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Bold moves, fast scale-up: Europe's path to cleantech competitivess

About €5 trillion in capital investment could flow annually into cleantech in 2035. How can European companies capture a major share of that value amid strong global competition?

October 2025

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This report is a collaborative effort by Anja Huber, Anna Granskog, Daniel Rexhausen, Hemant Ahlawat, Johannes Lüneborg, Stefan Helmcke, and Tomas Nauclér, with Magdalena Kupfersberger, representing views from McKinsey Sustainability.

Global capital expenditure spending on a suite of cleantech[1] solutions and processes has been on the rise.[2] If this trend continues unbroken, spending could reach as much as €5 trillion annually in 2035 for the 15 technologies explored in this article, according to our analysis. Beyond the environmental effects of cleantech, annual spending of this magnitude could contribute one to two percentage points in gross value added worldwide and potentially create employment opportunities for 25 million to 30 million people.

In some respects, Europe seems well placed to secure its future as a global cleantech leader and capture a substantial share of that value pool. The political commitment to meet net-zero goals remains strong in Europe, backed by major policy initiatives such as the European Commission's Clean Industrial Deal,[3] and European companies are leaders in some areas.

Nonetheless, global competition for cleantech leadership is already strong and may get stronger as the stakes increase. Already, other players, including those in the Chinese and US markets, are making inroads in some European markets. For example, the share of Chinese-made electric vehicles (EVs) in the European market rose from 5 percent in 2015 to almost 15 percent in 2023, while the share of European players fell from 80 percent to 60 percent, according to a study on European competitiveness authored by Mario Draghi, the former head of the European Central Bank.[4]

What can Europe do to not only stay abreast of the competition in cleantech but also maximize the opportunities that beckon? Prior McKinsey reports have examined the broad global challenges of scaling up climate technologies and discussed options for regional policy agendas for the net-zero transition,[5] including targeted public-sector interventions such as simpler permitting procedures, which could accelerate adoption.

In this article, we estimate the potential size of the 2035 global cleantech value pool, its broader potential economic impact, and the extent to which different shares of that pool are likely to be tradable—and hence potentially captured by other countries. We focus specifically on the opportunities and challenges for Europe as it looks to capture a significant part of the 2035 value pool. Business as usual isn't an option if the region wants to do so. The days are gone when agile and lean-manufacturing principles consistently led to competitive product outcomes and better technology efficiency year over year. Rather, European cleantech may need to adopt a disruptive new operating model that includes sharply reducing costs, rapidly scaling up capacity, and increasing speed to market. The public sector also has a role to play in establishing a regulatory landscape that enables rapid growth and transformation. In all, it amounts to another significant competitiveness challenge for the European region.

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1 Cleantech refers to technologies, products, and processes that enhance sustainability in various industries.
2 "The energy transition: Where are we, really?," McKinsey, August 27, 2024.
3 "Clean Industrial Deal: A plan for EU competitiveness and decarbonization," European Commission, February 26, 2025.
4 *The future of European competitiveness: A competitiveness strategy for Europe*, European Commission, September 2024.
5 *What would it take to scale critical climate technologies?*, McKinsey, December 1, 2023; *The energy transition: A region-by-region agenda for near-term action*, McKinsey, December 15, 2022.

The prize: Annual cleantech capital expenditures could total €5 trillion in 2035

Our research analyzed the potential value-creation opportunities of 15 types of cleantech, divided into six groups: clean energy, power systems, building decarbonization, e-mobility, green materials, and carbon-negative solutions (see sidebar, "Our research methodology"). While these groups differ in nature, with some being purely technological developments and others involving processes and materials, they nonetheless collectively amount to a suite of promising cleantech plays. We have defined the scope to cover the most relevant technologies; this means that we have included certain "moonshot technologies," such as fusion, as well as some tactical bridge technologies, such as alternative fuels.

The research explored the potential for European countries to access the opportunities arising from these technologies. For the purposes of this article, Europe refers to the 27 European Union member countries plus Liechtenstein, Norway, Switzerland, and the United Kingdom.

Exhibit 1 shows the research results for each technology group. Of the estimated global capital expenditures of €5 trillion in 2035, about half is concentrated in the e-mobility segment, comprising battery EVs (BEVs), fuel-cell EVs (FCEVs), zeroemission trucks, and EV charging infrastructure.

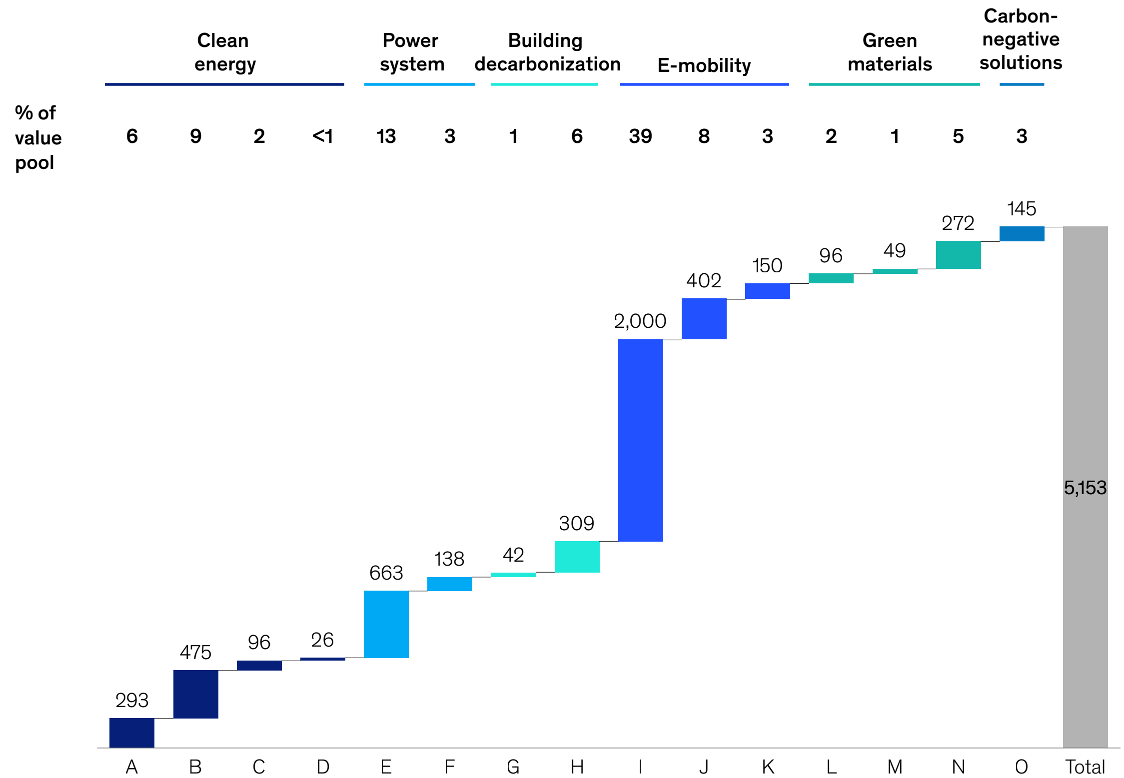
Next are clean-energy technologies, consisting of solar, wind, heat pumps, and geothermal energy, which account for almost 18 percent of estimated capital expenditures, followed by power systems, including grids and battery electric storage, with about 16 percent. According to our analysis, green materials, including electrolyzers, green steel, and green chemicals, make up about 8 percent of total 2035 capital expenditures, while carbon-negative solutions, primarily carbon capture, utilization, and storage (CCUS), account for about 3 percent.

Our research did not consider the potential impact of possible tariff changes or shifting political attitudes to climate technologies. While these may influence the unit economics of certain technologies and affect competition within certain regions in the short term, this article's long-term, throughcycle view is focused on the year 2035 and thus intentionally excludes potential tariff and other policy impacts.

Exhibit 1

Capital expenditure spending on e-mobility makes up about half of the €5 trillion global cleantech value pool.

Estimated capital expenditure spending on cleantech in 2035, € billion



A Solar[1]
B Wind
C Heat pumps
D Geothermal
E Grids
F Battery energy storage[2]
G District heating
H Retrofits
I Cars: BEV, FCEV[3]
J Trucks: ZEV[4]
K Electric-vehicle charging infrastructure
L Electrolyzers[5]
M Green steel[6]
N Green chemicals
O CCUS[7]

Note: Figures do not sum, because of rounding.
[1]Includes commercial and utility scale and distributed generation. [2]Excluding long-duration energy storage. [3]Battery electric vehicle and fuel cell electric vehicle. [4]Zero-emission vehicle. Includes BEV and FCEV. [5]Excludes other infrastructure and downstream hydrogen application. [6]Electric-arc-furnace steel. [7]Carbon capture, utilization, and storage.

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Operations within European borders . . . could yield about €1 trillion in annual capital expenditure spending and create about four million jobs in European countries.

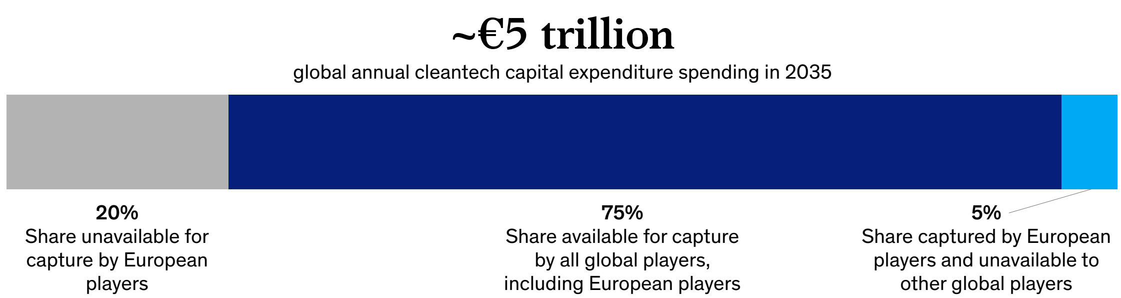
Exhibit 2 shows that about 25 percent of this estimated €5 trillion in capital spending—according to our analysis—is not available for capture by global players. Rather, it is bound locally for a variety of reasons, including geographic proximity. Our research suggests a 5–20–75 split is the most likely outcome: That is, about 5 percent of total capital expenditures will be available only to European market players, 20 percent will be available only to non-European market players, and 75 percent will be generally available and up for competition among companies around the globe.

In Europe, the 5 percent that can be captured by European players alone comprises pockets of value creation common to technologies with a substantial share that are only accessible locally. Examples cover deployment, such as permitting and project development for wind parks; engineering, procurement, and construction, such as assembly, installation, and construction for solar energy; onsite operations, such as drilling for geothermal energy; and low-complexity and oversize equipment parts, such as tower components for wind turbines, that are often localized to avoid high transport costs. Similar constraints exist in other regions, hence the 20 percent of the value pool unavailable to Europeans. Overall, operations within European borders (whether captured by local or foreign players) could yield about €1 trillion in annual capital expenditure spending and create about four million jobs in European countries.

Our analysis indicates that 75 percent of total capital spending in 2035 is available for capture by all global players, regardless of where the consumer demand originates. This spending refers to activities such as manufacturing easily transported equipment, including inverters and modules for solar, rotor and nacelle components for wind, and battery modules for storage solutions. It also includes production for easily transported goods and commodities such as BEVs or battery- and hydrogen-electric trucks, green steel, and green chemicals.

Exhibit 2

Most of the €5 trillion global cleantech value pool could be captured by European players.



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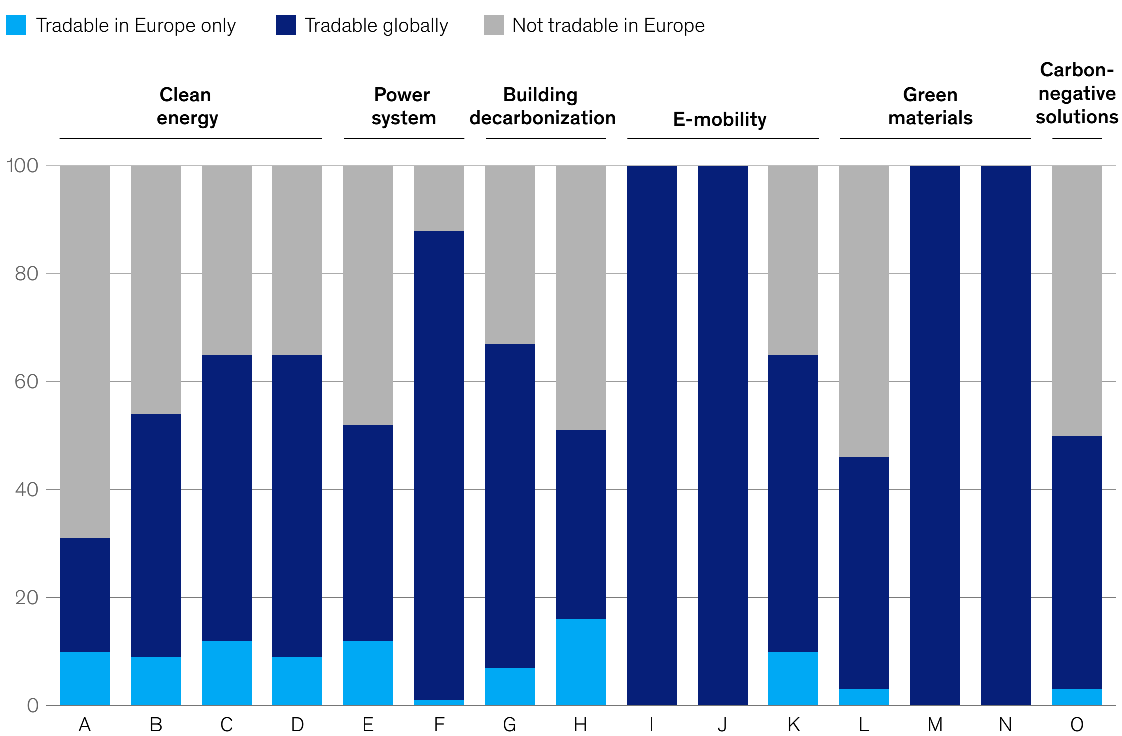
This is where the need to be competitive is so important for European players—because some of their competitors internationally may have lower operating costs, more-favorable regulatory landscapes, and other advantages.

When it comes to the potential tradability of each of the 15 cleantech technologies, our analysis suggests significant variability. Electric mobility and green materials, for example, feature some technologies that are highly commoditized and 100 percent tradable globally, as noted above. Entire upstream value-chain segments for these technologies could be imported and exported and potentially located within any geographies where producers manage to achieve the lowest end-to-end cost with sufficient at-scale availability, irrespective of energy prices, labor costs, and regulatory environments. By contrast, other technologies, such as solar power or building retrofits, are much less readily tradable within Europe (Exhibit 3).

Exhibit 3

The degree of global tradability varies greatly from one cleantech segment to another.

2035 annual capital expenditure spending, %



A Solar
B Wind
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D Geothermal
E Grids
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G District heating
H Retrofits
I BEV[1] cars
J ZEV[2] trucks
K Electric-vehicle charging infrastructure
L Electrolyzers
M Green steel
N Green chemicals
O CCUS[3]

[1]Battery electric vehicle.
[2]Zero-emission vehicle.
[3]Carbon capture, utilization, and storage.

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Europe's most promising cleantech opportunities will likely be in highly competitive industry groups

The cleantech opportunities we identified are at different stages of development: Some are in a stillnascent phase of concept and innovation, while others are already undergoing commercialization and scale-up. Technologies in a third phase are being deployed globally. Our research suggests that the biggest prize is to be found in the middle phase—that is, technologies undergoing commercialization and scale-up (Exhibit 4).

The largest of these opportunities by far is in e-mobility, principally BEVs—with a Europeaccessible value pool of about €2,000 billion per year (one-year investment need)—and zeroemission trucks (about €400 billion). According to our research, other technologies with significant potential are green chemicals in the concept and innovation phase (about €270 billion) and grids in the global deployment phase (about €345 billion).

We estimate that the share of value accessible to European players from technologies in this commercialization and scale-up phase exceeds 70 percent of the total. Therefore, the critical challenge for Europeans is scaling rapidly and cost-effectively. That, in turn, will likely require a radical transformation that goes far beyond current practices, as we describe further in the next section.

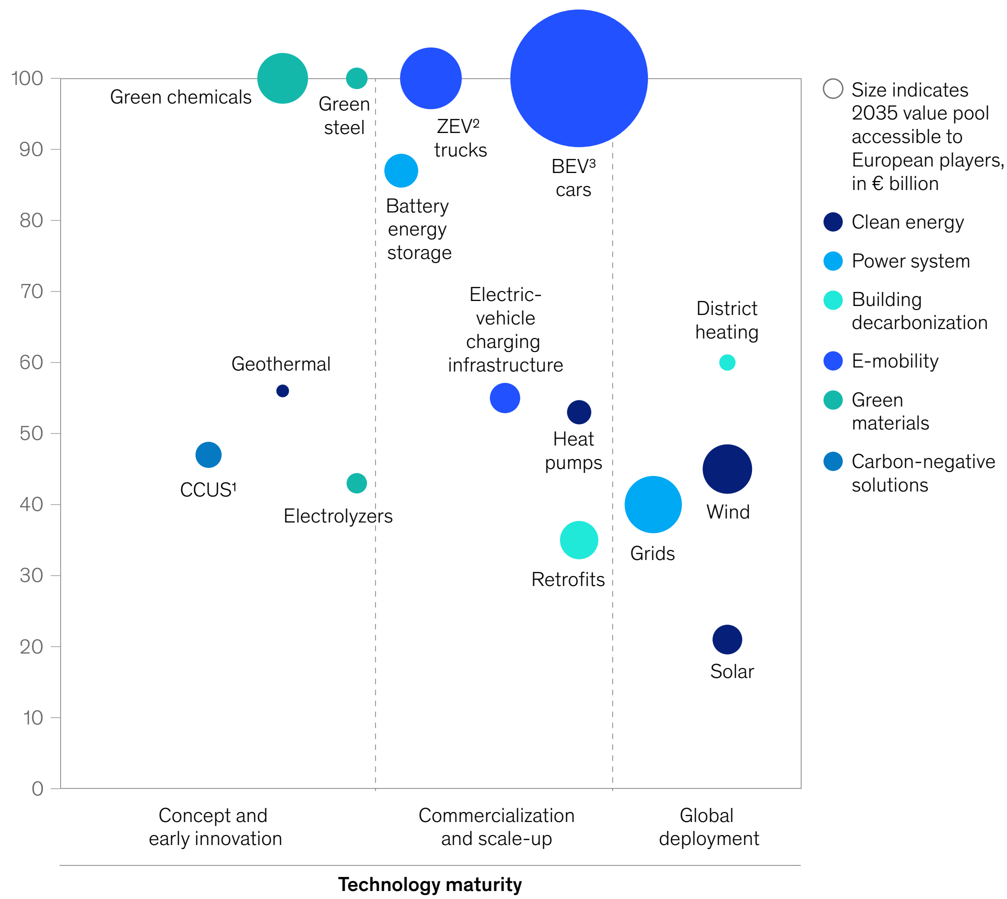
Zooming in on some key technology groups—emobility, green materials, battery energy storage systems, and other early-stage clean technologies—highlights the potential as well as the competitive challenges and other limitations that Europe faces. This section does not seek to provide a comprehensive overview, because other technologies have been extensively covered in prior McKinsey research. For example, the current state and prospects for wind and solar photovoltaics are featured in an article that took stock of the energy transition,[6] while the outlook and challenges for the power industry featured in McKinsey's annual Global Energy Perspective.[7]

[6] "The energy transition: Where are we, really?," McKinsey, August 27, 2024.
[7] *Global Energy Perspective 2024*, McKinsey, September 2024.

Exhibit 4

The majority of the global cleantech value pool accessible to European players is in the commercialization and scale-up phase.

Global tradability, % of capital expenditure spending needed to export value chain steps



[1]Carbon capture, utilizaion, and storage.
[2]Zero-emission vehicle.
[3]Battery electric vehicle.

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E-mobility. The automotive sector has been a cornerstone of Europe's economy for decades, showcasing the region's strength in industrializing best-in-class products and orchestrating complex R&D programs. Nonetheless, the European auto industry cannot rest on its laurels. Successful e-mobility players in the US and Chinese markets have demonstrated that market share can be expanded rapidly. For example, Chinese market players have achieved dramatic increases in sales of zero-emission vehicles (cars, trucks, and buses) in Europe in the past decade.

For BEVs, Chinese market players have led on design and production, with average costs that are 20 to 30 percent lower than the costs of most European competitors. This is largely due to the pure scale of manufacturing and earlier investments made in the full EV and battery supply chain, along with radical rethinking of the car and its requirements. European OEMs also take longer to bring products to market than some peers, with concept-to-pilot phases that can last as long as four years. In contrast, McKinsey research has shown that the fastest automakers in the Chinese market take only 21 months to move from concept to pilot.[8] In coming years, European OEMs will be able to build on consumer loyalty and brand recognition as well as their existing strengths in product quality, complex industrialization, and R&D excellence, but their ability to produce competitive EVs will need to improve radically. Along with a focus on cost reductions, time to market, and closing the productivity gap, European OEMs will need to put in place regional customer-focused operation models and take into account the different speeds at which various markets are moving. At recent auto shows, European OEMs have boosted confidence in their ability to catch up by presenting models with breakthrough ranges exceeding 800 kilometers, faster charging times, and more-competitive price points. They have also demonstrated innovative engineering and production techniques such as a higher share of circularity and the use of rare earth–free components.

Green materials. European industrial companies have made significant sustainability commitments in response to growing consumer demand for greener products and increasing regulatory pressures. However, achieving cost competitiveness while overcoming initial investment and scaling challenges remains a critical hurdle. To maintain technology leadership, European players must accelerate innovation, reduce costs, and adapt to regional market dynamics. Examples include green hydrogen and electrolysis, steel, cement, and chemicals.

For green hydrogen and electrolysis, decarbonization efforts are boosting global investment in clean-hydrogen production, and European players are at the forefront of this transition. McKinsey research suggests that today's electrolysis market is dominated by ten companies accounting for 75 percent of electrolysis capacity in more mature stages of development. Seven of these companies, with a collective market share of more than 50 percent, are based in Europe: HydrogenPro, ITM, John Cockerill Hydrogen, Nel, Siemens Energy, Sunfire, and Thyssenkrupp Nucera.

As a relatively easily exportable technology, electrolyzer manufacturing offers European OEMs a significant opportunity to expand beyond domestic markets and capture global market share. With growing demand for green hydrogen worldwide, European manufacturers could supply leading-edge electrolysis systems to international as well as domestic projects.

However, competition from Chinese players is putting pressure on European electrolyzer OEMs. Chinese OEMs are rapidly expanding in overseas markets, especially Europe and the Middle East, while some Chinese players are investing in projects in Europe, including through partnerships with European hydrogen players.

For their part, steel producers are exploring hydrogen- and natural-gas-based direct-reduced iron and electric arc furnaces to reduce emissions. However, these technologies are significantly more electricity-intensive than the conventional blast furnace–basic oxygen furnace process. Success in this sector will depend on access to competitively priced renewable electricity, which remains a challenge in many parts of Europe.

In the cement sector, companies are adopting a dual approach: scaling CCUS technologies—which are now operational at the first large-scale plants—and increasing the use of supplementary cementitious materials (SCMs) such as blast furnace slag and fly ash. SCMs not only reduce CO_2 emissions but also enhance competitiveness. However, the pace of scaling CCUS technologies remains slow, limiting broader impact.

In the chemicals sector, waste-to-chemicals technologies such as pyrolysis and gasification are being piloted to improve carbon circularity and reduce emissions. However, capacity has lagged behind despite strong regulatory demand, such as the EU's Packaging and Packaging Waste Directive, which mandates recycled-plastics content. In contrast, Asian players are scaling integrated waste-to-chemicals complexes more rapidly,

8 Andreas Cornet, Ruth Heuss, Patrick Schaufuss, and Andreas Tschiesner, "A road map for Europe's automotive industry," McKinsey, August 21, 2023.

supported by strong value-chain collaboration and government incentives.

European companies will also need to address time-to-market challenges because global competitors often bring innovations to scale more quickly. Leveraging consumer loyalty, brand recognition, and alignment with sustainability regulations will be critical to maintaining competitiveness. To succeed, companies would have to accelerate investments, deepen collaboration across the value chain, and adopt regionally tailored strategies to address varying market dynamics, such as renewable-energy availability and regulatory frameworks.

Battery energy storage systems (BESS). Rapid expansion of variable renewable energy sources, such as solar and wind, is driving unprecedented demand for flexibility across Europe and beyond. BESS is emerging as a critical enabler to balance supply and demand and ensure grid stability. By the end of 2024, Europe's BESS capacity reached about 60 gigawatt-hours (GWh), with about 22 GWh added in 2024 alone.

In response, European companies are actively positioning themselves across the BESS value chain. Upstream, this includes battery cell and module manufacturing, exemplified by Eni's planned eight-GWh lithium iron phosphate plant in Italy in partnership with FAAM, a local cell producer.[9] Midstream players, such as Finland's Wärtsilä, are focusing on system integration, while downstream firms such as the United Kingdom's Habitat Energy and Flexitricity and Sweden's Ingrid Capacity are deploying sophisticated software solutions to optimize asset performance and advancing project development.

However, Europe faces significant challenges in upstream manufacturing, which remains heavily concentrated in China. China accounts for more than 80 percent of global battery production, compared with less than 10 percent in Europe. Overcapacity and rapid innovation in China have driven a surge in high-quality, low-cost exports, intensifying competitive pressure on European players. US tariffs and regulations have redirected more Chinese shipments to Europe, increasing the pressure.

To compete, European manufacturers will need to match China's agility and offer scalable, containerized solutions for developers. The European Union's Net-Zero Industry Act supports this effort, targeting 40 percent local production of net-zero technology—including batteries—by 2030, with local content criteria for subsidies and procurement.

Beyond hardware, system integration and software are emerging as differentiators. A growing number of companies are developing hardware-agnostic solutions to optimize BESS performance across sites and markets. As AI and analytics advance, software will enable predictive maintenance, preserve battery health, and unlock greater value from energy trading and ancillary services. Additionally, firms such as Limejump, Polarium, and Octopus Energy are delivering hardware-adjacent virtual power plants or "energy as a service" offerings.

Other early-stage clean technologies. We included two other early-stage cleantech technologies, CCUS and geothermal energy, in our research for this article. These technologies are in the concept and development phase, where European industrial players continue to have a competitive advantage, in part because of EU climate policies and funding programs targeted toward creating incentives for early adoption and scaling breakthrough technologies. Europe's advanced engineering expertise, strong academic–industrial partnerships, and focus on industrial clusters enable rapid innovation, derisking, and commercialization of emerging cleantech.

[9] Andy Colthorpe, "Eni joint venture kicks off LFP battery cell factory development in Italy," Energy Storage News, September 25, 2025.

Europe's paths to cleantech leadership involve a new operating model and mindset to 'challenge everything'

What can European leaders in the private and public sectors do to enhance the competitiveness of European cleantech players' efforts to capture a substantial portion of the €5 trillion annual opportunity we have identified? As noted above, our research suggests the need for a radical transformation. In this final section, we outline some of the transformation's main characteristics.

For European companies, remaining competitive with global players, including US and Chinese peers, could require embracing a new operating model that would radically reduce costs, accelerate scale-up, and cut the time to market.

The public sector also has a role to play in enabling this transformative agenda by removing obstacles to it. And both public and private sector companies would need to find ways to collaborate so they can together enhance Europe's agenda of heightened competitiveness.

Transforming European cleantech performance through a disruptive new operating model

Despite all their expertise and backing, European equipment and technology companies have generally been falling behind Chinese and US companies such as BYD, Li Auto, XPENG, Xiaomi, and Tesla, which have gained significant market shares in cleantech and closely related electrification products. These disruptors are embracing operating models that emphasize innovation in every part of the business[10]—and particularly across the four dimensions of pace, cost, performance, and the efficiency of capital spending. They set higher ambitions, invest more in research, challenge universal "truths," and look for opportunities across the ecosystem, not just in manufacturing.

This disruptive operating model delivers cost, performance, and lead-time improvements at a high pace, year over year, combining large and small innovations across the whole value chain. Its focus is on getting innovations executed—not just invented.

Our research and work with clients suggest that this approach rests on four main pillars. The first pillar is a research approach that aims for a step change in performance every one to two years by harnessing exponentially advancing technology.

The second pillar is a product strategy that focuses on reducing costs and improving performance.

The third pillar is a supply chain with partnerships on a global scale to achieve step-change cost reductions and improved performance.

[10] "'Innovation Execution'—a new industrial paradigm emerges," McKinsey, September 4, 2025.

The fourth pillar is revamping manufacturing to reduce not only cost but also production times and capital spending. For now, European incumbents are used to operating in mature technologies with a relatively slow cost reduction. For internal combustion engine vehicles, for example, the cost reduction is about 0.1 percent annually. The next technology frontier has much larger cost reductions of 10 percent or more per year.

Underlying these elements of transformation runs a notion of setting a very high—even absurdly high—ambition that would need to be enabled by a strategic mindset, governance, and capabilities. The mindset needs to be one of "challenge everything"—that is, aiming to achieve sustained transformative change across the full value chain. The CEO would essentially serve as chief product officer, top-level engagement would be needed for product development and cost reductions, and the company culture would revolve around first-principles problem-solving and challenging the status quo, with a forgiving trial-and-error environment.

Governance would need to be optimized for rapid test-and-scale product cycles. For example, autonomous R&D teams could be structured around product innovation challenges, with governance essentially mission-driven rather than hierarchical. The point is to accelerate decision-making and reduce organizational complexity by removing levels of management.

R&D capabilities would need to be geared toward transformative cost reductions. That implies deep-research capabilities beyond continuous improvement and drastically reduced product cycle times that can fully leverage disruptive technologies as they emerge.

The public sector's enabling role to turn the new paradigm into a European reality

Radical business model transformation is fundamentally a challenge for private sector companies. But public sector leaders can also play a role. Indeed, as McKinsey has noted elsewhere, national decision-makers will need a comprehensive understanding of the trade-offs associated with different climate transition plays in order to meet four interconnected objectives: emissions reduction, affordability, reliability, and industrial competitiveness.[11]

EU member states would need to take transformative collective action to meet their climate goals, including substantial shifts in energy supplies and large-scale electrification—endeavors of tremendous magnitude.

In regard to the competitiveness of European climate tech companies, prior McKinsey research has noted a number of obstacles that stand in their way as they seek to scale up[12]—obstacles that the public sector could potentially help reduce. These include a lack of infrastructure and resilient, at-scale supply chains for key decarbonization technologies; sometimes overcomplex regulation; onerous permitting procedures; and a lack of financial support such as tax breaks for some technologies, which could help mitigate some of the risks for early adopters.

Both private and public stakeholders could help facilitate access to finance, for example by offering concessional capital such as blended finance to support the build-out of enabling infrastructure. This could help derisk investments and increase technology deployment.

For more-mature technologies, public sector stakeholders could help private companies come together through a range of possible actions, including potentially expanding free port–type policies and offering tax breaks and other incentives for industrial groups in priority areas where market share can be expanded.

[11] *Climate Transition Impact Framework (C-TIF): Planning for a sustainable and inclusive future*, McKinsey, March 2025.
[12] "Five key action areas to put Europe's energy transition on a more orderly path," McKinsey, August 8, 2023.

Europe has strong ambitions to lead on both climate issues and climate-related technologies. This article has highlighted the €5 trillion annual opportunity from cleantech alone in 2035. According to our research, for Europe to seize the opportunities, the region will require much bolder and faster moves by both public and private sector players. It may be fitting for Europe to lead the charge on cleantech, given the region's legacy of industrial excellence, technological innovation, and commitment to achieving sustainability targets—but to do so will require the region to tackle its core competitiveness challenges.

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Our research methodology

The value pool analysis for this article considered six industry groups and fifteen technologies.

The value pool sizing we conducted assumes perspectives on both macroeconomic and investment needs. The scope includes all global cleantech upstream activities as well as those specific to EU-27 countries plus Lichtenstein, Norway, Switzerland, and the United Kingdom.

The analyses assume a 1.5° pathway and achieving net-zero emissions by 2050. They are global in scope, with a focus on where European companies could engage along each value chain. For this reason, the standard currency and unit is expressed in billions of euros, unless indicated otherwise.

We broke down the value chain of each cleantech technology to its core segments to assess the extent to which each technology is tradable globally or bound locally.

Sizing the capital investment need. The research estimates the needed capital expenditure investment based on 2035 (in other words, annual rather than cumulative). The estimates are based on upstream and midstream activities only; downstream activities such as operations, maintenance, and end-of-life processes are excluded. We used the most recent data available and adapted them where necessary, as of the second quarter of 2025 from the McKinsey Global Institute, the McKinsey Global Energy Perspective 2024, and the McKinsey Center for Future Mobility. For the estimates of capital expenditures for green chemicals, we used public sources and adjusted them by using expert input to determine, for example, assumptions on the share of green chemicals in total chemicals' investment and the size of the capital expenditure shift toward low-carbon assets.

Sizing the gross value added (GVA) to the economy. Our analysis sized only the impact on GVA of the clean technology value chain steps in scope. It did not include raw materials or parts, manufacturing costs, or downstream aspects of the value chain such as sales, marketing, and finance. The sizing was based on the necessary capital expenditures and used GVA multipliers. Where needed, such as in the absence of readily available GVA multipliers, we quantified GVA to the economy using historic actuals of representative companies in each value chain, expressed as the sum of earnings before interest and taxes plus personnel costs divided by gross revenue. Induced effects are not included in this analysis.

Sizing the employment opportunity. We applied direct and indirect job multipliers to the investment need for each step in the value chain. In the absence of available job multipliers, we analyzed representative companies to derive a metric for labor intensity, such as labor intensity per unit of output. Induced effects are not included in this analysis.