Innovation in energy technology is taking place rapidly. Five technologies you may not have heard of could be ready to change the energy landscape by 2020.

Recent breakthroughs in natural-gas extraction highlight the speed with which game-changing technologies can transform the natural-resource landscape. Just over the horizon are others—such as electric vehicles, advanced internal-combustion engines, solar photovoltaics, and LED lighting—that are benefiting from the convergence of software, consumer electronics, and traditional industrial processes. Each has the potential to grow by a factor of ten in the next decade.

Placing rapidly evolving technologies such as these on a resource cost curve, however, is difficult: their impact could be very big or very small. And that’s even more the case for technologies that require significant scientific and engineering innovations to reach commercial scale at viable cost. This article describes five technologies that could start arriving in earnest by 2020 or so: grid-scale storage, digital-power conversion, compressorless air conditioning and electrochromic windows, clean coal, and electrofuels and new biofuels.

Not all of these will succeed in the market; they will earn a place only if they can outperform the rising bar defined by other rapidly advancing technologies. But even if only some of them pan out, those could transform the energy landscape. It’s possible, in fact, that the development of energy technologies is approaching a tipping point that will generate increases in energy productivity on a scale not seen since the Industrial Revolution. Leaders of companies and countries who neglect what is happening on the margins today risk being pushed to the margins themselves in the not-too-distant future.
Grid-scale storage

The large-scale storage of electricity within electric power grids allows power generated overnight to meet peak load during the day. Today, this kind of grid storage costs about $600 to $1,000 per kilowatt hour (kWh) and can be used only when the local geology supports pumped-hydro or compressed-air storage systems. Innovations using flow batteries, liquid-metal batteries, flywheels, and ultracapacitors could reduce costs to $150 to $200 per kWh by 2020 and make it possible to provide grid storage in every major metropolitan market. At these prices, by 2020 the United States alone would want to build more than 100 gigawatts (GW) of storage (the capacity equivalent of the current US nuclear-generation fleet).

That much storage capacity would be transformative: currently, our power grid tends to use only 20 to 30 percent of its capacity because we build it to meet very high demand peaks. With storage, we can flatten out those peaks, reducing capital requirements for transmission and distribution and making power much cheaper to deliver. Power companies also could use storage to smooth variability in the supply of weather-dependent renewables, such as solar and wind power, thereby converting them from intermittent power sources into much more reliable ones.

Digital-power conversion

Large-scale high-voltage transformers, developed in the late 1880s, set the stage for the widespread development of the electrical grid. Virtually the same technology is still in use today. A typical transformer costs $20,000, weighs 10,000 pounds, and takes up 250 cubic feet. High-speed digital switches made of silicon carbide and gallium nitride have been developed for high-frequency power management for everything from military jets to high-speed rail. They use 90 percent less energy, take up only about 1 percent as much space, and are more reliable and flexible than existing transformers. Today’s advanced applications include consumer electronics and variable-speed industrial drives for manufacturing. As such applications expand and the major semiconductor manufacturers begin to produce these technologies at scale, they could replace conventional transformers in the utility industry (at less than one-tenth the cost) by 2020. China is particularly well positioned to benefit from adopting digital-power electronics because of the scale of its planned grid expansion.
Compressorless air conditioning and electrochromic windows

Today, it costs about $3,000 to $4,000 a year to run a high-efficiency air conditioner in a hot region, and even the efficient windows now commonly used allow 50 percent of the cooling energy to escape. New compressorless air conditioners dehumidify the air with desiccants rather than the traditional “compress/decompress” refrigeration cycle. Electrochromic window technologies change the window shading, depending on the temperature difference between outside and inside. These technologies offer the potential to cut home-cooling bills in half. Advanced windows also could slash heating costs by half, allowing the sun to warm houses while keeping the cold out—the new windows are often better than the standard attic insulation in cold-climate homes today. These technologies are expensive now, but by 2020 they should cost only about half as much to install as current state-of-the-art cooling and window technologies do.

Clean coal

Today, carbon capture and sequestration (CCS) costs $8,000 to $10,000 per kilowatt (kW). Innovative processes now under development could help coal-fired generators to capture more than 90 percent of their carbon dioxide, at a cost of less than $2,000 per kW. If the technology is viable by 2020, it would be possible for nearly 70 percent of the roughly 200 US coal plants currently slated for closure in that year to stay open for decades. The same goes for similar plants in China and Europe. Without supportive carbon regulations, though, we are unlikely to see clean coal deployed at scale. Coal without carbon sequestration will always be cheaper than coal with it. On current course, though, coal with carbon sequestration could become cheaper, more reliable, and more widely deployable than many renewable technologies.

Biofuels and electrofuels

With crude-oil prices approaching $100 a barrel, market shares for biofuels such as cane and corn ethanol are rising rapidly. Although second-generation cellulosic biofuels have proved harder to make than many had hoped five years ago, innovative start-ups focused on cellulosic and algae-based biofuels are starting to create high-margin specialty chemicals and blendstocks, generating cash now and suggesting a pathway to deliver biofuels at $2 a gallon or less by 2020. At the same time, biopharmaceutical researchers are developing electrofuel pathways that feed carbon dioxide, water, and energy to enzymes to create long-chain carbon molecules that function like fossil fuels at one-tenth the cost of current biofuels. The key question is whether these new technologies can be scaled. If they can, today’s constraints on biofuels—the declining quality of available land and “food for fuel” trade-offs—may diminish.

Matt Rogers is a director in McKinsey’s San Francisco office.