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# Reimagining industrial operations

**Through innovation, advanced analytics, digitization, electrification, and process efficiencies, carbon-intensive operations underpinning the global economy can shape a more sustainable future.**


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**Ever since the steam engine** helped launch the Industrial Revolution, large-scale operations have boosted living standards, provided richer choices than our ancestors dreamed of—and generated unintended consequences, including pollution. The COVID-19 pandemic presents an unforeseen challenge to industrial operators as they face the immediate impact of plummeting demand for many products, as well as pressing needs to ensure the safety of employees. Yet even as industries grapple with structural changes, and as societies and economies pivot to the "next normal," companies themselves have a window of opportunity to adapt their operations to help reduce the disruption that climate change will ultimately bring. In this compilation, McKinsey experts and corporate leaders describe emerging opportunities for industrial operators to help lead the way to a lower-carbon future.

These range from introducing hybrid-electric equipment (a first step for some) and fully electrifying operations (a key emissions-abatement lever for oil and gas companies), to boosting efficiency through digitization, advanced analytics, and artificial intelligence (practices profiled in a case study of the chemical and consumer-goods company Henkel). Also on the table: business-model innovation aimed at satisfying demand for lower-carbon technologies and more sustainable products (opportunities for miners and cement makers); as well as reorienting supply chains toward more "circular" practices (which is described by apparel executives, the linear descendants of the textile innovators who started the Industrial Revolution). These quick-hit overviews should serve as useful thought starters, and sources of inspiration, for leaders in any industry seeking to chart their own sustainability journey.

# Hybrid equipment: A first step to industry electrification

**Shifting from fossil fuels to full electrification is a big leap for many factories; for some, hybrid equipment offers a practical step to meet long-term financial and environmental goals.**

*by Ken Somers, Eveline Speelman, and Maaike Witteveen*

**For more than a century,** fossil fuels have been essential to powering the world's largest factories. While a sweeping change won't happen overnight, electrification is on the rise, and our recent Global Energy Perspective shows that by 2035 renewables could produce more than half of the world's electricity—in most regions at a lower cost than through fossil-fuel generation.[1] The falling costs of both electrical equipment and renewable electricity generation itself are expected to boost electrification of industrial processes. Regulators, for their part, will continue to bear down on companies' greenhouse-gas emissions. Meeting the 1.5-degree Celsius pathway advocated by the Intergovernmental Panel on Climate Change (IPCC) would require multiple industrial subsectors to electrify at more than twice their current levels by 2050, which are beyond their current economics (for more, see "Climate math: What a 1.5-degree pathway would take," on McKinsey.com). All told, about half of the fuel consumed for energy in industry *could* be electrified with available technology (exhibit).

But practical considerations may slow full-scale electrification for many companies, regions, and applications. Hybrid equipment that can switch between conventional fuel and electricity may, on a case-by-case basis, be a cost-effective first step, particularly for processes such as drying and melting, whose heat requirements collectively account for about 35 percent of fuel consumption for energy in industry today.

## Hybrid: The future begins now

The costs of fossil fuels versus electric power vary, and there is a good deal of uncertainty as to when electric power will become decisively and irreversibly cheaper. Cost-effectiveness depends not only on the relative prices of fossil fuels and renewable electricity at a given industrial site at the moment of purchase, but also on carbon pricing (a rise in which would make industry electrification more feasible), and on whether electric equipment is more energy efficient than conventional equipment over time. Energy costs can be well over ten times greater than capital-investment costs over the lifetime of a typical industrial furnace or boiler, so the stakes are high.

Rather than waiting it out, companies in some circumstances can make a partial switch to electricity right now, by going hybrid for specific applications—using equipment that can run

[1] See *Global Energy Perspective 2019: Reference Case*, January 2019, McKinsey.com.

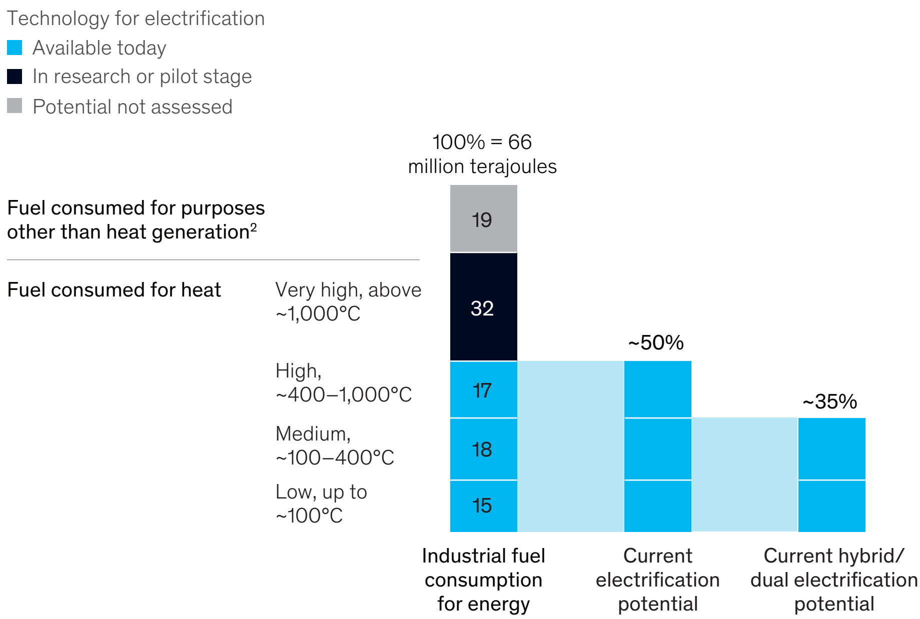
on either electricity or conventional fossil fuel—or installing additional electrical equipment such as electrical boilers in a "dual" setup. Such dual or hybrid equipment is available for producing low- and medium-temperature heat, with steam boilers; key sectors using steam boilers include the chemical, petrochemical, and food industries. Although part-time electrification might not be an end-state solution, hybridization offers significant benefits for industrial companies and society.

With hybrid equipment, companies can make more cost-effective energy choices, using electricity when it costs less than fossil-fuel energy (such as at times of peak renewables production) and switching back to fossil fuels when electricity prices are high. That ties into an additional cost-benefit component: payments that industrial companies could collect as a result of "grid balancing" practices. Grid operators can reward customers for consuming the excess electricity that is generated during peak periods of renewable generation. Making these payments helps grid operators avoid the even greater costs they incur when grids experience strain or outages as more intermittent renewables such as solar or

Exhibit

**About half of the fuel consumed for energy in industry can be electrified with available technology.**

Estimated share of industrial fuel consumption for energy in 2017,[1] %




[1] Figures do not sum to 100%, because of rounding. Sectors included are chemicals and petrochemicals, iron and steel, nonmetallic minerals, nonferrous metals, food and tobacco, transport equipment, machinery, textile and leather, wood and wood products, paper pulp and print, mining, industrial feedstock and other industrial nonenergy use. Excludes industrial fuel consumption for feedstock and current industrial electricity consumption.
[2] Approximately 80% of fuel consumed for energy in industry is fuel consumed for heat. Other uses include HVAC, refrigeration and cooling, and on-site transport. Industrial energy consumption for which the source data does not specify a sector is assigned to this category as well.

Source: Arnout de Pee et al., "Decarbonization of industrial sectors: The next frontier," June 2018, McKinsey.com; expert interviews; "Manufacturing energy and carbon footprints (2014 MECS)," US Department of Energy Efficiency & Renewable Energy, September 2018, energy.gov; Nicolas Pardo et al., *Heat and cooling demand and market perspective*, Joint Research Centre, 2012, publications.jrc.ec.europa.eu; *World Energy Balances 2017*, OECD Publishing, 2017; McKinsey analysis wind power come online. With hybrid equipment, industrial facilities could pocket incentives when grid operators reward them for consuming electricity during these higher-output, lower-demand times. Indeed, grid payments, fees, and connection costs are critical factors that can make or break a business case, and often require contractual renegotiation or regulatory intervention.

In addition, hybrid equipment can enable direct use of electricity from a nearby intermittent renewable-production site, such as a solar or wind farm. Such an off-grid setup could lower electricity costs for industrial companies significantly, as grid-connection costs, taxes, and other levies are mitigated or avoided. Industry could even be considered as a cheap battery, using electricity when available and switching back to fossil-fuel power when required, serving to help stabilize an entire grid.

## The right mix

Purchasing hybrid equipment is most sensible when a company replaces expired equipment or sets up a new facility. For greenfield plants, companies should seriously consider full electric to be future ready. Installing hybrid equipment during replacements and new construction in the near term, though, could make electrification more economical than installing conventional equipment now and switching to electric equipment later. As renewable-electricity prices fall in other regions, hybridization could become an economical near-term option at even more industrial sites.

Changeovers of equipment on industrial sites are slow paced, as the lifetime of industrial equipment can exceed 50 years with regular maintenance. The optimal mix of equipment types will also vary over time based on local factors such as energy prices, regulation, and current setup of the industrial site. These challenges, though, should be interpreted not as a call to go slowly as new technologies continue to be perfected, but as a clarion for industry to begin changing now.

Making the switch can have positive, second-order consequences as well. When industrial players significantly increase their electricity consumption as electricity prices drop below that of conventional fuel, that decreased price level may well act as a floor in the power market. This could further spur the energy transition as it increases the attractiveness of investments in renewable-energy production. Cost leaders, ever focused on how to best allocate their capital, will be ready as the shift gains momentum. Q

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# Meeting big oil's decarbonization challenge

**Oil and gas companies face a serious, even existential decarbonization challenge. One source of quick progress: addressing their own direct emissions.**

*by Chantal Beck, Stephen Hall, and Eveline Speelman*

**Any discussion** about how to mitigate climate change invariably leads to oil and gas. Consumption of the industry's fuels creates one-third of all greenhouse gases (GHG), and operations from oil and gas companies account for another 9 percent of GHG emissions directly. The total—42 percent—is the largest share attributed to any single industry.

Consequently, the pressure on oil and gas producers to change is substantial—and rising. Investors are demanding stronger emissions-reductions plans or are divesting from fossil fuels entirely; wind and solar energy are becoming more effective and affordable; and governments everywhere are eyeing aggressive emissions-reduction targets, with many pledging net carbon neutrality by 2050 or sooner.

For fossil-fuel providers, the long-term implications of such trends are significant, even existential. (For more about what it would take to reach a 1.5-degree Celsius pathway, including the implications for the global consumption of oil and gas, see "Climate math: What a 1.5-degree pathway would take," on McKinsey.com). Indeed, to help keep temperatures below the 1.5-degree threshold set by the Intergovernmental Panel on Climate Change (IPCC), the industry would have to cut its direct emissions 90 percent by 2050, relative to today's levels. Clearly, reaching this target would be easier if the use of oil and gas declined. But even if demand doesn't fall by much, the sector can abate the majority of its direct emissions now and more cost effectively than companies may realize.

## Unwelcome by-products

The production-related activities of oil and gas companies contribute 9 percent of global GHG emissions (3.7 $GtCO_2e$).[1] The biggest GHG culprit—linked to more than 60 percent of the industry's emissions—is natural gas. The gas (primarily methane) often accompanies oil discoveries, but since it is less valuable than oil it is typically burned off. Flaring, or the intentional burning of natural gas, converts the methane into $CO_2$ and accounts for 14 percent of the industry's direct emissions.

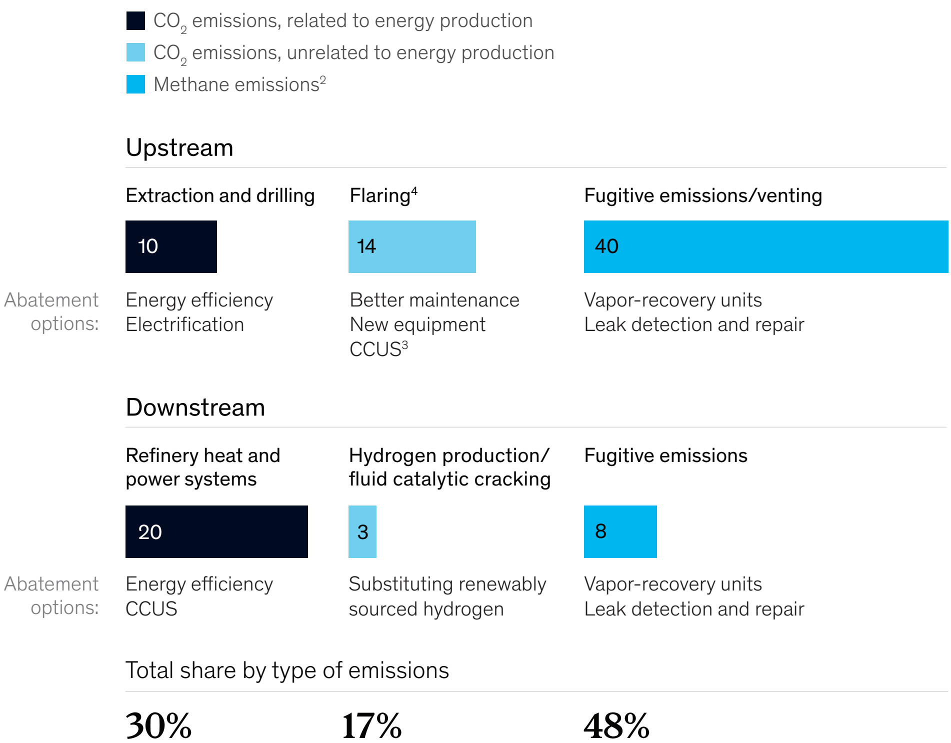
Unburned gas, meanwhile—whether released intentionally or accidentally—represents the largest single source of the industry's direct GHG emissions, at 48 percent. Any methane released into the atmosphere is worrying, as the gas is 86 times more effective than carbon

[1] $CO_2e$ stands for "carbon-dioxide equivalent," a standard unit used to measure greenhouse gases. Emissions are measured in metric tons of $CO_2e$ per year, or multiples such as million ($MtCO_2e$) or billion ($GtCO_2e$) metric tons.

Exhibit

**Flaring, venting, and leakage of natural gas produces more than 60 percent of the industry's direct greenhouse-gas emissions.**

Share of greenhouse-gas emissions in oil and gas industry by production stage,[1] %




**Explanation of terms**

**Flaring** is the intentional burning of gas that emerges during oil and gas extraction and industrial processes.
**Venting** is the intentional release of $CO_2$, methane, or other gases into the atmosphere without combustion.
**Fugitive emissions** include unintentional leaks—eg, those caused by equipment failure or accidents.

[1] Fugitive emissions from midstream are included in upstream to be consistent with IEA's World Energy Outlook 2018 classification; share by type of emissions does not sum to 100%, because midstream energy-related emissions from transport are not modeled—their contribution to the industry's direct emissions is 5%.
[2] Assumes global warming potential (GWP) for methane of 28 on a 100-year horizon.
[3] Carbon capture, use, and storage.
[4] Includes only $CO_2$ component of flaring; methane component is included in fugitive emissions/venting category.

dioxide at trapping heat during the first 20 years of its release. By all accounts, the amount of methane released each year through oil and gas operations is considerable; in 2017 it was equivalent to 6 percent of the global energy sector's total GHG emissions.[2] Other sources of oil and gas emissions, as shown in the exhibit, occur along the industry's value chain, including downstream production activities, which account for about 30 percent of the industry's direct GHG emissions.

## Making moves

While the economics underpinning various decarbonization initiatives depend on factors

[2] *Tracking fuel supply: Methane emissions from oil and gas*, International Energy Agency, November 2019, iea.org.

such as a company's geography and asset mix, our work highlighted a range of options across the industry's value chain—everything from advanced leak detection in pipelines, and renewable-power alternatives for equipment, to carbon-capture and -storage technologies, and the use of bio-based feedstocks in refining. Most options cost less than $50 per ton $CO_2e$ on average (exhibit). The key is to start by prioritizing the most economic moves. One company found that about 40 percent of the initiatives it identified had a positive net present value, and that an additional 30 percent would be "in the money" if the company assumed an internal carbon price of $40 per ton.

Upstream initiatives that typically offer fast paybacks include electrifying equipment and changing power sources. For example, replacing on-site generators with a solar photovoltaic and battery setup helped one oil and gas company reduce its emissions considerably, while breaking even on the investment in five years. Similarly, better leak detection helped another company identify the seals in its pressure-safety valves where methane was escaping. Now, the company sells the captured gas. Another company found that 70 percent of its flaring emissions were the result of poor equipment reliability. The resulting operational improvements helped the company reduce these emissions and improve the overall production of its wells. The collective impact of such moves is huge: we estimate that reducing fugitive emissions and flaring could contribute 1.5 $GtCO_2e$ in annual abatement by 2050, at a cost of less than $15 per ton.

In some circumstances, however, reducing methane emissions would require new infrastructure. Gas flaring in the US Permian Basin, for example, reached an all-time high in the first quarter of 2019, a worrying trend for decarbonization efforts. New gas-processing facilities and pipeline construction would help in situations where oil discoveries otherwise outpace a company's ability to capture and transport the gas. Nonetheless, infrastructure expenses are understandably difficult to entertain in circumstances where it can be more economical for a company to flare natural gas than capture and sell it.

Addressing such thorny dilemmas will test the leadership of oil and gas executives, even as it gives them opportunities to signal the industry's willingness to decarbonize and chart a new future for the industry. And they will want all the good will they can get, recognizing, of course, that the bigger challenge is not the industry's direct GHG emissions but the combustion of its products. Still, every improvement helps, and the speed at which the operational opportunities can be implemented might help gain valuable momentum for the hard work that lies ahead. Q

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# Digital technology and sustainability at Henkel

**Operational excellence is lowering costs and emissions at a "lighthouse" manufacturer.**

*by Francisco Betti, Enno de Boer, and Yves Giraud*

**The industrial sector** is a top energy consumer and the source of more than one-quarter of global $CO_2$ emissions. Process optimization and increased energy efficiency are key to reducing emissions, and digital technology is a big piece of the puzzle.

The World Economic Forum, in collaboration with McKinsey, has been studying how top companies are improving operations using Fourth Industrial Revolution (4IR) technologies. The research has spanned thousands of manufacturing sites, and an independent panel has identified 44 manufacturing "lighthouses," company sites that are resetting benchmarks in areas such as productivity, sustainability, and customization. Henkel, a new member of this Global Lighthouse Network, is using 4IR technologies to lower its carbon footprint across a network of facilities, including the company's Düsseldorf factory, singled out as a 4IR lighthouse site. A closer look at the company's practices offers lessons for manufacturers everywhere.

## Efficiency in practice

Henkel, the German chemical and consumer-goods company, is widely known for its consumer brands—think Dial, Persil, Schwarzkopf, and Loctite. Henkel's adhesive technologies are used in phones, shoes, cars, and planes. The company is seeking to reduce carbon emissions from its 185 production sites by three-fourths by 2030. To do so, it is working to improve its energy efficiency: Henkel aims to triple its value creation relative to the carbon footprint of its operations, products, and services and to halve its energy use per ton of product at its production sites by 2030 (as compared with 2010). This equates to improving its efficiency by a hefty 5 to 7 percent per year.[1]

Digital technology is central to these efforts. Henkel's Laundry & Home Care business unit has implemented a digital backbone that uses the cloud to continuously link global operations end to end. Upon its launch, in 2013, Henkel's Environmental Management System showed simple line diagrams; today, it includes digital twins of the unit's 33 production sites and ten distribution centers. Digital twins are representations (of factories, systems, machines, processes, or products, for example) that incorporate sensor data, user feedback, and other inputs. Each of Henkel's Laundry & Home Care production sites has more than 3,500 sensors, which together with cameras and robots feed 1.5 billion data points into the platform every day.

[1] "Henkel: Sustainable & competitive," CBS News, January 17, 2020, cbsnews.com.

With the help of artificial intelligence and advanced analytics, Henkel is using the data it collects to improve its product quality as well as its operational, financial, and environmental results. The platform tracks and displays efficiency data and energy and water use at each plant (with “traffic light” displays or bar charts, for example), along with data related to fossil fuels, sewage, compressed air, and steam. This allows Henkel to compare the performance of different production sites and identify and promulgate the most effective practices. The platform also helps find patterns and improvement opportunities, as well as malfunctions. For example, if the platform registers an increase in a particular machine’s energy or water consumption, it alerts employees automatically to check for leaks in onsite steam and water pipes; workers are similarly notified if a machine exceeds benchmark consumption levels.

These “local” data are shared in real time, aggregated, and used more broadly across the organization. Henkel Laundry & Home Care’s supply-chain managers have access to data on the business unit’s energy consumption, for example. Employees can also access data from the unit’s production sites, processes, and sensors, using it to coordinate improvement measures.

## Getting results

The impact of Henkel’s moves is evident at the company’s lighthouse facility in Düsseldorf, where the platform helped increase overall equipment effectiveness (OEE) for Persil laundry detergent by 30 percentage points compared with the 2010 level. The site’s energy consumption fell by 38 percent, water use by 28 percent, and waste by 20 percent compared with 2010 levels. Employees at the Düsseldorf site also benefitted: the digital backbone contributed to a 60 percent improvement in plant safety (for example, through the use of electronic warning zones that automatically shut off forklifts when workers get too close).

The company’s digital backbone has helped boost the business unit’s efficiency as well: OEE is up more than 10 percent since 2010, and between 2010 and 2019, the unit’s energy consumption fell by about one-quarter—a reduction of 800,000 metric tons of $CO_2$. (The platform itself was responsible for more than half of these savings; data collected through the platform informed investments that helped further reduce consumption.) All told, the business unit achieved energy savings roughly equivalent to the annual energy consumption of 300,000 people (about the population of Cincinnati). In turn, over the course of the past decade, the unit’s annual energy costs fell by €18 million; the energy savings attributed to Henkel Laundry & Home Care’s digital backbone currently amount to €7.5 million per year. Moreover, the energy savings supported a 36 percent reduction in the business unit’s environmental footprint (encompassing energy use, water use, and waste) over the past decade. Q

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The authors wish to thank Henkel’s Dr. Dirk Holbach and Wolfgang Weber for their contributions to this article.

# Tackling the mining sector’s climate-risk challenge

**The global mining industry faces increasing physical risks from a changing climate and mounting pressure to decarbonize. Creating a climate strategy is challenging—and increasingly urgent.**

*by Liesbet Grégoir, Kimberly Henderson, and Jukka Maksimainen*

**Mining is no stranger** to harsh climates: much of the industry already operates in inhospitable conditions. But forecasts of heavy precipitation, drought, and heat indicate that these effects will become more frequent and intense, creating new physical risk for mining operations.

Meanwhile, the industry also faces a stiff decarbonization challenge. Mining operations are directly responsible for 4 to 7 percent of global greenhouse-gas (GHG) emissions, at least three-quarters of which are methane emissions from coal mining.[1] The industry has begun setting emission-reduction goals, with some companies’ published targets as high as 30 percent by 2030—significant, although still below a pathway that is aligned with the Paris Agreement.

Rising pressure from the changing climate, as well as from governments and investors, is starting to catalyze additional action. More is needed, and, as it comes, it should help mining companies benefit from emerging opportunities to provide the raw materials needed for new technologies—and to work toward a more sustainable future.

## Water stress

Today, 30 to 50 percent of production in copper, gold, iron ore, and zinc is concentrated in areas where water stress is high, and it is likely to grow as climate change causes more frequent droughts and floods.[2] Seven water-stress hot spots stand out: Central Asia, the Chilean coast, eastern Australia, the Middle East, southern Africa, western Australia, and a large zone in western North America. Altering the supply of water to at-risk mining sites, which collectively accounted for roughly $150 billion in revenue in 2017, could disrupt operations at many of them.

To improve resiliency, companies can reduce the water intensity of their mining processes, recycle used water, and reduce water loss from evaporation, leaks, and waste. Longer-term approaches such as dams and desalination plants are possible, but expensive. Companies

[1] The industry’s indirect emissions (also known as “Scope 3” emissions) are much larger, accounting for 28 percent of global GHG emissions. These include the combustion of coal.

[2] High water stress denotes a ratio of water demand to water supply of 40 percent or greater.

can also rely on so-called natural capital—for example, wetland areas—to improve groundwater drainage (For more about how companies can mitigate water stress, see “Water: A human and business priority,” on McKinsey.com.)

Flooding can also cause operational disruptions, including mine closures, washed-out roads, and unsafe water levels in tailing dams. Safe-guards include improving drainage and pumping techniques, as well as adapting roads (by, for example, using hard metal or crusted rock for speed drying or building sheeted haul roads). First Quantum Minerals did the latter at its Sentinel copper mine in Zambia. Another option for some mines is to bypass trucking altogether with conveyors.

## The decarbonization challenge

All industries have critical roles to play in limiting warming to 1.5 degrees Celsius above preindustrial levels, a goal that the Inter-governmental Panel on Climate Change believes will mitigate the worst risks of climate change (for more, see “Climate math: What a 1.5-degree pathway would take,” on McKinsey.com). Mining’s piece of the puzzle is big: a reduction by 2050 of at least 85 percent of direct emissions from 2010 levels. (A 50 percent reduction would be more consistent with a 2.0-degree pathway.) Achieving such reductions would require major contributions across the industry’s value chain.

While the decarbonization potential for mines varies by commodity, mine type, power source, and other factors, our work suggests that mines could fully decarbonize their direct $CO_2$ emissions (equating to roughly one-quarter of the industry’s direct GHG emissions) through a mix of operational efficiency, electrification, and renewable-energy use. Capital investments are required to achieve most of this potential, but certain measures are economical today for many mines.

Moving to renewable sources of electricity should become increasingly feasible, even in

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off-grid environments, as the cost of battery packs is projected to decline by 50 percent by 2030. In some cases, battery electric vehicles have a 20 percent lower total cost of ownership than traditional internal-combustion-engine vehicles. That said, the electrification of mining equipment, such as diesel trucks and gas-consuming appliances, is only starting to become economical, and just 0.5 percent of mining equipment is fully electric at present.

The remaining three-quarters of mining industry GHG emissions would be much tougher to mitigate. These are the emissions that result from coal mining, specifically the release of naturally occurring methane found in many coal beds. While solutions exist for capturing this so-called fugitive methane and using it to generate power, there are no ready solutions for all types of mines, and the required investment is not economical in many cases.

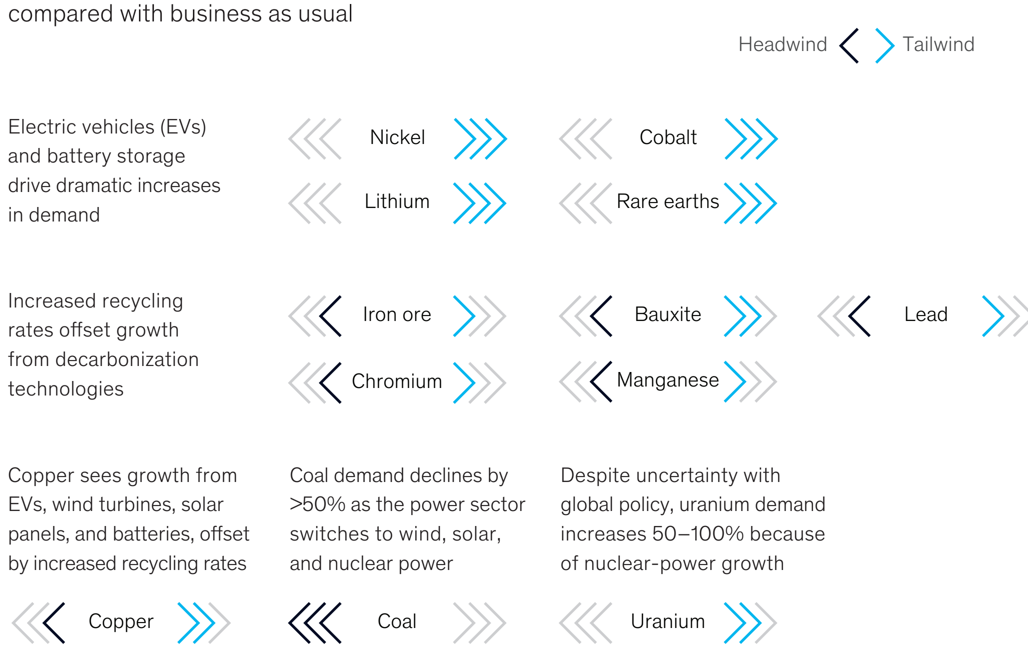
## A look ahead: Shifting demand

Against a stark backdrop of physical risks and operational challenges, a warming climate would bring opportunities for some mining companies as well. If global industries commit to cutting emissions in line with Paris Agreement targets, demand would grow for low-carbon technologies such as wind turbines, solar photovoltaics, electric vehicles, energy storage,

Exhibit

**Even a 2°C scenario would be a significant deviation from business as usual, leading to a range of demand shifts for many minerals by 2030.**

Degree of headwind and tailwind in 2°C scenario[1] in 2030, compared with business as usual




[1] Based on 2°C scenario from International Energy Agency (IEA).

Source: *Energy Technology Perspectives 2017*, IEA, June 2017, iea.org; *The growing role of minerals and metals for a low carbon future*, World Bank, June 2017, documents.worldbank.org; World Bank; McKinsey analysis metal recycling, hydrogen fuel cells, and carbon capture and storage. The mining industry could provide raw materials for many such technologies, creating “tailwinds” for mined commodities including copper, nickel, cobalt, and lithium (exhibit).

Meanwhile, the evolution of downstream production processes may boost demand for low-carbon metals. For example, some automotive companies that manufacture products using a carbon-neutral process are asking suppliers to deliver carbon-neutral parts, often made with niche metals. Niche commodities would probably not be able to replace earnings from coal, which currently represents about 50 percent of the global mining market, but they could help manage losses. For miners, a rebalanced portfolio would require sophisticated market intelligence and flexible assets, agile characteristics that could become a competitive advantage in enabling responses to mineral-demand shifts.

There’s no sugarcoating it: The effects of climate change on mining companies are likely to be significant, systemic, and long term. Still, by getting creative—through innovation to adapt operations and business models—mines can boost their resilience, and their decarbonization potential. Q

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*For the full report on which this article is based, see “Climate risk and decarbonization: What every mining CEO needs to know,” on McKinsey.com.*

# Spotlight on sustainable sourcing in fashion

Four apparel-industry executives describe the need for collaboration, transparency, and a long-term view.

## The good guys will win

*Edwin Keh, CEO, HKRITA (The Hong Kong Research Institute of Textiles and Apparel)*

I think it is apparent to everybody right now that we have too much of everything—too many brands, and too many manufacturers consuming too much material and producing too much waste. There will be a zero-sum game where the good brands and the good manufacturers will win at the expense of the ones that are not as prepared. Consumers will start picking sides—and the good guys will win.

At HKRITA, the traditional research methodology is an eight- to ten-year timeline, but, for sustainability, that pace is too slow. We are looking to move to a faster cycle in which we do a lot of things in parallel—comparable to software development in how it flows very quickly from an idea to industry scale.

For example, we recently proved the business case for recycling. We opened a recycling mill in Hong Kong to process postconsumer waste, turning it back into usable yarn for manufacturing. In fact, this yarn is now selling at a discount to comparable virgin yarn. If a recycling mill can operate in the most expensive economy in the world, there is no city in the world that has a reason not to recycle.

## A race to the top

*David Savman, general manager, global production, H&M Group*

Sourcing is changing. For decades, it's been about moving further away from home and finding areas with large workforces. Now, it's not a race to the bottom, it's a race to the top—you need the most efficient suppliers, and you need the most mature and developed suppliers. Those two parameters put enormous, and different, demands on the industry.

Within that, sustainable sourcing poses a huge opportunity, as it makes the industry itself sustainable. It's also one of the biggest areas in attracting and retaining talent. But sustainability issues are complex. As an industry, we have work to do in understanding all the elements and collaborating with different stakeholders to meaningfully engage.

There is a misperception that incentivizing sustainability and focusing on cost is a balancing act. A supplier that is a high performer in sustainability will often be the one that offers better control of their cost, as they are efficient—they run a good business and don't waste resources.

Ultimately, there is no downside to transparency. It leads to better engagement with consumers on complex issues and serves as a driver for development. It's easy for brands to hide behind complexity—we need to simplify as much as possible through transparency.

## No shortcut to sustainability

*Teresa Yang, vice chairman, Esquel Group*

Today, the impacts of climate change are undeniably felt by all. Our colleagues across our global operations in China, Malaysia, Sri Lanka, Mauritius, and Vietnam have experienced firsthand the consequences of typhoons, floods, and droughts in increasing frequency and magnitude.

In this regard, I like to think of ourselves as pioneers, having the ability to demonstrate how to manufacture with a minimal impact on the environment. We also look for innovative ways to weave available technology into our operations. Our investment in the water-recycling facilities in Gaoming, China, currently treats 38,000 tons of wastewater and recirculates 2,000 to 3,000 tons of treated water daily back to our manufacturing operations, substantially surpassing regulatory standards. Since 2005, we have reduced per-unit output consumption of water by 67 percent and electricity by 49 percent.

On the recycling front, we are working on reclaiming and recycling cotton waste. With spinning, weaving, and knitting experts working in close collaboration, we are able to create recycled blended yarn of high quality and strength. In recycling, there is still a lot of work needed around the whole supply chain because the collection process and logistics cost of recycling discarded garments are still major challenges.

Investing in sustainability almost never guarantees immediate returns. There is no shortcut to sustainability. Only if we continue to collaborate with clients, governments, suppliers, and partners can we look back years from now and say that the world we live in has improved.

## Know your starting point

*Cameron Bailey, executive vice president, global supply chain, VF Corporation*

In the not-so-distant past, "sustainability" was used primarily as a tool to mitigate reputational risk and ensure compliance. Our world changed quickly, and companies, including VF, have come to clearly understand that transparency and traceability are critical to the future. To that end, [we have] set a goal to trace all products through our entire supply chain and share as much information with our consumers as possible. This may come in the form of "ingredient" labels for our products or pictures or videos direct from the factory floor with testimonials from the workers themselves.

However, like most things within a global supply chain, it's complicated. Consider our Vans brand: we found there are as many as 56 different suppliers involved to make one pair of shoes. While [traceability] work is tedious, it's vital to fulfilling our purpose-led commitments. We expect to achieve similar transparency for another 150 products by the end of 2021.

The responsibility of the supply chain is to align the commercial view with our purpose-led vision of protecting the planet and improving the lives of people. An essential first step is to establish a clear baseline of data; you can't know the best path forward if you don't know your starting point.

*For the full interviews, see "Fashion's new must-have: Sustainable sourcing at scale," on McKinsey.com.*

# Reimagining the cement industry in a low-carbon world

**The cement industry is a top source of emissions—but abatement pressures could prompt efforts to reimagine the business.**

*by Sebastian Reiter, Patrick Schulze, and Ken Somers*

**As a key component of concrete—**the second most consumed product globally after potable water—cement is an integral part of our everyday lives. Cement production is also a major source of global $CO_2$ emissions, accounting for 7 percent in 2017. Two-thirds of the industry's emissions result from the calcination, or chemical decomposition, of raw materials such as limestone; decarbonization is especially challenging, as carbon emissions are intrinsic to the calcination process.

Nonetheless, our research suggests that, in principle, the industry could reduce its 2017-level emissions by more than three-quarters by 2050 (exhibit). About one-third of the abatement would come from traditional operational measures, with the remainder requiring new technologies and the adoption of alternative building approaches. This innovation imperative would be beneficial for the industry as it increasingly coexists—and competes—with more sustainable building materials. Growth and decarbonization therefore represent big, interrelated challenges: cement makers that pursue technological advancements and rethink their products, portfolios, and partnerships will be better positioned to succeed at both.

## Operational advances

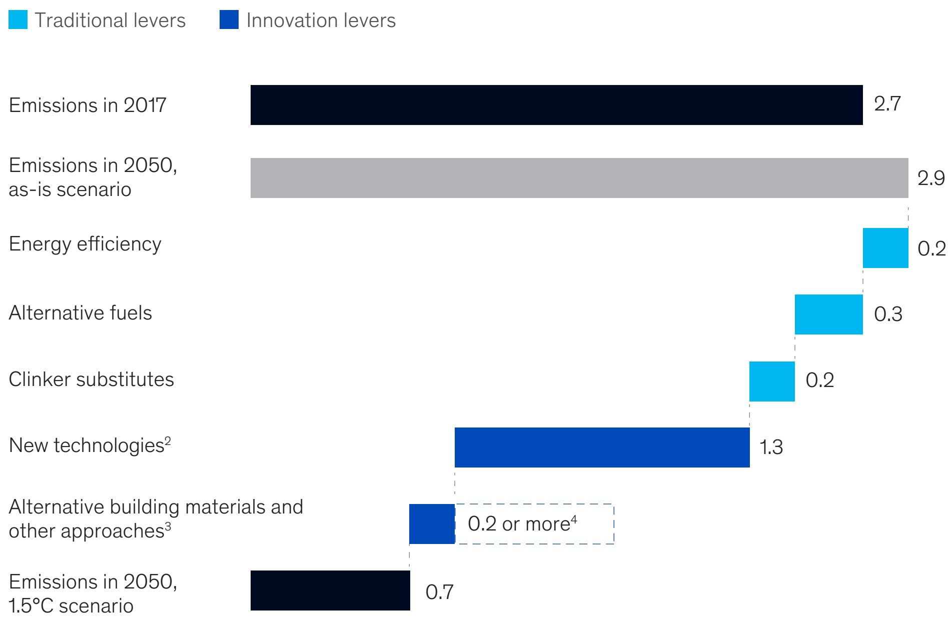
Building on decades of efforts to improve efficiency, traditional abatement levers could reduce emissions by about one-fifth by 2050. Cement kilns use a tremendous amount of heat to produce clinker, the core component of cement. In addition to deploying more clinker substitutes, the industry could reduce energy intensity through better plant utilization and by increasing equipment effectiveness; recovering waste heat could also provide carbon-free electricity. Another promising efficiency lever: advanced analytics. A European cement producer achieved 6 percent fuel savings by creating self-learning models of the kiln's heat profile and optimizing the shape and intensity of the kiln flame. Future cement plants could leapfrog competitors by combining digital and more sustainable operations. Finally, incorporating alternative fuels such as waste and biomass to replace fossil fuels, a multidecade trend in the industry, could reduce emissions by nearly 10 percent by 2050.

None of this will be easy. Biomass supplies vary by region, and other industries are vying for them. Clinker substitutes, too, are limited.

Exhibit

**The cement industry could cut three-quarters of its carbon-dioxide emissions by 2050.**

Potential $CO_2$ emissions and reductions,[1] $GtCO_2$ annually




[1] Effect might be smaller or larger depending on speed of shift.
[2] For example, carbon capture, use, and storage; carbon-cured concrete; 3-D printing.
[3] For example, cross-laminated timber, lean design, prefab/modular construction, building information modeling.
[4] Alternative building materials and other approaches will likely play an important role in the decarbonization of the cement industry, but a great deal of uncertainty remains as to how much they will reduce emissions.

Source: "Getting the numbers right," Global Cement and Concrete Association, 2017, gccassociation.org; *Global Cement*, fifth edition, Freedonia Group, May 2019, freedoniagroup.com; *The Global Cement Report*, 13th edition, CemNet, cemnet.com; Umweltbundesamt (German Environment Agency); McKinsey 1.5-degree-pathway model; McKinsey Cement Demand Forecast Model

Natural pozzolans (volcanic rock and ash, for example) have not yet been assessed at scale. And industrial byproducts that serve as clinker alternatives, such as fly ash from coal-fired power plants and slag from steel blast furnaces, could be in shorter supply as the power and steel industries decarbonize and produce less waste.

## Technological innovation

Innovation will be critical to achieving the cement industry's sustainability and performance potential, with promising avenues already emerging. For example, Solidia, a New Jersey start-up, uses a lower proportion of limestone in its cement, which results in fewer process and fuel emissions; the company's process also locks in additional $CO_2$, which is added before the concrete cures.

Adding $CO_2$ makes the concrete stronger and reduces the amount of cement needed. Carbon-cured concrete could also use $CO_2$ captured during cement production. Today's methods could sequester up to 5 percent of the $CO_2$ produced during production, but newer technologies could sequester 25 to 30 percent. Products such as carbon-cured concrete, positioned differently, could earn a "green premium," potentially giving companies an edge among environmentally conscious buyers—and greater pricing power.

On the horizon are carbon capture, use, and storage (CCUS) technologies. While frequently costly and perhaps (for now) more suitable for making higher-value products, such as steel, by 2050, they could more than halve emissions. A number of postcombustion carbon-capture pilots are underway, driven by the large cement players. Other companies are testing oxyfuel combustion, a promising but expensive technology that results in high concentrations of $CO_2$ in flue gas, which in turn allows for near-total carbon capture.

Ultimately, capitalizing on technology and innovation will require more investment, as well as a shift in mindset for companies that have become too comfortable with the status quo. Many cement players are not used to relying on partnerships, or to operating in the kinds of ecosystems that are second nature in other industries. With innovation timelines of five to ten years, some companies could soon find themselves playing catch-up.

## New growth horizons

Sustainability ultimately may be the catalyst that pushes the industry to seek growth via new business models, partnerships, and construction approaches. Cement-based concrete will remain the global construction material of choice, but "sustainable construction" value chains are likely to emerge on the regional and local levels, necessitating a reorientation of many corporate portfolios.

In the United Kingdom, for example, recycled material from construction and demolition waste is increasingly being used to replace aggregates in concrete. Cement makers have been slow to seize the opportunity, ceding the

waste-recycling business to local construction companies. Meanwhile, in other markets traditional cement may compete with an improved variety—energetically modified cement (EMC)—which releases less carbon and requires less energy to produce. EMC has already been used (in combination with traditional cement) for a variety of projects in Texas.

Other opportunities lie beyond cement and concrete. Alternative building materials and other approaches will likely play an important role in the decarbonization of the cement industry, though a great deal of uncertainty remains as to how much they will reduce emissions. Cross-laminated timber (CLT), for example, is already in use in a number of markets and has been buoyed by its reputation as a green material. Should roughly 10 percent of cement be replaced with CLT, carbon emissions would be reduced by up to 750 million tons each year (about 2 percent of global emissions).[1]

Additional new value pools include prefab, modular housing, which incorporates off-site production, as well as building information modeling (BIM), which allows stakeholders to visualize products digitally, evaluate various building materials, and plan large projects more efficiently. Greater transparency means less waste and likely a reduction in the amount of cement or concrete required. Indeed, digital technology is at once supporting the cement industry's decarbonization efforts and contributing to its growth challenges.

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Cement makers are approaching a moment of truth. Challenges such as decarbonization, ongoing value-chain disruption, and competition against the construction ecosystem's entire patchwork of players all loom large. With the right mindset, decarbonization and reinvention can go hand in hand: just as automakers increasingly view their role as providing mobility—not just making cars—cement companies could likewise be in the business of providing construction solutions. As climate pressures increase and sales of traditional cement and concrete face threats, the combination of new thinking, innovation, and new business models will be critical to helping ensure a profitable—and greener—future. Q

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[1] This would require the sustainable harvesting of about one-tenth of the existing boreal forest (located in the Northern Hemisphere). CLT comes with the advantage of considerable carbon sequestration: for each ton of carbon emissions avoided, two additional tons of carbon are sequestered.