production, given Nigeria's large and rapidly urbanizing population. Our analysis indicates that the potential market opportunity for assembling electric two-wheelers in Nigeria could be worth between $90 and $140 million by 2030, assuming a 1 percent penetration rate for the vehicles.

As Nigeria progresses on its decarbonization journey, stakeholders, including government, corporates, investors, international organizations, and civil society, could work together to overcome its resource disadvantages and support the shift to a greener economy, with a particular focus on green transportation. Even in the most challenging of circumstances, the opportunities to grow green exist.

The potential market opportunity for assembling electric two-wheelers in Nigeria could be worth between $90 and $140 million by 2030, assuming a 1 percent penetration rate for the vehicles.

[8] Company websites, nayotechnology.com and auxanosolar.com.

Chapter 4

Exploring Africa's new green prospects: What businesses could entrepreneurs build now?

8 high-potential **new green business opportunities** identified

700,000 **jobs created** by 2030

up to **2** **billion** per year in revenue in 2030 for new green businesses

This report has thus far looked at the decarbonization of Africa's manufacturing sector in the aggregate and mapped out three possible pathways to 2050, but there are also clear and concrete actions that could be taken in the near term to move Africa towards net zero. Specifically, the rapid uptake of new green manufacturing opportunities can transform Africa's economy and society, create new jobs, produce new products that are less carbon-intensive, and embrace new low-emitting production processes that help reduce GHG emissions and support green growth.

Many of these businesses may create the impetus to decarbonize the manufacturing sector and adjacent sectors, notably agriculture and power. As the world embraces a low-carbon future, these business opportunities will likely become more and more viable. This chapter explores where these opportunities may lie and how to unlock them.

African entrepreneurs could act now to capture new, game-changing business opportunities. Our analysis has identified 24 new business opportunities across several sectors, including agriculture, biofuels, basic materials, energy, packaging and plastics, transportation, textiles and apparel, and recycling—each having substantial potential for green growth and stimulating commercial activity across the economy (Exhibit 18). These opportunities offer African entrepreneurs and financiers exciting prospects. Those who act fast to take advantage of them could likely benefit the most from Africa's unique resource advantage, including its range of natural resources, solid renewable energy capabilities, and a significant amount of uncultivated or under-cultivated arable land.

For example, Africa has an estimated 60 percent of the world's uncultivated arable land.[47] Agnes Kalibata, President of AGRA (Alliance for a Green Revolution in Africa), points out that this makes agricultural-based technologies such as plant-based protein, cross-laminated timber, and biofuels particularly appealing on the African continent. "Agriculture-based technologies may offer solutions for Africa's low-carbon growth agenda. These will not only help abate GHG emissions but can also help increase farmers' incomes and create new jobs," she says.

Africa's potential for renewable energy could also drive the development of new green businesses. Michael Turner from Actis says: "Plentiful green energy [on the continent] will be a critical enabler of the development of green-accredited assets in Africa such as green-by-design real estate development and green buildings that can make the continent a safer and healthier place to live and work."

Of the 24 businesses we identified, eight stand out as offering significant promise on three key dimensions: their market potential for 2030; their probable environmental impacts, both in terms of GHG emissions abatement and other sustainability factors such as water use and pollution; and their near-term feasibility, particularly with regards to technology readiness. Our analysis looked at whether the technology needed to drive the industry had already been developed and deployed in Africa and if the infrastructure and other required environments were readily available or not. The cost to set up each industrial unit and the availability of the necessary skills and human resources were also assessed (Exhibit 19).

Agriculture-based technologies (e.g., plant-based protein, cross-laminated timber, biofuels) offer many solutions for Africa's low-carbon growth agenda. These new technologies will not only help abate GHG emissions but can also help increase farmers' incomes and create new jobs.

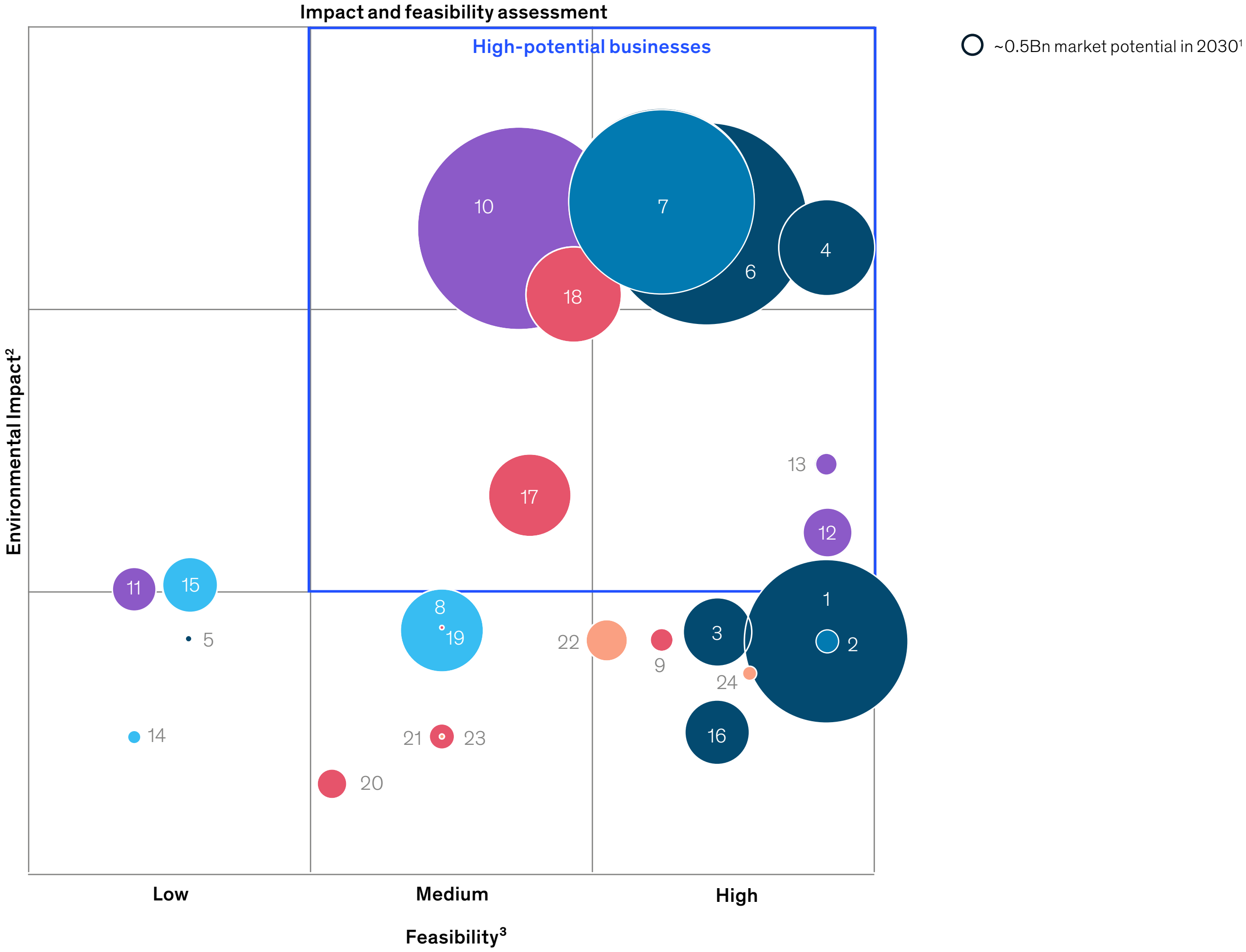
Agnes Kalibata, President of AGRA

[47] Wim Plaizier, "2 truths about African agriculture", January 2016, World Economic Forum Agenda, weforum.org

Exhibit 18

Eight out of 24 new green business opportunities have potential for high impact by 2030

Impact and feasibility assessment



Agro-processing

1. Convert waste into black soldier fly animal feed (or other insect proteins)
3. Manufacture biological crop protectors such as bioherbicides, biofungicides and bioinsecticides
4. Manufacture plant-based protein
5. Manufacture cultured meat
6. Produce bioethanol as a low-carbon fuel alternative for transportation and cooking (replacement of firewood and charcoal)
16. Produce bioplastic using agricultural products

Power

10. Manufacture parts for wind turbines (primarily turbine towers)
11. Manufacture solar panels
12. Assemble off-grid solar systems (e.g., solar home systems, water pumps) for local markets
13. Assemble micro-grids for local markets

Forestry products manufacturing

2. Manufacture high-end cosmetic creams using forest friendly natural products
7. Manufacture cross-laminated timber (or other alternatives to cement)

Transportation

17. Assemble (with future potential to manufacture) electric vehicles for personal and commercial uses
18. Assemble (with future potential to manufacture) electric motorbikes and other two/three wheelers
19. Assemble (with future potential to manufacture) electric fishing boats
20. Manufacture storage inputs (batteries and fuel cells) for electric vehicles and boats
21. Manufacture charging facilities (and local infrastructure) for electric vehicles

Basic materials

8. Manufacture direct reduced iron (DRI) using hydrogen or biomass fuel for export markets
9. Manufacture insulated glass using hydrogen fuel furnaces
14. Manufacture electrolyser for green hydrogen production
15. Production of green hydrogen for local (substitute fossil fuel for transportation) and export (ammonia) markets

Textiles

22. Set up mechanical recycling plant to recycle PET flakes into polyester fibres
23. Set up an "early-mover" hydrothermal plant to recycle polycotton into polyester and cellulose powder
24. Manufacture textiles from alternative fibres (e.g., fruit, vegetable, hemp)

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1. Market potential = African market captured by local manufacturers + export outside of Africa
2. 70% weight is given for CO_2e emission reduction potential of new businesses, and the remaining 30% weight is given to other environmental impacts
3. Equal weight is given for all the feasibility assessment dimensions: capital intensity, human resource and technological capability and infrastructure and other considerations

Source: Expert interviews, interviews with manufacturers, internal and external reports, press scan

Exhibit 19

Eight high-value businesses could drive significant value and job creation by 2030

		Market size, $ Bn	Emissions abatement, $MtCO_2e$	Direct jobs	Indirect jobs
4	Manufacture plant-based protein	0.5	6	23k	153k
7	Manufacture cross-laminated timber	1.8	25	41k	67k
17	Assembly of electric vehicles	0.3	3	1k	22k
18	Assembly of electric two wheelers	0.5	5	1.5k	30k
6	Produce bioethanol	2.1	14	26k	190k
10	Manufacture wind turbine parts	2.1	5	1.2k	9.5k
12	Assembly of off-grid solar systems and mini-grids	0.2	5	30k	120k
13	Assembly of mini-grids	0.1	5	7k	20k

Source: DSE, FCDO Development Impact Model, McKinsey EU Net-Zero report

In addition to offering substantial revenues and environmental benefits in the form of GHG abatement, these eight new green businesses could create a significant number of jobs. A conservative forecast to 2030 estimates that around 700,000 direct and indirect new jobs could be created, and these numbers would likely continue to grow over the ensuing decades.

These high-potential new green businesses would primarily be focused on servicing the local market, but many have significant export potential too. They fall into two broad categories: businesses that support the green transition and businesses that manufacture alternative low-carbon products.

For example, two of our top eight businesses—assembling electric vehicles for personal and commercial use and building two- and three-wheeled electric vehicles such as electric motorbikes—would play a key role in supporting the shift to a greener transportation system (see Box 7). The manufacture of plant-based protein as an alternative to existing carbon-intensive meat products and cross-laminated timber as an alternative to cement fall into the category of low-carbon alternative products (see Box 8).

BOX 7: CASE STUDY

Assembling electric two-wheelers: An opportunity to revolutionize African mobility

The use of two-wheelers is growing rapidly across Africa as populations urbanize, opening up a new manufacturing opportunity with high feasibility for uptake in the short term.

In 2019, Africa had around 44 motorized two-wheeled vehicles (including motorbikes, electric bicycles, and scooters) per 1,000 people, a figure that is expected to grow in the next 10 years to around 70 per 1,000.[1] Motorbikes with internal combustion engines (ICE) currently dominate the market, and GHG emissions from ICE bikes accounted for 65 $MtCO_2e$ in 2019; this could double by 2030 as populations grow and vehicle ownership increases. By comparison, electric two-wheelers are a cost-effective, cleaner ride, emitting a massive 80 percent less in GHG emissions than ICE bikes.[2] They are also more straightforward to assemble than ICE engines, making this an attractive industry to break into.

Globally, shifting regulation and technological advances are also making this an attractive business prospect. Transportation is facing significant disruption from e-mobility on three fronts. First, the regulatory environment is pushing the market towards electric vehicles through a combination of subsidies and ICE bans and restrictions. Second, a decline in battery costs is making electric vehicles more cost competitive. And third, developments in technology and charging infrastructure are improving rapidly.[3]

In Africa, the shift has already begun. As of March 2021, the global manufacturers of approximately 70 percent of vehicles used in Kenya had committed to end production of ICE vehicles within the next two decades.[4] Additionally, the United National Environment Program (UNEP) is funding electric vehicle projects in several African countries and expects sales of both electric and traditional two and three-wheeler motorcycles to double by 2050.

Our analysis shows that, owing to these shifts, about 1 percent of the total motorized two-wheeler market in Africa could be electric by 2030, ramping up significantly from there. If African players get their pricing right, they could capture around 20 percent of the local demand for electric two-wheelers in 2030, a market worth $465 million per annum by 2030. And through the direct avoidance of scope 3 emissions from ICE motorbikes, electric two-wheelers could help reduce GHG emissions by about 4,8 $MtCO_2e$ in the next decade.

Much would depend on the level of government incentives—the sector could require $50 to $100 million investment per plant, and government incentives and loans may be needed to make this attractive for investors.

$465million

Potential market size 2030

1 "Global Motorcycles - Demand and Sales Forecasts, Market Share, Market Size, Market Leaders", Freedonia, 2020, freedoniagroup.com.
2 Ibid.
3 McKinsey Centre for Future Mobility.
4 Jonathan Gaventa, "Africa's bumpy road to an EV future", Energy Monitor, February 2021, energymonitor.ai.

The bulk of the businesses identified, including the production of ethanol biofuel as green energy for use in cookstoves, the production of biodiesel from used cooking oil to replace transport fuels, the production of biofuels at scale from sustainable biomass plantations to provide zero-carbon alternatives for transport, and the manufacturing of parts for wind turbines or manufacturing and assembling off-grid solar systems, would be instrumental in supporting the energy transition (see appendix 5 for more information on these and other business opportunities).

Green businesses offer good value and realistic investment opportunities for players big and small

Africa's natural and human resources provide a strong basis on which to build new businesses and industries. Ready access to the raw materials needed in production, such as minerals, forests, livestock, agricultural land, and renewable energy, could provide businesses with a sustainable competitive advantage and improve export potential by reducing and stabilizing costs and reducing or avoiding dependence on imports.

Based on these criteria, the eight high-value businesses identified could offer good value and realistic investment opportunities for players big and small, with the added benefit that some are highly scalable. It is important to point out that these opportunities vary by country, with some businesses fitting better in different geographies and contexts than others. For example, central and western African countries with abundant land to grow timber would be well placed to develop cross-laminated timber businesses, while electric two-wheeler and wind turbine component manufacture are more suited to Africa's relatively mature economies such as South Africa, Morocco, and Kenya. Additionally, the bulk of new renewable wind energy capacity is likely to be installed in North Africa, making this a particularly good region for manufacturing wind turbine parts.

The development of grid solar systems and mini-grids could be rolled out throughout Africa as renewable energy potential is widely distributed across the continent. By 2050, renewable energy sources such as solar and wind power could make up about 90 percent of Africa's power mix in a net-zero scenario, with wind generation likely to account for around 30 percent, reaching 445 GW of installed capacity by 2050.

The production of biofuels, particularly bioethanol production, would be suited for regions where arable land is plentiful. Bioethanol feedstocks are split between sugar plants, such as sugar cane and sugar beets, starchy plants like cassava and potatoes, and grains such as corn and wheat. All these crops grow readily on the continent. Just one million hectares of land is enough to cultivate the feedstock required to produce around 2.4 billion liters of bioethanol per year.

To realize the potential of these business opportunities, a concerted focus that cuts across sectors and geographies would be required. The right incentives, regulations, and policies targeted towards economically feasible green opportunities would be a vital factor in helping to encourage entrepreneurs and financiers to take the necessary risks and move into these spaces to fuel low-carbon economic growth and job creation. The areas of action to consider are unpacked further in the case studies presented in this chapter and in chapter 5.

BOX 8: CASE STUDY

Plant-based proteins: Can Africa help feed a world hungry for healthy meat alternatives?

With a potential market opportunity of $470 million per annum, manufacturing plant-based protein could create a cleaner, greener future for Africa while providing significant economic opportunities.[1]

Despite relatively low levels of meat consumption in Africa, GHG emissions from meat production on the continent are high. In 2019, meat production accounted for 322 $MtCO_2e$ of emissions—mainly derived from animal farming—which is almost as high as emissions from all manufacturing activities on the continent.[2,3] And, with the population in sub-Saharan African estimated to double by 2050, the industry could contribute an additional 82 $MtCO_2e$ by 2030.[4]

Plant-based meat substitutes, by comparison, are around 85 percent less carbon-intensive than beef while providing the same nutritional content.[5] Globally, the alternative-protein market is growing at around 7 percent per annum compared to 3 to 5 percent for other types of proteins, as health and environmental concerns and animal welfare considerations drive consumers to make different choices; alternative proteins are becoming cost-competitive with meat products too.[6] This paves the way for start-ups such as Impossible Foods and South African-based Infinite Foods to roll-out such products.[7]

The continent is well-placed to succeed in this emerging industry. With the lowest protein intake per capita in the world—just 55 grams per person per day according to the Food and Agricultural Organization—there is room to grow the market in Africa, especially as the population grows. Additionally, the plant-based protein manufacturing process is not capital intensive. It can easily be scaled up, making it an attractive prospect for investors and small and medium-size enterprises. Africa is also unique in having significant tracts of uncultivated agricultural land available to increase the production of relevant crops.

The benefits of getting it right could be significant; our analysis shows that African players have the potential to capture 50 percent of the local demand for plant-based protein products by 2025 and 100 percent by 2030. What's more, they could also look to export an additional 20 to 30 percent of produce on top of local demand to a world increasingly hungry for quality, healthy meat alternatives.

$470million

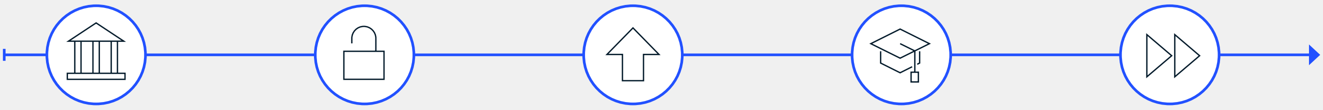
Potential market size 2030

[1] Zafer Bashi, Ryan McCullough, Liane Ong, Miguel Ramirez, "Alternative proteins: The race for market share is on", August 2019, McKinsey.com.
[2] "Meat: The future series—alternative proteins", World Economic Forum white paper, January 2019, weforum.org.
[3] Emissions from meat production fall outside of scope 1 and 2 manufacturing emissions and are mostly derived from the farming of livestock.
[4] World Population Prospects, United Nations Department of Economic and Social Affairs, 2019, un.org.
[5] "Meat: The future series—alternative proteins", World Economic Forum white paper, January 2019, weforum.org.
[6] "Plant-based Protein Market by Source (Soy, Wheat, and Pea), Type (Isolates, Concentrates, and Textured), Form, Application (Food[Dairy Alternatives, Meat Alternatives, and Performance Nutrition] and Feed), and Region—Global Forecast to 2026", Market report, Markets and Markets, February 2021, marketsandmarkets.com.
[7] Company website, impossiblefoods.com, infinitefoods.com.


Charge
Charge

Chapter 5

Africa's opportunity to unlock green manufacturing



Shift to a net-zero mindset and policy environment
All stakeholders can strive to change the prevailing mindset to a 'net-zero new normal' and encourage other relevant groups to decarbonize

Unlock green financing
Significant efforts would be needed to mobilize $2 trillion green financing on the continent

Upgrade green infrastructure
Important precursors for green manufacturing growth include renewable energy, transport, recycling, an enabling business ecosystem (e.g., green financing apps), and data infrastructure (e.g., online databases)

Upskill and reskill the workforce
A methodical approach can develop the skills to drive decarbonization

Accelerate R&D
Investors and the public and private sectors can drive the development of viable new green sectors, technologies, and products that are specific to Africa's needs

Africa is in a unique position to capitalize on the green transition that is gaining momentum worldwide. By committing to reaching net zero by 2050, the continent has an opportunity to set itself on a growth path that delivers economic transformation, builds resilience and adaptive capacity in the manufacturing and power sectors, and meets its sustainable development goals. To realize these benefits, a cohesive effort from governments, investors, businesses, international organizations, and civil society would be required.

"Green transformation will involve all aspects of manufacturing and power," comments Dr Arkebe Oqubay. "The earlier Africa responds to climate change, the better its prospects of not being left behind in the race to net zero. To achieve this vision, we need a New Green Industrialization Deal for Africa."

Our analysis points to five areas of action to consider to help achieve Africa's green manufacturing potential.

1. Shift to a net-zero mindset and policy environment

A strong correlation exists between countries where the population is highly aware of the climate risk issue and those with strong decarbonization commitments. A recent survey of population awareness showed that countries that have significant commitments for GHG emissions reduction—more than 30 percent by 2030 and net zero by 2050—were highly aware of the climate change emergency.[48] In Africa, awareness levels around climate change vary, with only three countries ranked in the top 20 in terms of awareness (Exhibit 20).

To help shift the prevailing mindset on the continent to a 'net-zero new normal', stakeholders could take steps to raise public awareness around the dangers of climate change, its impact on African countries, and the benefits and opportunities of decarbonization and the switch to green technologies. This can be achieved through public debates and education campaigns at all levels. For example, in Morocco, a regional platform for policy makers, industry leaders, research experts, and global innovators has been set up to explore the potential of green hydrogen and its applications for that country (see Box 9). And in Rwanda, the Rwanda National Environment and Climate Change Policy, launched in 2015, seeks to promote a greener economy through the promotion and procurement of green technologies and a focus on green urbanization and green rural settlements.

Green mobility is also a key focus of this policy. These objectives are given prominence in society by measures ranging from ensuring that climate change concerns are included in all national and sectoral plans to widely publicized incentives for private players to take up green opportunities.

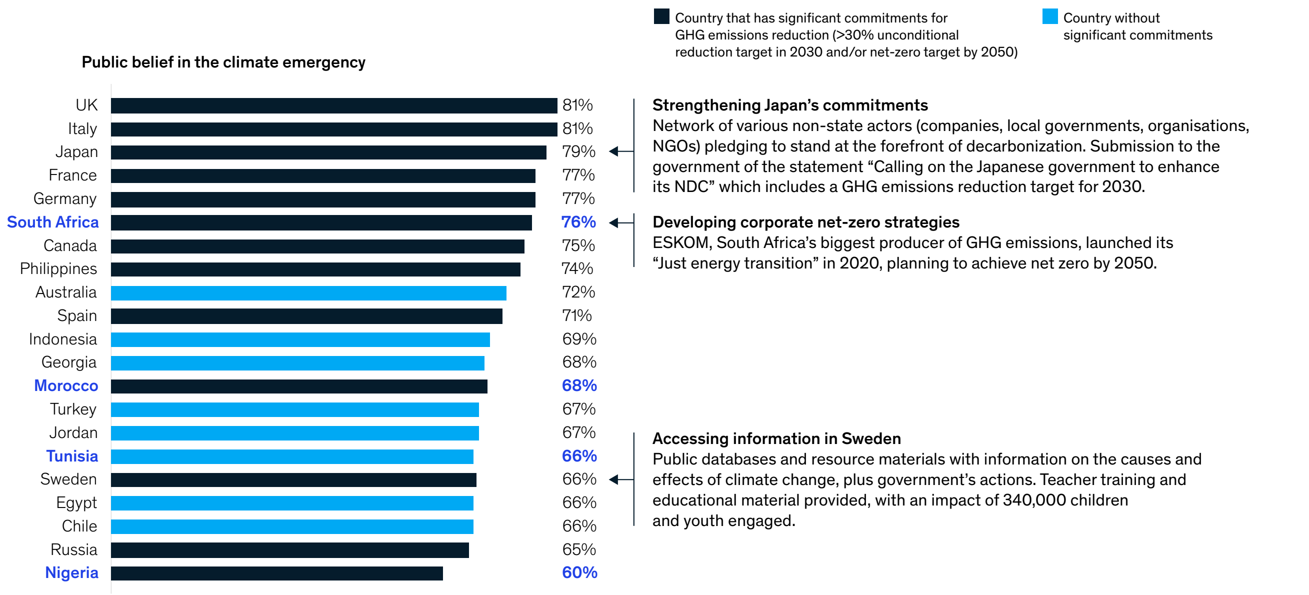
To accelerate a shift in public perceptions around climate risk, countries could also develop green growth strategies to ensure that they capture the full opportunity emerging from green businesses while adapting and improving the resilience of their manufacturing sectors. For example, India is pursuing a deliberate strategy to promote the uptake of electric vehicles and manufacturing through a series of policy actions (see Box 10).

To ensure that the poverty crisis and the environmental crisis are addressed concurrently, just transition principles could be adopted. One route to achieving this could be to boost African livelihoods by developing and promoting African 'green' labels and trademarks to increase the

Exhibit 20

Population awareness for climate risk is correlated to countries' decarbonization commitments

A strong correlation exists between countries where the population is highly aware of the climate risk issue and the ones that have made strong decarbonisation commitments[1].



1 Share of respondents answering "Yes" to the question "Do you think climate change is a global emergency?", Top 20 countries and Nigeria (27th)

Source: UNDP & Oxford-Peoples' Climate Vote, UNFCC (United Nations Framework Convention on Climate Change), TED

48 UNDP and Oxford – The Peoples' Climate Vote, United Nations Framework Convention on Climate Change (UNFCCC).

Box 9: CASE STUDY

What taking action to become a leader in green hydrogen looks like in Morocco[1]

The development of green hydrogen production at scale is key to Morocco's strategy for a net-zero future, and the country is taking concrete action to achieve progress.

All stakeholders, including government, civil society, corporates, and international organizations, are working together to achieve this. For example, in a bid to raise awareness around the role that green hydrogen could play in Morocco's future, the Moroccan Research Institute for Solar Energy and New Energies (IRESEN) and the Mohammed VI Polytechnic University (UM6P) organized the World Power-to-X Summit in 2020 to create a regional platform for policy makers, industry leaders, research experts, and global innovators to explore the potential of green hydrogen and its applications in the Power-to-X (PtX) economy.

The country also makes sure it participates in other key international discussions on hydrogen, for example the Portuguese Conference on Hydrogen held in April 2021.

To support the shift to a green economy with hydrogen at its center, the Moroccan government is working hard to create an enabling regulatory environment. In July 2020, it set up a Hydrogen National Committee to lead hydrogen feasibility studies and facilitate the setting up of a hydrogen roadmap. And it is looking to shore up the infrastructure needed to support this industry. For example, the National Office of Hydrocarbons and Mining (ONHYM) is leading the gas infrastructures task force in the National Hydrogen Commission to make recommendations on the conversion of existing gas pipelines for hydrogen and the development of a logistics hub to ship hydrogen to Europe.

The government is also working to build partnerships with various European countries, including Germany and Portugal, to develop hydrogen production research through joint working groups, and explore financing, research, and training mechanisms. For example, a collaboration agreement with Germany's National Hydrogen Strategy includes the setting up of research and investment projects such as the Power-to-X research platform. In addition, the GreenH2 Maroc national innovation cluster was established in March 2021 to drive R&D in this area. A collaboration between industry, universities (e.g.,UM6P), and research centers (e.g., IRESEN), the cluster's mission is to "further promote technology transfer and industrial integration within the hydrogen industry, to strengthen the capabilities of local players, to stimulate collaborative innovation, as well as to promote Moroccan hydrogen at regional and international level", according to a press release from the Ministry of Energy, Mines, and Sustainable Development in Morocco.

An investment in green hydrogen has spin-offs for other industries and sectors—notably the fertilizer industry—and there are also actions to consider in these sectors. Furthermore, a prerequisite to produce green hydrogen is renewable energy. Developing a thriving renewable energy sector in Morocco would require financing and building new green infrastructure, upskilling people, and creating an enabling regulatory environment. In Morocco, 960 MW of renewable energy sources has been developed in just four years (from 2015 to 2019), reaching a total installed renewable capacity of 3,865 MW by the end of 2019. The Noor Ouarzazate solar plant represents the highest capacity at 580 MW.

[1] National Strategy of Sustainable Development 2030 (SNDD), IEA, MASEN, World Bank, Ministry of Energy, Mines and Sustainable Development (Morocco), Press research.

credibility and viability of sustainable products. EcoMark Africa and Afrisko Certified Organic are examples of this kind of labelling.

Having a strong green policy in place can help to ensure that change happens. African governments can help drive decarbonization by choosing to set ambitious targets and NDCs and putting in place the enabling regulatory environment and direct support mechanisms for a green manufacturing ecosystem.

Many countries have already adopted green policies to foster more sustainable practices. For example, Germany's feed-in tariffs and subsidies, set up in 2014, have played a critical role in driving the growth of renewable energy and improving product competitiveness in that country.[49] Sector-specific regulations and incentives can help drive decarbonization, especially in high-emitting or hard-to-shift industries such as iron and steel, and cement. For example, in Kenya, incentives for renewable energy development have been implemented, including a tax exemption from value-added tax (VAT) and import duties for supplies related to the construction of a power-generating plant and geothermal exploration.[50]

Such tax incentives and subsidies to encourage the adoption of green technologies, especially those that may not be profitable in the short term, can be highly effective in driving cost decline in the long term. Governments could also consider including emissions criteria in public procurement to boost green industries and setting higher import taxes on high-emitting products that have local green alternatives.

A third important step towards creating a net-zero policy environment could be to explore how transparency on current carbon emissions and decarbonization progress can be implemented. Tracking and monitoring the transition could be important for individual high-emitting companies and industries. Governments could put enabling green standards in place, such as requiring environmental Key Performance Indicators to be published by listed companies and mandating the publishing of scope 1, 2, and 3 emissions, and implementing green investment standards such as a minimum requirement of renewable energy sources in energy investments. The introduction of mandatory energy targets such as energy efficiency standards could also be helpful.

Green transformation will involve all aspects of manufacturing and power. The earlier Africa responds to climate change, the better its prospects of not being left behind in the race to net zero. To achieve this vision, we need a 'New Green Industrialization Deal' for Africa.

Dr Arkebe Oqubay, Senior Minister and Special Adviser to the Prime Minister of Ethiopia, former Mayor of Addis Ababa

[49] German Energy Transition, US Department of Energy.
[50] Kenyan National Energy Policy.

Box 10: CASE STUDY

How India is fast-tracking its electric mobility sector

Deadly air pollution, reported to be responsible for the death of a child in India every three minutes, contaminates urban spaces across the sub-continent.[1] Twenty-two of the world's most polluted cities are in India, and this, coupled with huge expenditure on the import of crude oil, is prompting a massive government push to ensure electric mobility is at the forefront of India's green recovery.[2]

Multiple incentives and tax benefits have been implemented across the value chain since 2012, impacting buyers, manufacturers, and investors in charging stations and commercial usage. The Indian government initiated a regulatory framework to promote electric two-wheelers (E2Ws) and electric four-wheelers (E4Ws) under the National Electric Mobility Mission Plan (NEMMP) nine years ago and since then has introduced and bolstered the Faster Adoption and Manufacturing of Hybrid and EV (FAME) program. First implemented in 2015, this saw the introduction of a $110 million subsidy for the purchase of all electric vehicles, while in 2019, the FAME II initiative provided a further $282 million in demand incentives for E2W buyers and $140 million in incentives for players setting up charging stations needed to support these vehicles.[3]

In a further bid to level the EV playing field, a tax rebate of up to $2,100 on interest paid on loans to buy EVs was granted in 2019, while investment-linked income tax exemptions were instituted for charging infrastructure and lithium storage batteries. The government also lowered customs duty on imported components to promote domestic assembly of electric vehicles in India, intending to phase out ICE 3Ws, public buses, and 2Ws by 2030.

Despite these robust government initiatives, the ultimate driver of the adoption of EVs is the price-tag relative to ICE vehicles. The latest analysis from McKinsey shows E2Ws and E3Ws closing the gap on ICE vehicles, with the total cost of ownership of an E2W falling below that of an ICE 2W within five months, if driven 40km per day.

The most recent government subsidies and entrepreneurship and creativity across the EV value chain, could spur substantial demand for E2Ws. A host of companies are poised to reap the benefits from the electric mobility juggernaut, from battery manufacturers that are leading the vehicle development and production space with e-scooters, E2Ws and E3Ws, to e-mobility and ride-hailing services. This could be a game-changer, accelerating the sector's growth in the months and years to come.

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1 "Global, regional, and national deaths, prevalence, disability-adjusted life years, and years lived with disability for chronic obstructive pulmonary disease and asthma, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015", The Lancet Respiratory Medicine, 2017, thelancet.com.
2 Ibid
3 "Faster Adoption and Manufacturing of Hybrid and EV (FAME) II", International Energy Agency, May 2021, iea.org.

Both governments and development finance institutions also have a role to play in supporting businesses interested in transitioning to a low-carbon operation by providing guidance and facilitating technology transfer.

2. Unlock green financing

With an estimated $2 trillion investment over 30 years required to achieve net zero in Africa, significant efforts are needed to mobilize green financing on the continent. There are increasing examples in developing countries of actions to encourage green projects that can act as a reference point. For example, the Sustainable Banking Network (SBN) within the International Finance Corporation is a community of financial sector regulatory agencies and banking associations from emerging markets committed to advancing sustainable finance in line with international good practice.[51]

There are three principal actions to consider for fostering sustainable finance. First, countries could take steps to develop a strong pipeline of investable green projects, either focusing on the decarbonization of existing industries, for example green steel, or on new high-potential green businesses, starting with the eight businesses identified in this report.

Second, new green financing instruments that match the different risk and return profiles for green investments could be mandated. These might include carbon credits, green insurance, green bonds, green guarantee mechanisms, and payments for performance, which could be effective in attracting increased official development assistance linked to green outcomes. For example, the Guarantee Fund for biogas projects in Brazil provides financial guarantees on credit lines from banks' lending, increasing access to credit for projects that may be considered too risky for traditional lending processes.

Third, it would be important to establish a strong baseline and verification system for GHG emissions to give financiers confidence that their investments yield the expected carbon savings.

The financial industry can play a crucial role in ensuring an efficient transition to a low-carbon world guided by market signals rather than policy enforcement, but only if certain conditions are fulfilled. Accurate and consistent disclosure in corporate financial statements would be vital, helping investors decide which firms are making progress and which companies to avoid.[52]

In this way, investors could become the *de facto* enforcers of green standards. For example, Norges Bank Investment Management, one of the world's largest investors, recently announced that it had sold off some of the biggest names in commodities and utilities—including African players—after concluding that they had breached its guidelines on the use of coal.[53]

3. Upgrade green infrastructure

Africa's infrastructure lags behind that of the rest of the world, which is a major roadblock for development. However, the potential advantage here is that the continent can build new green infrastructure that is resilient to future climate scenarios. Our analysis suggests that to lay solid foundations for manufacturing growth on the continent, upgrading renewable energy, transport, recycling, and data infrastructure, and creating an enabling business ecosystem could be vital.

Developing renewable energy sources to draw power for future growth would be a key prerequisite for realizing the continent's net-zero ambitions. As we have shown, increasing the share of renewable energy sources (particularly wind and solar) in the generation mix and replacing fossil fuel generation with batteries and hydrogen when such technologies mature is important. Developing transmission and distribution infrastructure to enable a high share of intermittent renewable power is also critical.

Recycling and transportation infrastructure, too, could help to support the shift to a greener future. A priority here could be developing EV-charging infrastructure, while the development of bioethanol and petrol-blending facilities could also be important. Regarding recycling, waste collection, sorting, and recycling

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51 Company website, ifc, org.
52 Benedict Weller; "Green finance: investors need transparency", London School of Economics, May 2020, lse.ac.uk.
53 Richard Milne, "Norway's oil fund sells out of Glencore, Anglo American and RWE", Financial Times, May 2020, ft.com.

Africa needs a CO_2e measurement system to account for carbon offsets resulting from waste reuse. This will improve the attractiveness of circular-economy-related initiatives.

Ani Vallabhaneni, Co-Founder, Sanergy

infrastructure, targeting materials such as Polyethylene Terephthalate, aluminum, steel, cotton, and electronics, could offer the largest gains. Startups such as Taka Taka Solutions, are demonstrating the potential for value creation through recycling. Its supply chains and collection networks enable the collection of up to 60 tons of waste in Nairobi daily, 95 percent of which is recycled. The company's commercial customers gain value by being able to improve their operations and reduce costs.[54]

Finally, better data infrastructure could enable the ongoing capturing and sharing of knowledge to drive towards net zero in the same way that the Climate Action Tracker, an independent scientific analysis that tracks government climate action globally, does. As Ani Vallabhaneni, Co-Founder, Sanergy, suggests: "Africa needs a CO_2e measurement system to account for carbon offsets resulting from waste reuse. This would improve the attractiveness of circular-economy-related initiatives."

Interventions could include developing a network of sensors to measure, monitor, and analyze carbon emissions over the next three decades to help manufacturers meet targets. Such metrics could create transparency and inform decision-making. Over time, these systems could be extended to track other sustainability metrics, including water use—much of the continent suffers from water scarcity—and pollutants.

Public-private partnerships could play a key role in helping to speed up new builds and investments in green infrastructure to ensure that new green industries can operate efficiently. For example, in South Africa, a public-private partnership model has proven to be an effective financing solution to create renewable energy sources, which the rest of the continent could emulate (see Box 11). A similar model in Indonesia is also achieving environmental goals by developing vital recycling infrastructure to cut plastic pollution. The aim is to grow plastic waste collection by 80 percent by 2025 through investment in waste-collection infrastructure, both state-funded collection and informal and private sector systems. The project also seeks to double recycling capacity while building safe waste disposal facilities for non-recyclable plastic materials.[55]

[54] Company website, takatakasolutions.com.
[55] Indonesia National Plastic Action Partnership, World Economic Forum Annual Meeting.

Box 11

South Africa's Renewable Energy Independent Power Producer Procurement (REIPPP) program is an example of an effective public-private partnership

The South African government launched the Renewable Energy Independent Power Producer Procurement (REIPPP) program in 2011 to increase investment in renewable power by channeling substantial private sector expertise and investment into grid-connected renewable energy at competitive prices.[1] As of 2020, 112 projects had been awarded; 71 were online and represented an installed capacity of 4,459 MW out of 6,422 MW capacity that had been tendered through the program. Private sector investment totaling $14.4 billion has been committed, with most of the successful bids being awarded to large international players in partnership with emerging local players. The program had also created over 55,000 jobs by 2020, with local content spending of about $4 billion.[2]

Even more significantly, estimated portfolio costs for all technologies under the REIPPP program have dropped consistently in every bid window, with the combined average price reduced by a factor of three from bid window one to four.

1 Company website, ipp-projects.co.za.
2 Development Bank of Southern Africa, dbsa.org; Department of Mineral Resources and Energy, Republic of South Africa, dmr.gov.za.

4. Upskill and re-skill the local workforce

The drive to decarbonize would require major changes in the manufacturing sector, and skills needs would change with them. Policy makers may want to think through how to do this without compromising people's jobs and economic stability, in line with the 'just transition' principles. Stakeholders could approach this challenge methodically.

First, with job losses likely in legacy industries, along with the creation of millions of new jobs in new green industries, it could be helpful to conduct workforce planning to identify key changes and anticipate future skills required in the job market, as well as to define new occupational standards and develop new training and curricula. The private sector would typically lead here.

Second, governments could develop skills certifications for new green jobs to support skills mobility. The development of a universal framework of skills and accreditations would help to formalize new qualifications, and the creation of skills passports could boost workforce mobility and help ensure easy access to relevant skills across the continent.

Third, all stakeholders could work together to develop the infrastructure, such as training institutes, to facilitate training, and to find ways to make training more accessible, perhaps by creating short and modular programs that combine both classroom and on-the-job elements. To enable the workforce's transition, governments could also focus on incentivizing training—including financial inducements—and ensuring the transferability of skills.

Interventions may need to be crafted for specific localized situations. For example, in countries with high potential for forestry, and thus cross-laminated timber, such as Angola and Zambia, a direct reskilling initiative may be most effective to help people transition away from cement into the new industry. In countries with low forestry potential, the situation is different, and stakeholders may need to put the just transition principles at the center of cement replacement discussions.

Some oil and gas players are already investing in the necessary reskilling. For example, Actemium

Oil and Gas Training has been delivering OPITO's global renewable energy qualifications on offshore wind at its center in Nigeria since 2020.[56] USAID is also supporting Egypt in introducing new renewable specializations through its Workforce Improvement and Skills Enhancement (WISE) project. To date, 75 new occupational standards have been defined under WISE.[57]

To drive change at the pace and scale required, stakeholders may need to be vigilant for opportunities to deploy skills to new and emerging industries with minimal reskilling required. For example, oil and gas skills such as drilling technology are already being absorbed into the emerging geothermal industry in the US, where start-ups are hungry for skills and innovation to drive their growth.[58]

5. Accelerate research and development (R&D)

Finally, developing viable new green sectors, technologies, and products specific to Africa's needs is important. Investors and the public and private sectors could support significant R&D efforts to drive this.

On the one hand, local research could focus first on projects relevant to Africa, but not a priority globally, such as local circular economy solutions and processes to reduce emissions. For example, Sanergy, an East African start-up, is working on organic recycling by transforming waste into agricultural inputs that can replace high-emitting fertilizers.[59]

This report has identified eight key green businesses that are well-suited to the African market, one of which is the development of biofuels. R&D could support this emerging industry through research into suitable crop development and yield improvement. For example, researchers could investigate improving agricultural productivity by developing more efficient fertilizers, crop protection products, or smart irrigation. They could also investigate the development of crops that are adapted to harsh African conditions, especially cassava, potato, grains, and sugarcane. Another avenue could be to invest in pyrolysis research to enable wood-scrap-based biofuel production.

On the other hand, Africa would need to ensure the fast development of its new green businesses. One action to drive this could be to set-up dedicated green manufacturing accelerators to spur innovation and scale-up new green manufacturing and tech businesses across the continent. These accelerators could enable the sharing of best practices and provide high-potential entrepreneurs with access to critical support and assistance in navigating complex administrative and legal environments. They could also facilitate matchmaking between venture capitalists and other financiers and investible African green businesses.

To support these R&D initiatives, governments have a key role in cutting red tape, removing obstacles, and optimizing processes. It would also be important to foster ongoing knowledge creation and sharing through the publishing of reports on key opportunities and lessons learned to inform decision-making in the ecosystem, especially for investors and the private sector.

56 "OPITO Marks Strategic Shift, Launching New Product Suite for the Renewable Energy Workforce", September 2020, opito.org.
57 Annual Report, USAID/Egypt Workforce Improvement and Skill Enhancement Project, December 2019, usaid.org.
58 David Roberts, "Geothermal energy is poised for a big breakout", October 2020, Vox.com.
59 Company website, sanergy.com.


LAKE TURKANA

Conclusion

There is an African proverb that says, "Do not stand in a place of danger trusting in miracles", which resonates at this juncture. While the path to net zero in Africa's manufacturing sector is unavoidably challenging, the risks of not achieving this goal, are likely to outweigh the costs and sacrifices that would have to be made to get there. Action is more urgent now than ever, as the window to keep global warming below 1.5°C narrows.

The Africa Union's Agenda 2063 clearly articulates a bold strategic vision for sustainable and inclusive economic growth and development on the continent. It is a plan that understands that, while African governments need to significantly industrialize their economies to meet the basic needs of growing populations and transition from lower to higher valued-added production, they cannot afford to follow the same route to economic prosperity that developed nations have pursued. Globally, pressure is mounting for countries and businesses to cut their GHG emissions by the middle of the century and unchecked emissions growth in Africa will likely lead to a slowdown in economic growth owing to reduced financing options and emissions-related export penalties.

Given the critical role that the manufacturing sector plays in both growth and decarbonization, nothing less than a coordinated and committed response from all stakeholders is required—for the long haul. Fostering a just transition that protects African livelihoods and natural resources will depend on breaking ground in new and unfamiliar sectors and technologies; it will require meticulous long-term planning and collaboration across sectors, and a concerted effort to foster innovation, entrepreneurship, and investment.

Our hope is that the facts laid out in this report concerning the current situation, estimated costs, and the likely benefits across the value chain, can help guide decision-makers and manufacturers alike in making informed choices for the future. A green manufacturing sector could boost competitiveness, opening new markets, both local and global, creating much needed jobs and stimulating commercial activity throughout the economy. An abundance of natural resources on the continent, notably solar and wind power and the minerals needed for the development of new green technologies, put the continent in a commanding position in a new green world economy.

Africa's manufacturing story can be one of innovation, a story of new kinds of jobs, financing mechanisms, and technologies geared towards building a more sustainable and equitable society that will benefit generations to come.

Appendix 1

Glossary of abbreviations

BAU	Business-as-usual
bn	Billion
CAGR	Compound annual growth rate
CAPEX	Capital expenditure
CCS	Carbon capture and storage
CEO	Chief Executive Officer
CLT	Cross Laminated Timber
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DRI	Direct Reduced Iron
DRI H2 EAF	Hydrogen Direct Reduced Iron in Electric Arc Furnace
DSE	Decarbonization Scenario Explorer
e.g.	Exempli gratia (For Example)
EAF	Electric arc furnace
EMC	Energetically modified cement
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicle
FCDO	Foreign, Commonwealth & Development Office
G	Giga
GDP	Gross Domestic Product
GHG	Greenhouse Gas
Gt	Giga ton
GW	Giga watt
H_2	Hydrogen
H_20	Water
ICE	Internal Combustion Engine
IEA	International Energy Agency
IRESEN	Institute for Research in Solar Energy and Renewable Energies (Morocco)
kg	Kilogram
KW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelized Cost of Energy
m	Million
mbpd	Million barrels per day
MGI	McKinsey Global Institute
Mt	Mega/Million ton
SME	Small and Medium Enterprise
SSA	Sub-Saharan Africa
t	Ton
Tn	Trillion
TWh	Terawatt hours
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	US Agency for International Development
WISE	Workforce Improvement and Skills Enhancement Project
WTO	World Trade Organization
yr	Year

Appendix 2

Scope and methodology

In this report, we are using the term manufacturing as defined by the International Standard Industrial Classification, which includes 23 sub-sectors across Africa, including:

Alumina; Aluminum; Ammonia; Cement; Coal-to-liquids; Ethylene; Iron and Steel; Lime

Other Industry, High-Temperature Heat

— Paper pulp and print

— Part of other industry (including plastics)

Other Industry, Low-Mid-Temperature Heat

— Food and tobacco

— Textile and leather

— Transport equipment

— Wood and wood products

— Machinery

— Part of other industry (including plastics)

Petroleum Refining

Power

The primary focus of our analysis is on greenhouse gas (GHG) emissions, measured as tons of carbon dioxide equivalent (CO_2e), a metric that compares the emissions from various GHGs based on their global warming potential. (Exhibit 21) This is in line with the Paris Agreement and the global push to net zero by 2050 in order to maintain a 1.5°C pathway.

Exhibit 21

A focus on the reduction and avoidance of GHG emissions

Primary focus areas   Selected case studies

Environmental impact		Description	Unit
Pollution	CO_2 and Other GHGs	CO_2 and other greenhouse gas emissions (Methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), Sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3))	Tons CO_2e
	Waste	Wastes are substances or objects, which are disposed of at any step in the value chain under the provisions of national law. (Basel Convention) They are disposed at a landfill	Tons
	Hazardous materials	In contrast to waste, hazardous materials are not disposed of in landfills (e.g., heavy metals)	Tons
Resource intensity	Energy consumption	The amount of electrical energy used throughout the value chain	MJ
	Water consumption	The amount of fresh water (water with less than 500 parts per million [ppm] of dissolved salts) consumed throughout the value chain	M^3
Biodiversity	Fauna	Animals, insects, microscopic organisms, etc., affected by pollution	Diversity Volume
	Flora	Plants affected by pollution	Diversity Volume

This report explores the green manufacturing opportunity at two levels:

1. Africa's manufacturing emissions and outlook at a macro level

BASELINE:
First, we estimated the 2018 baseline of CO_2e emissions from manufacturing sector activities in Africa, based on a combination of bottom-up analysis for the highest-emitting sectors of installed production capacity and outputs, technologies used (to estimate process, power, and fuel consumption), emission factors by fuel and technology, and of a top-down estimate for the lowest emitting sectors, based on a combination of fuel and electricity consumption in low emitting sectors.

PROJECTIONS:
Second, we projected this baseline of manufacturing emissions in a business-as-usual or 'do nothing' scenario to understand how manufacturing emissions are expected to grow. Note that business-as-usual is a modelling tool that is not presented in the report. The projection is based on the expected activity level increases for high emitting sectors (e.g., cement), in addition to manufacturing value add (MVA) growth forecasts for both high and low emitting scenarios. As detailed activity level, MVA and emissions data is only available for a limited set of countries (varies depending on data, for example, detailed MVA breakdown by sub-sector is only available in nine countries), we grouped countries into clusters that would have a similar manufacturing sector composition and outlook. These clusters were defined based on the contribution of manufacturing and services to total GDP, GDP per capita, and dependency on the oil and gas sector.

SCENARIOS:
Third, we developed three green manufacturing scenarios to estimate the potential of emission reduction in existing manufacturing activities by implementing green manufacturing levers. We looked at four main types of levers: alternative energy sources, process efficiency, circularity and feedstocks, and technology shift, and applied them in our scenarios depending on their potential for CO_2e emission reduction, their technological readiness, and economics.

ECONOMIC IMPACT:
We estimated the implications of the net-zero pathway in terms of investment requirements and jobs using multiple assumptions, including:

- Labor productivity is fixed at 2018 levels;
- Emissions intensity by technology is fixed at 2018 levels for low-emitting sectors; and
- Dollar values are fixed at 2019 levels.

Although we would expect these ratios to evolve over a 30-year period, we used simplified assumptions due to the lack of reliable forecasts.

Growth in gross output[60], GDP, and jobs created all have a multiplier effect on the value of investments in new technology. These multipliers may be ***direct,*** for example, directly employing people in manufacturing processes, ***indirect***, that is, the jobs and contribution to GDP and growth of suppliers to manufacturing industries, or ***induced***, that is, a contribution to growth and jobs in other sectors due to the spending power of people in the above jobs. Finally, impacts can be ***cascading,*** that is, as a result of all the above contributions aiding local innovation, economic development, and boosting human capital. Our analysis only covers direct, indirect, and induced effects from the manufacturing and power sectors.

Our methodology for calculating job impacts has been to apply a full set of country- and industry-specific multipliers related to gross output, GDP growth, and jobs. In this process, we used country- and industry-specific indirect and induced job multipliers provided in the Foreign, Commonwealth and Development Office (FCDO) Development Impact Model (DIM).[61] In this model, direct jobs are an assumed input, while direct multipliers are not specifically included. To derive country-specific direct job multipliers, we grouped countries based on their GDP per capita to extrapolate the direct and indirect ratios.

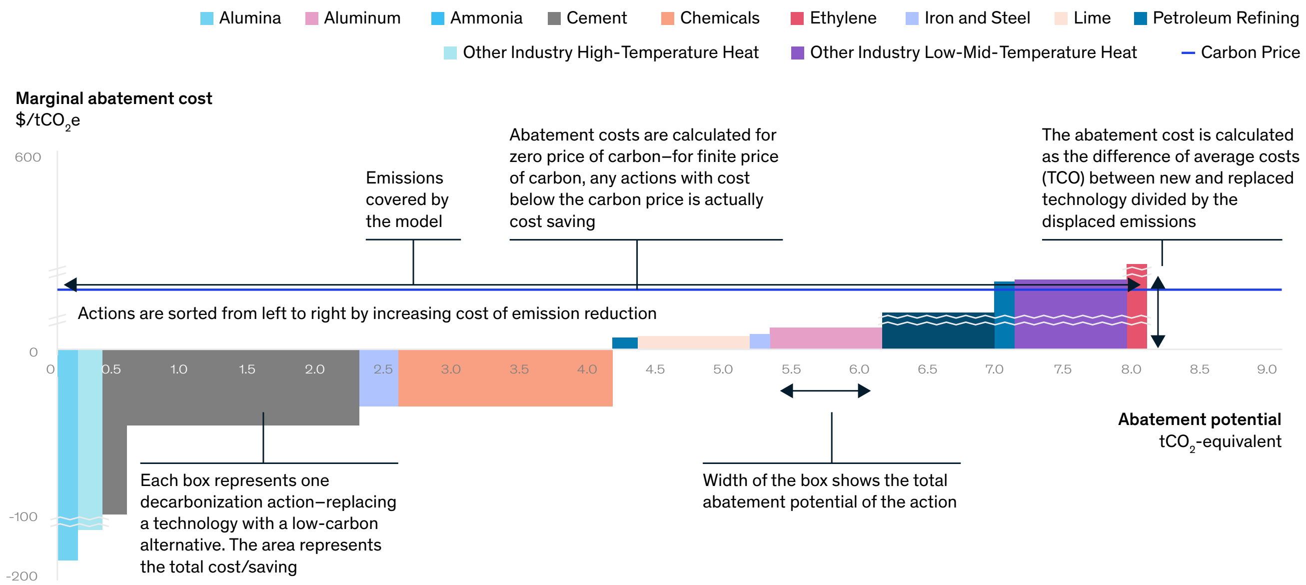
MANUFACTURING BUSINESS OPPORTUNITIES IN AFRICA AT A MICRO-LEVEL:
We explored the potential of developing specific green businesses corresponding to manufacturing activities that do not currently exist and their impact on CO_2e emission reduction. This section is not meant to be an exhaustive outlook of green manufacturing opportunities but a first view into the main green business opportunities discussed today with a high-level assessment of their economic and CO_2e-saving potential at an African level.

For information on how to read a cost curve see Exhibit 22 below.

Exhibit 22

How to read: A cost curve provides a fact base on cost-effective technologies to reduce emissions in line with targets

$/tCO₂e (y-axis), in tCO₂e (x-axis)



[60] Value add plus intermediate input costs.
[61] Development Impact Model, MGI.

Appendix 3

Market sizing for new high-value businesses

Our methodology for market sizing for high-value new industries looked at several factors from projected consumption and demand in 2030 to their potential for the local market and export. We compared this with total projected consumption of the industry they were likely to supplant (e.g., legacy industries such as the meat industry and the cement industry) and looked at the costs of existing products or products that could act as a proxy for the new product. The environmental impact and feasibility of each business was then considered along six key criteria: CO_2e emissions reduction; other environmental impacts; capital intensity per industrial unit; human resource capability; technological readiness; infrastructure readiness and other considerations (Exhibit 23).

Exhibit 23

Environmental impact and feasibility assessment criteria

		High	**Medium**	**Low**
Environmental impact	**CO_2e emissions reduction (Mt)**	> 5 CO_2e emissions reduction compared to existing products	5 – 1 CO_2e emissions reduction compared to existing products	< 1 CO_2e emissions reduction compared to existing products
	Other environmental impacts (e.g. water pollution)	Significantly improved	Somewhat reduced	Remain the same as business as usual
Feasibility	**Capital intensity per industrial unit ($M)**	< 50	50 – 100	50 – 100
	Human resource capability	Skills required are available in Africa	Skills required are partially available in Africa, can be readily developed or can be sourced	Long-term capability building required to develop skills is unavailable
	Technological readiness	Technology has been developed and deployed in Africa	Technology has been developed but has not been deployed in Africa	Technology is still in development
	Infrastructure readiness and other considerations (e.g. regulatory readiness)	Infrastructure and other required environments are available in Africa	Infrastructure and other required environments are partially ready in Africa	Infrastructure and other required environments are not ready in Africa

Appendix 4

Industry deep dives

Ammonia

A chance for Africa to lead in the production of green ammonia

Ammonia is a simple compound of nitrogen and hydrogen and a key component of nitrogenous fertilizers, which are used to increase agricultural yields. In Africa, the production of ammonia is an emerging industry. Despite a reduction in global demand for fertilizers due to saturation in developed agricultural economies and environmental degradation in China, demand is expected to double by 2050 in Africa, where it is needed to improve soil productivity, especially in grain production, to feed the continent's growing population.[62]

The value offered by ammonia comes at a cost, however, as its energy-intensive manufacture, which uses methane steam reforming as a key input, generates about 1.7 tons of CO_2 per ton of ammonia. As a result, several large global producers in this industry are committing to reach net zero by 2050.[63]

In our base-case scenario, our analysis assumed that, apart from a small-scale hydrogen pilot in South Africa, no new technologies would be introduced into Africa over the next three decades, resulting in an increase in GHG emissions from ammonia production of about 50 $MtCO_2e$ by 2050. By contrast, the decarbonization of this industry could help Africa abate overall manufacturing emissions by about 48 $MtCO_2e$ by 2050, with the early adoption of carbon capture and storage and green hydrogen from 2030 onwards eliminating nearly all emissions in the net-zero scenario by 2050. In developing our decarbonization scenarios for Africa, we have pinpointed two key technology levers for successful abatement in this industry (Exhibit 24).

[62] McKinsey Fertilizer Nutrient Demand Model.
[63] Science Based Targets initiative (SBTi), sciencebasedtargets.org.

1. Employing carbon capture and storage: 19 $MtCO_2e$ reduction by 2050

About two-thirds of CO_2 emissions produced when using natural gas to fuel the water-gas shift reaction to form hydrogen emerge in a very pure form. This makes it particularly suitable for carbon storage without the need for expensive capture technology. The application of this carbon capture and storage technology, which is already mature although still expensive, would involve a cost for the transport and storage of concentrated CO_2 of around $30 to $40 a ton.

2. Switching to green hydrogen: 31 $MtCO_2e$ reduction by 2050

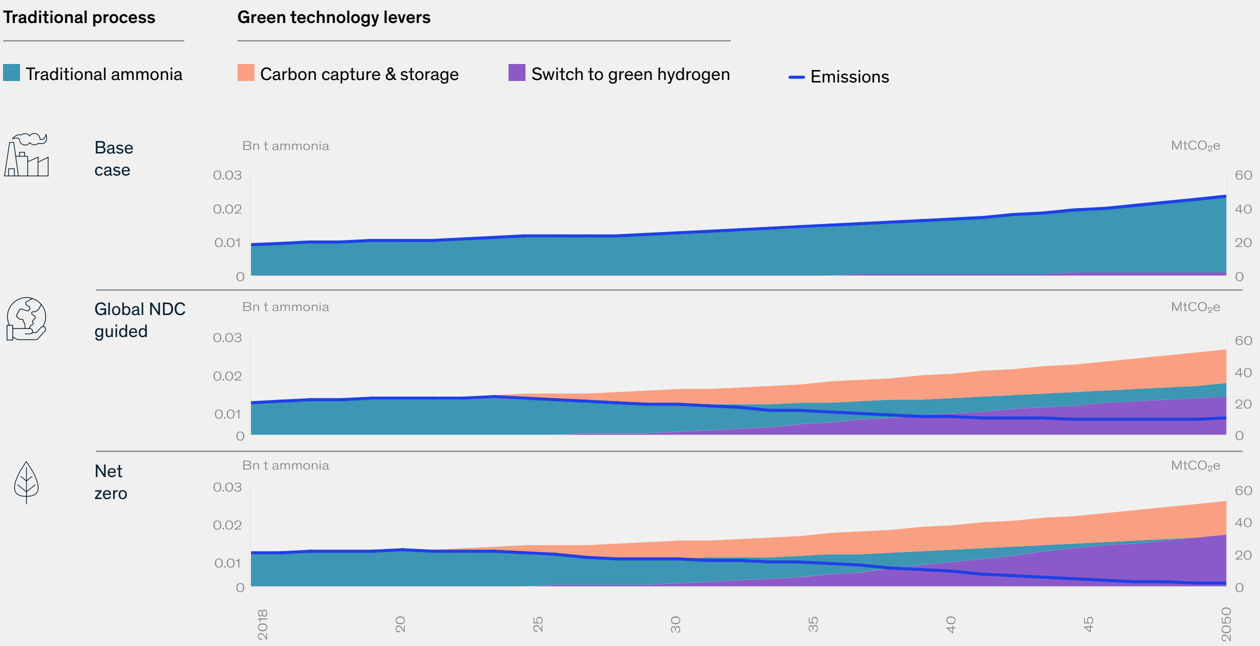
The use of green hydrogen in the production of ammonia could eliminate carbon-intensive hydrogen production processes. However, the cost of this technology is strongly dependent on the availability of cheap green electricity needed to produce hydrogen through the electrolysis of water. While water electrolysis technology is relatively mature, with about 200MW installed capacity in pilot projects around the world, it is unproven at scale. However, early indications are that green hydrogen-based products could fetch premium prices.[64] This trend could significantly lower the cost of investments in such plants over their lifetime.

To reach net zero, a minimum 40 percent uptake of carbon capture and storage and a switch to 60 percent of production to external green hydrogen sources would be required by 2030. More significantly, given the abundant potential for renewable energy sources on the continent, upon which green hydrogen is dependent, Africa has a real opportunity to become a global leader in green ammonia production.

Exhibit 24

Carbon capture and storage and green hydrogen are key levers in reducing emissions in ammonia manufacture

Technology share ammonia in Bn t p.a. and GHG scope 1 emissions in $MtCO_2e$



Source: DSE, FCDO Development Impact Model, McKinsey EU Net-Zero report

[64] Joe Deaux, "European aluminum buyers are starting to pay up to go green", Bloomberg Quint, February 6, 2021, bloombergquint.com

Iron and steel

Retaining Africa's license to operate

Steel is a ubiquitous commodity of the modern world—found in everything from cars, cargo ships, and skyscrapers to washing machines and surgical scalpels—and the industry is among the three biggest producers of global GHG emissions.

Every ton of steel produced in 2018 emitted on average 1.85 tons of CO_2, equating to about 8 percent of total global emissions from industry.[65] The global industry is facing pressure to decarbonize, and major companies are joining those committing to reaching net zero by 2050.[66] At the same time, changing customer requirements and growing demand for carbon-neutral steel products, for example in the automotive industry, tightening carbon emission regulations and investor interest in sustainability are driving the industry to consider alternatives to traditional high-GHG-emitting steel production processes.[67]

Our analysis indicates that steel production in Africa is likely to double over the next three decades, and in the base case, this could result in emissions of up to 27 $MtCO_2e$ by 2050 (Exhibit 25).

There are three fundamentally different ways to obtain iron and steel from iron ore: smelting (a process involving heating and melting the iron ore), direct reduction (the removal of oxygen from the iron ore using carbon monoxide and grey hydrogen from reformed natural gas, syngas, or coal to produce direct reduced iron), and Faradaic reduction (an electrochemical process). Each has a different emissions profile; however, the biggest impact on carbon footprint in all instances is achieved by replacing coal as a fuel with carbon-neutral reductants such as sustainably farmed biomass or green hydrogen. In switching to these technologies, our analysis highlights two major opportunities for Africa:

1. Tapping into green hydrogen: 23 MtCO2e reduction by 2050

The use of green hydrogen in direct reduced iron electric arc furnaces (DRI-EAF)—a technology that extracts iron from iron ore without using coal—could enable nearly emission-free steel production. This technology is being piloted with industrial-scale production starting in 2024. Because green hydrogen requires cheap renewable electricity, Africa has an opportunity to tap into its solar potential, especially in northern and southern Africa, to drive the production of green hydrogen on the continent and set up hydrogen-based steel production processes.

[65] World Steel Association, worldsteel.org.
[66] Science Based Targets initiative (SBTi), sciencebasedtargets.org.
[67] Christian Hoffmann, Michel Van Hoey, and Benedikt Zeu, "Decarbonization challenge for steel," McKinsey & Company, June 2020, McKinsey.com.

2. Implementing biomass technology: 3 MtCO2e reduction by 2050

The Tecnored process is a mature, environmentally friendly, and relatively easy-to-implement technology that uses biomass-based fuel, primarily sugarcane or Biochar, to produce iron. Developed in Brazil, Tecnored technology drops the carbon footprint of the steel manufacturing process from 1.3 tons of CO_2 per ton of iron in direct emissions to a carbon-neutral position.[68] This technology holds significant potential for sub-Saharan Africa, which has some climate zones suitable for growing sugar cane. Other crops in other regions could also be used as biomass feedstock to drive the Tecnored process at a lower yield.

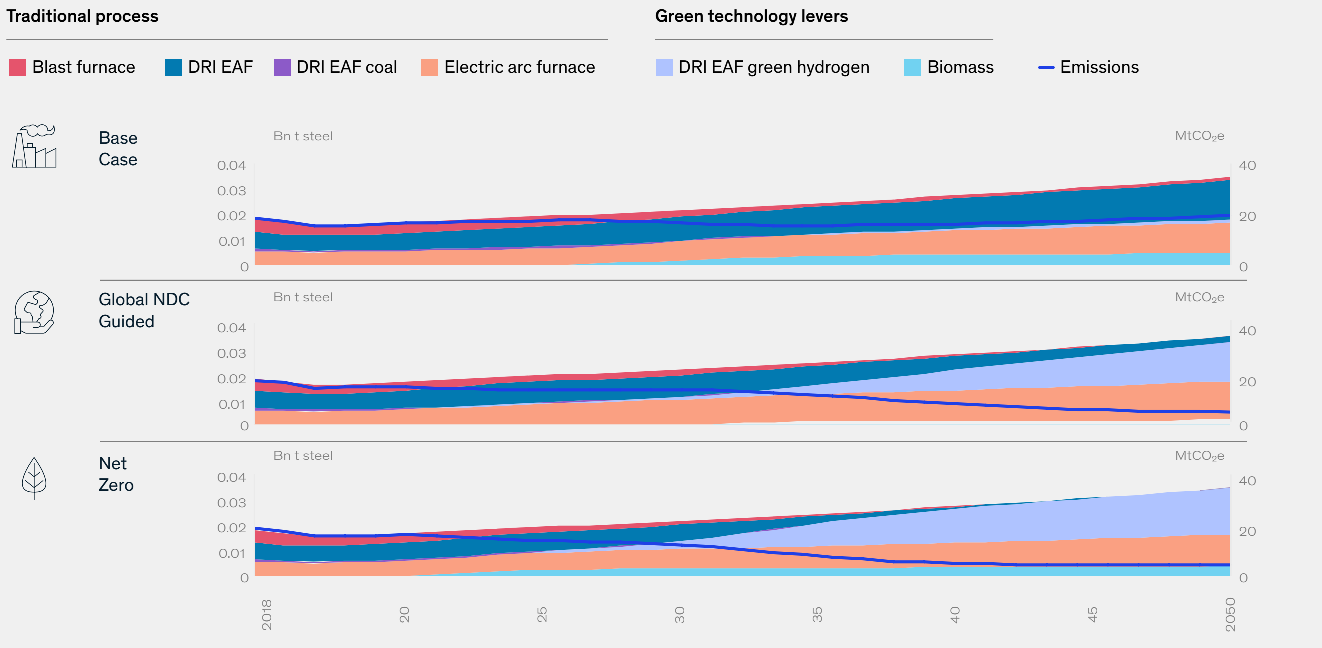
To reach net zero in Africa, hydrogen DRI would need to displace blast furnaces entirely from 2030, and the biomass-based Tecnored process would have to take over all virgin steel production in South Africa. Outside of South Africa, some Tecnored capacity would also switch to DRI EAF as this reaches maturity. This could see emissions fall by around 80 percent relative to 2018 levels to just under 5 $MtCO_2e$ by 2050, with the remaining emissions coming from natural gas used in the EAFs processing recycled steel.[69]

A third and important lever in the drive to net zero would be to increase the share of steel recycling. This could grow to nearly 45 percent by 2050 in the global-NDC-case as recovery rates improve and the ability to clean scrap gets better.

Exhibit 25

Hydrogen and biomass are key levers to decarbonize Africa's steel industry

Technology share steel in Bn t p.a. and GHG scope 1 emissions in $MtCO_2e$



Source: DSE, FCDO Development Impact Model, McKinsey EU Net-Zero report

[68] Tecnored website, www.tecnored.com.br.
[69] To achieve net zero, not every sector would need to achieve 100% reduction in emissions in order to contribute towards achieving the 90 percent reduction target in the manufacturing sector as a whole.

Appendix 5

New business opportunities case studies

Cross-laminated timber: Can Africa house its growing population sustainably?

As Africa's population grows and urbanizes, cement consumption, which is currently low per capita, is expected to increase, driving up GHG emissions from 150 $MtCO_2e$ in 2020 to about 210 $MtCO_2e$ by 2030. To house Africa's growing population while avoiding further emissions, it would be necessary to find a cleaner alternative. Cross-laminated timber is emerging as a promising option with the potential to replace about 40 percent of cement demand.[70]

Providing strength and stability at a low cost, cross-laminated timber is an engineered wood product and a sustainable substitute for concrete and steel in building construction globally. Wood outperforms steel and concrete in terms of cost, embodied energy, air pollution, and water pollution, and because cross-laminated timber panels are manufactured for specific uses, a further environmental benefit is less waste. Additionally, due to the thickness of the panels and the ability to fit the panel joints tightly to reduce airflow, interior temperatures in finished structures can be maintained with one-third less heating or cooling energy than is usually required.[71]

The technology can increasingly compete with traditional materials in terms of scale, too. In March 2019, Mjøstårnet by Voll Arkitekter in Brumunddal, Norway—an 85.4-metre-high tower that was built using cross-laminated timber—was verified as the world's tallest timber building by the Council on Tall Buildings and Urban Habitat (CTBUH).[72] CTBUH has revised its guidelines to recognise timber as structural material in response to an increase in the number of tall timber buildings around the world.

Switching just 2 to 3 percent of cement demand in Africa to cross-laminated timber by 2030

[70] This assumes that of the 60 to 70 percent of cement used in buildings, 30 percent is not replaceable because it is needed, for example, in the foundations, and that between 30 to 40 percent of cement used in infrastructure is not replaceable.
[71] "Solid Advantages: Cross laminated timber (CLT) offers a new building system option for non-residential and multi-family construction" Woodworks, 2012, woodworks.org
[72] "Mjøstårnet in Norway becomes world's tallest timber tower", dezeen, March 2019, dezeen.com.

represents a $1.7 billion market opportunity, and could abate about 25 $MtCO_2e$ by 2030 from the direct avoidance of scope 1 and 2 emissions in the cement industry. However, some emissions would remain from kiln drying the wood and the harvesting and transportation of timber.

Our analysis shows that Africa has the technological readiness, forestry resources, human-resource capability, and manufacturing technology required to realize this green building opportunity, although challenges remain; building regulations to allow for the use of cross-laminated timber would need to shift, and the timber would need to be sourced from a certified (preferably local) source. Such forests would offer significant carbon sequestration opportunities, although they would also be water intensive. Water availability will therefore be a critical requirement.

Assuming that these hurdles can be overcome, African players could capture 90 percent of the local market by 2030, with further economic opportunity in exporting.[73] To drive adoption, marketing campaigns to help shift consumer perceptions towards this new building material could also be helpful.

Cotton fiber recycling: Cottoning on to fiber recycling in East Africa

Our analysis indicates that the recycling of cotton fibers in East African countries is a $600 million untapped market that could provide economic opportunity and a 35 percent reduction in textile waste traditionally generated by the apparel industry.

Making clothes is a resource-intensive industry, typically requiring a lot of water and chemicals and emitting significant amounts of GHGs and other pollutants. The global industry accounts for around 4 percent of global freshwater use a year and is responsible for 24 percent of insecticide use, despite only using 3 percent of the world's arable land. It is also responsible for 10 percent of global annual CO_2 emissions.[74] In addition to being water and carbon-intensive, the apparel industry produces a large amount of solid waste; around 73 percent of textile fibers end up in landfills, are incinerated, or dumped.[75]

Developing the circular textile economy in Africa presents a key environmental and investment opportunity, especially in Kenya and Ethiopia. The combined total textile export market of these two countries in 2019 was $534 million, and the market is expected to grow by between 2 to 3 percent per annum in Kenya, well above the current global textile market growth rate of less than 1.5 percent.[76]

One of the most viable opportunities here is recycling cotton fibers—both post-consumer and pre-consumer waste—with a market potential of more than $600 million by 2030. Around 47,000 tons of cotton-rich waste are available in East Africa, roughly 13 times what's needed to make just one cotton recycling plant feasible. Currently, only 7,000 tons of this waste are recycled, with only one mechanical cotton recycling player in the region.[77] A further untapped opportunity exists in recycling unsold second-hand clothing imported into Africa. According to data from the Observatory of Economic Complexity (OEC), the continent has consistently imported more than $1 billion in used clothes per year, about 32 percent of total world imports.

This could be a win-win opportunity for East Africa, offering economic growth while diminishing waste and reducing emissions. However, to unlock these opportunities, the sector may need to develop textile waste collection and sorting capacity. The latter may prove particularly challenging and labor-intensive as sorting technology is still nascent. Growing skill levels in recycling technology and sensitizing the public to recycling may also be required.

Wind turbines: Wind component production set to rise on the continent

With wind energy rapidly becoming a key part of Africa's power generation mix, a market is opening for the local manufacture of wind turbine parts. Our analysis shows that this could

73 McKinsey Decarbonization Scenario Explorer (DSE) models.
74 Earth 911, McKinsey & Co's State of Fashion report 2018, United Nations Partnership on Sustainable Fashion and the SDG's, Ellen MacArthur Foundation, NRDC.
75 "A new textiles economy: Redesigning fashion's future", Ellen MacArthur Foundation, 2017, ellenmacarthurfoundation.org.
76 Achim Bert, Saskia Hedrich, and Bill Russo, "East Africa: The next hub for apparel sourcing?", McKinsey, August 2015, mcskinsey.com.
77 ETUR Textile PLC, eturtextile.com.

be worth around $2 billion per annum and help abate about 5.5 $MtCO_2e$ in GHG emissions by 2030 by producing renewable power. North Africa, a region with the skills and technology readiness to put the wind in the sails of this high-value new industry, is well placed to capture this opportunity.

By 2050, renewable energy sources such as solar and wind power would make up about 90 percent of Africa's power mix in a net-zero scenario. Of this, wind generation would account for around 30 percent, reaching 445 GW of installed capacity by 2050. The bulk of new wind capacity would likely be installed in North Africa.

A wind turbine is a multifaceted industrial machine consisting of about 15 sub-components—some complex to manufacture, others less so. The tower and blades of the turbine, which accounts for about half of the total wind turbine cost, are considered to be of low to medium complexity to produce. Responsible for 20 percent of a turbine's cost, tower production in particular is well-suited for local manufacture as the assembly is typically decentralized and does not require major capital expenditure or high levels of technological expertise. Additionally, there is sufficient regional demand in North and South Africa to make the business viable—about 500 MW per year will be required by 2030—and old steel yards and shipyards can be easily repurposed to manufacture turbine towers.

The blades of a turbine require higher manufacturing precision, but the advanced technology and skills needed to manufacture them are already in place on the continent, with Africa's first rotor blade factory coming online in Morocco in 2017.

With the right support and incentives, both wind tower and wind blade manufacturers in Africa could capture 10 percent of the local demand by 2025 and 20 percent by 2030. Key here would be the need to create an import-friendly environment for steel, as Africa is currently a net importer of steel. Incentives to develop the local steel industry could also help substitute more expensive imported steel in the longer term, while regulations and incentives supporting local sourcing of wind turbine components would also be necessary to kickstart the industry.

With between just $10 to $30 million investment per plant, major players are not needed to invest and develop the industry. The field is wide open to local players.

Biofuels: Powering cleaner energy using nature's bounty

Africa's biofuel production is negligible compared to international outputs, accounting for less than 0.2 percent of global production.[78] But with abundant sources of biomass on the continent, our analysis indicates that biofuel technologies present an annual market opportunity of over $2

With the right support and incentives, both wind tower and wind blade manufacturers in Africa could capture 10 percent of the local demand by 2025 and 20 percent by 2030.

[78] McKinsey Energy Value Pools Model, July 2020

billion by 2030 and could cut GHG emissions from the transportation and household cooking sectors by 14 $MtCO_2e$ each year.

Used globally as a substitute for fuels such as petroleum, propane, coal, natural gas, traditional biomass, and charcoal, biofuels contain no sulphur and can reduce GHG emissions and increase energy security. And while not eliminating emissions, they provide a viable alternative to high-emitting conventional fossil fuels.[79] Global biofuel production was around 4.2 million barrels per day (mbpd) in 2020 and is projected to reach 5.2 mbpd in 2030, with 60 percent of the market concentrated in the US, Brazil, China, and Indonesia.[80]

Africa has an opportunity to grow its share of this market, notably in the production of bioethanol, one of the most widely-used liquid biofuels for transportation. Bioethanol production feedstocks are split between sugar plants, such as sugar cane and sugar beets, starchy plants like cassava and potatoes, and grains such as corn and wheat, using a fermentation technique. These crops grow readily on the continent. Just one million hectares of land is enough to cultivate the feedstock required to produce around 2.4 billion liters of bioethanol per year. Substituting just 1 percent of projected transportation fuel consumption and around 2.5 percent of household energy consumption with this bioethanol could unlock an annual market opportunity of over $2 billion in 2030. A further benefit is that, as a by-product of sugar cane ethanol, there is potential to produce renewable electric energy from bagasse power plants, creating additional revenue.[81]

The agricultural and manufacturing skills required to gear up this industry are available in Africa, and manufacturing processes for ethanol production are not complex and have been developed and deployed on the continent. However, care must be taken to ensure that production is sustainable. Actions to combat climate change that are too narrowly focused risk directly and indirectly harming nature and vice-versa. To produce biofuels sustainably, diversification of planted crops and improved management of cropland would be important.[82] Another factor to keep in mind is that while biofuel feedstock can compete with food supply, low agricultural productivity on the continent—currently around 60 percent below the global average—could reduce the price competitiveness of locally produced bioethanol.

Nevertheless, if these considerations are taken into account, sustainable biofuels could have an important role to play in Africa's development, providing job creation and access to energy along with reduced pollution and climate change mitigation. Start-ups like Koko Networks are demonstrating the potential. Koko provides low-carbon liquid bioethanol cooking fuel as an alternative to dirty cooking fuels such as charcoal via an informal network of 'fuel ATMs' located inside local shops. Customers can buy fuel in the small daily quantities that are often preferred in the informal sector. The company also makes and sells a cooker and canister and as of August 2021 celebrated a milestone of 200,000 household subscribers in Nairobi using its solution.[83]

This success has, in part, been enabled by government policies, notably the Kenyan Ethanol Cooking Fuel Industry Masterplan, which was co-developed with the Ministries of Industrialisation, Agriculture, Energy and Environment with funding from the International Climate Initiative.[84] The Government of Kenya recently passed one recommendation of the Masterplan, exempting ethanol cooking fuel from VAT in the 2021/22 Finance Act, in order to enable lower consumer prices and accelerate the switch from deforestation-based charcoal.[85]

[79] BioEnergy Research Center 2007-2017 bioenergycenter.org.
[80] McKinsey Energy Value Pools Model July 2020, Energy Insights, IHS.
[81] When burned in a sugar mill, bagasse, the fibrous material left over after juice is extracted from sugarcane, usually produces enough electricity to power all of the mill's operations (biomassmagazine.com).
[82] "Workshop Report on Biodiversity and Climate Change", Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), June 2021, ipbess.net.
[83] Company website, kokonetworks.com.
[84] Kenya Ethanol Cooking Fuel Masterplan, SouthSouthNorth, June 2020, southsouthnorth.org.
[85] "A big win for Kenya: Government reinstates VAT exemption on renewable energy products", Gogla, July 7, 2021, gogla.org.