

The decoupling of GDP and energy growth: A CEO guide

Energy intensity is decreasing, renewables are gaining, and new efficiencies are on the way. Here's how to build the resilience you need to navigate rapid change.

by Namit Sharma, Bram Smeets, and Christer Tryggestad

It's long been axiomatic that economic growth and energy demand are linked. As economies grow, energy demand increases; if energy is constrained, GDP growth pulls back in turn. That's been the case since the dawn of the Industrial Revolution, if not long before.

But past is not always prologue. Our latest global energy perspective—part of a multiyear research effort examining the supply and demand of 55 types of energy across 30 sectors in some 146 countries—suggests that we're beginning to see a decoupling between the rates of economic growth and energy demand, which in the decades ahead will become even more pronounced.

That's not because the world will be less “energy hungry.” People will continue to use energy in their daily lives, and happily, in the decades ahead, more people will have access to more modern appliances and on-the-grid housing. Businesses will still need energy to run; economies will require it to grow. Nonetheless, new technologies and larger trends should cause the energy demand curve to flatten.

Indeed, the energy landscape as we know it is poised for foundational change between now and 2050. What does this mean for companies and their leaders? For starters, your core business model may be tested, and new opportunities—and challenges—beyond it will almost certainly arise. Moreover, determining the right path

will require companies to adapt both urgently and in measured stages. Navigating the great decoupling will take resilience. Farsighted leaders should start preparing now.

Energy and industrialization: A slow burn

Energy demand has long tracked economic growth. So much so that for the past two centuries, the amounts of energy that economies need have increased virtually in lockstep with the amounts of wealth that economies create. And, to a remarkable degree, wealth creation has depended on a society's proficiency at burning things.

In 1800, the fuel of choice was biomass, such as wood from fallen trees. Even during the latter half of the 19th century, after the United States and parts of Europe had begun to industrialize, many economies ran primarily on biomass. Biomass was highly inefficient as fuel, as almost all of its embodied energy was lost in its burning. Still, before widespread industrialization, the conversion loss was bearable; generally, there was enough wood to burn to make economies grow. The resulting wealth creation wasn't enormous, but it was pointing up. Primary energy demand (the demand for energy in its raw form, before it has been converted to secondary energy such as electricity or district heating) pointed up as well, growing at about 1 percent per year from 1850 to 1900.

Then, at the turn of the 20th century, rates of both energy demand and economic growth took off. From 1900 to 1950—as horses gave way to cars, oil lamps to electric lighting, and ice boxes to refrigerators—primary energy demand nearly doubled. Economic growth rates soared as well; in the United States (by far the largest economy in the world), GDP per capita in 1950 was more than twice that of 1900.¹ For that level of wealth creation, burning trees and other forms of biomass wouldn't suffice.

But burning fossil fuels would suffice, and the 20th century's embrace of petroleum (to accompany coal) sent production and consumption into overdrive. Fossil fuels lose about 40 to 70 percent of their embodied energy when converted into electrical or mechanical energy—a lot, but not when compared with the near-total loss incurred by burning wood. While larger economies need more tons of coal and barrels of petroleum to grow faster, the burning goes a longer way (Exhibit 4).

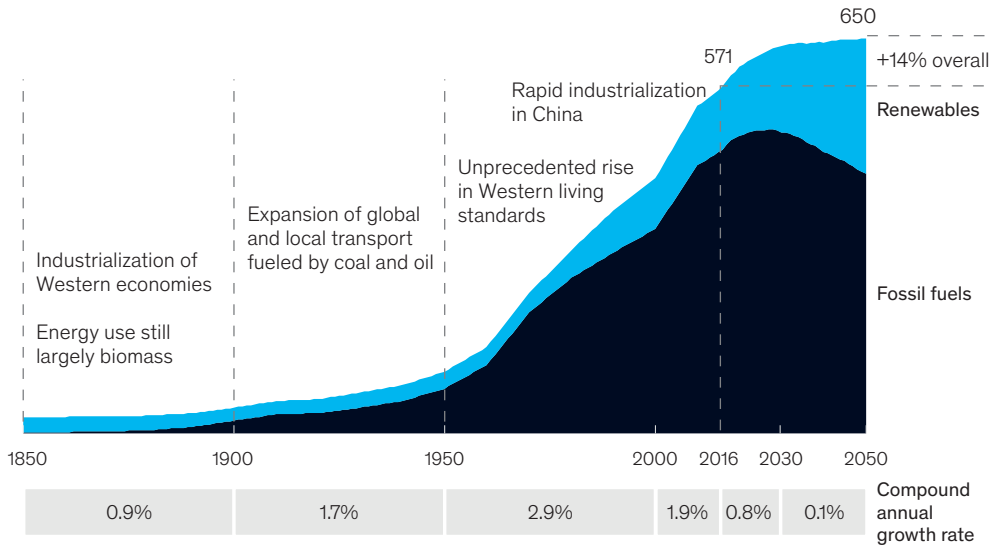
Over the second half of the 20th century, with living standards in the West and other advanced economies rising, the growth in energy demand accelerated even more. Those dynamics have continued into this century, as China has helped power global GDP to a median rise of 3.7 percent per year since 2000, with global energy demand continuing to rise as well. And 21st-century economies will continue their ascent. The world population will continue to grow, potentially reaching ten billion by midcentury; the plateauing of Chinese and Organisation for Economic Co-operation and Development (OECD) populations will be more than offset by significant increases in India, other parts of Asia, and, especially, Africa, where more than 50 percent of the world's projected population increases will occur through 2050.

¹ See Jutta Bolt, Marcel Timmer, and Jan Luiten van Zaden, "GDP per capita since 1820," in *How Was Life?: Global Well-being Since 1820*, ed. Jan Luiten et al. (Paris: OECD Publishing, 2014), pp. 57–72.

Exhibit 1

After a century of rapid growth, energy demand is likely to plateau around 2030, primarily driven by the penetration of renewable energy sources into the energy mix.

Global primary energy demand, millions of terajoules



Source: McKinsey Energy Insights' Global Perspective, January 2019

Nonetheless, our analysis suggests that while a more populous world will create more wealth than ever, energy demand rates will plateau and demand rates for fossil fuels will begin to *decline* worldwide. How can that be?

Decoupling energy demand from economic growth

The decoupling of the rates of economic growth (climbing steadily) and energy demand growth (ascending, but less steeply) will largely be a function of the following four forces:

- **a steep decline in energy intensity of GDP**, primarily the consequence of a continuing shift from industrial to service economies in fast-growing countries such as India and China
- **a marked increase in energy efficiency**, the result of technological improvements and behavioral changes
- **the rise of electrification**, in itself a more efficient way to meet energy needs in many applications
- **the growing use of renewables**—resources that don't need to be burned to generate power—a trend with the potential not only to flatten the primary energy demand curve but also to utterly change the way we think about power

These drivers will rewrite the world's growth-and-energy story and thus have big implications for a range of industries. Each driver is worth a closer look.

Service economies and the decline of energy intensity

Advanced economies tend to become service economies, and the energy intensity of service sectors is substantially lower than that of industrial sectors—in some cases, as low as one-twentieth. Services already are dominant within OECD countries, with the service sector in the United States, for example, contributing about 80 percent to national GDP. In China and India, lately two of the greatest engines for energy demand, the share of services in GDP will grow by almost ten percentage points in the next two decades.

The efficiency effect

The second factor checking energy demand is the increased efficiency with which energy is put to use. While a growing middle class in many emerging economies will trigger spectacular increases in the demand for products such as refrigerators, laundry machines, and air conditioners, advances in LED lighting, smart appliances, and other applications will substantially lessen the energy intensity of households worldwide. In more developed countries—and to an extent, globally—changes in users' mind-sets will also boost efficiency. Not only are people beginning to be more conscious about their behavior (such as turning off lights and air conditioners when they're not in use), they're benefitting from innovations such as automatic sensors and controlled devices, which eliminate the bother of worrying about such things.

Companies across sectors will reap the benefits as well. Precisely, because energy costs can comprise a significant share of total expenses in a variety of business models, energy savings often have an outsized effect on the bottom line. This incents implementation of efficiency measures and makes it likely that large-scale improvements will come faster. And while it is conceivable that if electricity costs decline dramatically, incentives to change behavior, invest in efficiencies, and alter consumption patterns could be diminished as a result, so far the trends toward efficiency continue unabated as the demand for electric power grows. Government-mandated standards will also help accelerate adoption and enforce switching. Efficiency investments that are more quickly in the money, such as lighting and improved heating, ventilation, and air-conditioning (HVAC) systems, will likely be implemented first. Yet even projects with longer payback times and more expensive efforts, such as significant decarbonization initiatives, will eventually be commercialized, tamp down energy needs over the longer term, and prove a net positive for value creation.

For plants and factories, energy efficiencies will manifestly help move the needle. Within the global buildings segment, energy intensity will decline as new, energy-efficient technologies are adopted. As a result, the energy needs per capita at a global level will be 10 percent less in 2050 than they were in 2016, despite the rapid rise in demand from the many households entering the middle class in emerging economies. And the transportation sector will realize some of the most dramatic efficiencies of all. The shift to electric vehicles (EVs), combined with improvements to

internal-combustion-engine (ICE) vehicles, means that overall energy needs for road transport will increase only slightly—even while the total number of cars and trucks on the world’s roads will likely more than double.²

The rise of electrification

A third reason why energy demand should plateau is the promise of electrification. Combustion-powered motors top out at about 40 percent efficiency; electric motors can exceed 90 percent. Given forecasted declines in electric-battery costs, passenger-car EVs could reach cost parity with their ICE-powered counterparts before 2025, with many larger types of vehicles reaching price parity soon thereafter. The rise of EVs will not only shift demand from petroleum, it will also curb the total amount of energy required for road transportation. For passenger cars, electric motors require less than one-third the energy as ICE motors for every kilometer driven. Critically important as well to the overall energy mix is exposure to price signals; oil is becoming significantly more price elastic (for more about our modeling assumptions and conclusions, see sidebar “Methodology and aggregate conclusions”).

The growth of renewables

The growth of renewables is essential to understanding why the primary energy demand curve will level off between now and 2050. When we think about how much gasoline our cars need to go, how much electricity needs to come out of a socket to make an appliance work, and how much coal, natural gas, or nuclear fuel must be fed into a power plant to generate the steam that turns the turbines, we naturally start with the amount of fuel inputs needed. With renewables, however, those metrics are practically meaningless. We don’t measure what fuels a solar panel or pushes a windmill—we measure the energy that comes out.

Most important, the near total absence of any conversion loss is radically different: nothing is lost in the burning. Nor do sunshine or wind power need to be generated at large, centralized plants; companies, and indeed individual consumers, can in many cases harness the energy on-site. While most businesses will not be able to go completely or even largely off the grid, many will be able to lessen their electrical costs materially—and some, particularly large retailers, may even in certain locations produce a net energy surplus.

Of course, these types of renewable energy need to be captured and stored. Technological improvements to solve those challenges and reduce costs substantially, however, are in process. The levelized cost of energy (that is, the net present value of the unit cost of electricity over an asset’s lifetime) for renewables has been declining remarkably during the past two decades. We expect that by 2020, wind and solar generation will be cheaper than electricity generated conventionally by new-build coal and natural-gas plants, almost everywhere. By 2025, renewables should be competitive even with the marginal cost of just running existing conventional plants in many countries and regions (Exhibit 2). Our analysis further suggests that renewables, including wind, solar, and also hydro power, will provide more than half of the world’s electricity by 2035.

² Matthew Nitch Smith, “The number of cars will double worldwide by 2040,” *Business Insider*, April 20, 2016, businessinsider.com.

Methodology and aggregate conclusions

Although the great decoupling of GDP and energy growth reflects enormous forces and trends at the highest level, our findings are grounded in a model built from the bottom up. The result is an integrated outlook on global energy systems based on the inputs of hundreds of McKinsey experts around the world, from fields including oil and gas, transportation, renewable energy, and basic materials.

Many of the global trends that shape the future of energy are in fact driven by a multitude of local trends, which will occur at different magnitudes and speeds in specific geographies and sectors. To capture this granularity, our model offers a detailed outlook across 146 countries, 55 energy types, and 30 sectors and then aggregates these developments to establish a global outlook as a basis for our insights.

Reflecting on our own analyses and stress-testing them with numerous experts, we find that three important tipping points in the energy landscape will come within reach in the very near future:

- 1. Renewables.** As the cost of renewables has come down further, many countries will reach a tipping point in the coming five years, where new-build solar or wind capacity is cost-competitive with the fuel cost of existing conventional plants. As a result, we see a further acceleration of the ramp-up of renewables.
- 2. Vehicles.** Similarly, as the cost of batteries continues to decline within the next five to ten years, many countries will reach the point at which electric vehicles are more economical than internal-combustion-engine vehicles. This will be true not only for passenger cars but also for most commercial-vehicle segments such as trucks and buses.
- 3. Emissions.** For the first time, we project a peak in global carbon emissions, despite continued economic growth and a growing global population. Triggered by a drop in global coal demand and flattening oil demand, carbon emissions are expected to start to decline by the mid-2020s.

As we compared our outlook to forecasts from previous years, we found that critical developments in the energy transition are dramatically speeding up. Technological improvements beyond the expected have been a common theme for forecasters in the past. While there will doubtlessly be checks on the great decoupling going forward, the stark conclusion is that foundational changes are not only advancing, they're accelerating.

A playbook for energy resilience

Advances in efficiency are a net positive, but they also will roil through industries and companies in complex ways. Navigating the energy changes, therefore, and continuing to adapt as the foundations shift will take resilience.

Once more, consider EVs. Five years ago, though you'd have perhaps driven a Prius, Tesla, or Leaf, electric cars were still just a tiny niche, comprising only 0.4 percent of new-car sales in 2014. In 2018, the share of new-car EVs has more than tripled—and that's as a global average. In several countries, the share exceeds 5 percent. In Norway, with the support of aggressive regulatory incentives, EVs make up about 40 percent of new-car sales—and the level is rising. Every major automaker is moving aggressively to add EVs to their portfolios, with new players joining worldwide. That will transform not only the mix of cars on the roads but also the very definition of mobility: from the inevitable growth of charging stations to the possible reinvention of the dealer-maintenance model (let alone car insurance), as autonomous vehicles change mobility further. What were once “best guesses,” something to be aware of over the next decade, have become key inputs that can make or break a project's net present value today.

More opportunities and harder choices are approaching, many of them rapidly. Regulatory responses to emissions challenges may well have an impact on energy costs and could especially affect balance sheets in carbon-intense industries. As well, bans or limitations on such things as single-use plastics or diesel-fueled cars in city centers will introduce new constraints on an immense number of businesses, while giving rise to second-order effects with unforeseen implications.

Don't assume you'll have enough lead time to react on the fly. As a first step to getting ahead of the energy transition, we encourage leaders to think critically about potential sources of value, shifting competitive dynamics, and regulatory policies that could affect both the revenue and expense sides of the ledger (Exhibit 3). To achieve energy resilience, your business should preserve flexibility in its core—and seize opportunities beyond it.

Flexibility at the core

We know that the aggregate energy intensity of global economies will fall. We know, too, that different types of energy will capture expanding slices of the pie. And we suspect that comprehensive environmental regulations may increasingly take hold. A new world offers new opportunities for value from flexibility in resources: refineries that can pivot from producing diesel to making gasoline (and vice versa), greater power storage capabilities than ever before—to name just a few examples. Yet for leaders trying to align their operations with shifting energy realities and deciding how to invest accordingly, going all-in too fast can come with a first-mover disadvantage. To maximize your degrees of freedom, strive for modularity and smaller projects. The first electric heat pumps will be expensive, and the rapid advances of energy technologies will make all-or-nothing investments perilous.

Winning companies will stage smart bets over time. For example, one multinational energy company has adopted a 15-year plan to invest in different energy segments, specific infrastructure projects, and targeted regions. The strategy isn't pie in the sky.

Be prepared with a watchlist for the energy transition.

The shifts in the energy landscape will have profound implications for many companies, far beyond the energy sector itself, changing the roles they play or the products they offer.

Transformation of businesses

A retailer becomes an energy producer—eg, installing solar panels on store roofs.	As transport as a service eclipses car ownership, an OEM becomes a service provider.	Producers of fossil fuels move into new energy types or invest in storage solutions.
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New market dynamics

New forms of competition emerge—eg, energy systems become giant network economies.	Consumer preferences shift increasingly to green products and circular solutions.	Value chains transform—eg, utilities operate and maintain their own wind turbines instead of outsourcing to OEMs.
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Government policy and regulation

Climate change mandates affect energy costs and alter the balance sheet of carbon-intensive sectors.	Bans—eg, on plastics or diesel—constrain business operations.	Performance standards—eg, forced efficiency improvements for cars or appliances—accelerate adoption of next-generation technologies.
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Out of the multiple initiatives the company vetted and modeled, more than two dozen have been given the green light, staffed, and funded. The objective is to double earnings within ten years even while accounting for a wide range of price environments. The plan also pushes the company out of its traditional comfort zones and into cleaner energy technologies, including significant investments in biofuels.

Remember, even if you don't plan for your energy profile to change, the world does. Those shifts can be transformational, and they're coming sooner than you think. China, for instance, has introduced mandates that call for seven million electric cars to be sold every year beginning in 2025. That would amount to some 20 percent of sales in the world's largest car market and would be a quantum leap from today's approximately 4 percent share in China, which itself is several times the present level of EV-car sales worldwide. Multiple countries around the world have announced full or partial bans of ICE-vehicle sales by 2030. Imagine how many businesses across the value chain will be affected (suppliers, gas stations, metals and mining companies, and shippers, to name just a few) when electric becomes the new norm.

Opportunity beyond the core

Changes on that order of magnitude bring radical new opportunities. For example, any company with a roof can install solar panels. For large retailers with massive floor space under broad roofs, that's not trivial: it can afford them a measure of independence from the electrical grid, protection from price fluctuations, and new opportunities for profit by trading in electricity markets.

In some industries, particularly those that are currently heavily invested in traditional modes of power, the changeover to renewables will require significant capital expenditures, at least at the start. For other companies, entry barriers that had

The evolving energy mix

by Ole Rolser

Since the mid-19th century, fossil fuels have been an engine of economic development. Looking toward 2050, they still will be. But their growth will slow dramatically. Based on our bottom-up assessment of energy demand, we believe that global demand for coal will decline, and oil demand will peak in the early 2030s and then decline as well. Alone among the fossil fuels, only natural gas will see demand increase notably in the coming 15 years. Here's a closer look:

Coal. Coal demand is projected to decline, due in large part to the rapid growth of renewables. The role of China will be key. Today, about 70 percent of the country's power is generated from coal, and China is responsible for about half of global coal demand. As renewables become cost advantageous, we expect China to shift increasingly from coal. Coal represented just over 60 percent of China's primary energy mix in 2017, a decline from 62 percent in 2016 and a nearly 15-percentage-point drop over the last decade. A similar dynamic will hold true for other high-growth regions, such as India. Where previously we had expected coal to continue to play a more important role for a longer time, our latest perspective now identifies renewables as the largest energy source in the coming decades.

Oil. Oil demand grew by 1.2 percent per year on average from 1990 to 2000, and again from 2000 to 2010. From 2010 to 2020, as the world continues to emerge from the Great Recession, we expect the compound annual growth rate to actually tick up to 1.3 percent. Still, we anticipate a peak in global oil demand by the early 2030s, when demand reaches 108 million barrels per day, or nearly 10 percent more than today's demand. Thereafter, we expect oil demand to decline and the trend to accelerate. The main cause for the decline in demand will come from road transport as electric-vehicle penetration increases; another factor in the short run is the phaseout of oil as a source for power generation, especially in the Middle East. Perhaps even more important is oil's increasing exposure to price signals. In 2007, about 80 percent of oil demand was relatively insulated from oil-price changes—government subsidies helped absorb price shocks. Now, approximately two-thirds of oil demand is exposed to oil prices (when prices fell in 2014, many countries used the opportunity to drop subsidies). That adds up to oil being significantly more price elastic (and more expensive) than previously. As a result, the link between growth in oil demand and growth in GDP has declined from approximately 0.8 to 0.3 percent. Even so, the oil sector will need to find and develop new production of around 40 million barrels per day, given typical field-decline rates.

Natural gas. We project a continued increase of global gas demand by approximately 20 percent, or 700 billion cubic meters, until 2035. That amount represents approximately the level of gas demand from Europe, Japan, and Korea today, combined. China will be the key contributor, making up almost half of all growth globally until 2035. Other regions, particularly the Middle East, Europe, and Asia-Pacific, will see a slowdown in demand growth. Over time, we project that the aggregated gas demand growth curve will flatten as well, plateauing in 2035, followed by a modest decline, driven largely by the ascendance of renewables.

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previously required massive capital expenditures will likely fall. Precisely because many energy-efficient technologies can scale, the marginal benefits of adding bigger power plants will decline—and eventually could disappear altogether. As well, decentralized power generation can make some consumers and businesses electricity producers, which opens up possibilities for those seeking to enable a connecting network. Enhanced energy management to realize efficiency gains will also require increasingly smart devices—and companies to make them. Because having plants and operations with the capabilities to monitor, adjust, and lower energy expenses will become table stakes, billions of devices will need to become connected, and the Internet of Things will move more into the mainstream. Energy systems will increasingly take on aspects of networked economies, and the possibilities for value creation across the energy spectrum will be significant.

In our experience, many businesses are primed to capture opportunities from energy efficiency, electrification, or decarbonization—and sometimes from all three—yet lack the awareness or organizational mandate to get started. As your own business prepares for change, remember the imperatives of your competitors, suppliers, partners, and stakeholders will be changing as well. Consumer preferences, including attitudes about greener products and industries, are already shifting. Regulators are gearing up to speed the change. Proactive companies will consider adjacent markets, different parts of the value chain, and even new industries that could eventually prove essential (for instance, makers of convenience-store fare will need to find new sources of shelf space as gas stations fade from the scene). You'll also want to sharpen your partnership paradigm, whether with technology providers, financial companies (essential for new energy-trading markets and capital management), or the public sector.

Cities, for example, are beginning to turn light poles into next-generation charging stations. And car manufacturers are partnering in innovations such as wireless charging, as BMW has done recently with WiTricity. Those kinds of mash-ups will become the new normal under conditions of seismic transformation. The resilient will not only adapt to the uncertainty, they'll be able to capture opportunities as a result.

The centuries-old linkage between economic growth and primary energy demand is beginning to decouple. Even as populations soar and economies continue to develop, the global rate of energy demand will rise at a notably flatter trajectory. Energy intensity is decreasing, new sources of power are poised to ascend, and remarkable efficiencies are coming to bear. The changes will be foundational. The resilient will be ready.

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