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# Adopting Clean Technologies: The Energy Resilience Dividend

## Clean technology deployment can strengthen energy and economic resilience, but it also creates new dependencies.

From the **S&P Global Institute**

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## HIGHLIGHTS

Clean tech deployment can improve the energy security equation, where economies manage to replace imported fossil fuels with domestic renewable energy production.

Across nine advanced economies, we find less reliance on oil imports reduces the GDP impact of oil supply shocks by around 0.25 percentage point. Yet, countries that have significantly lowered energy imports have largely done so by increasing domestic fossil fuel production. Fossil fuels remain deeply embedded in the energy system and rising energy demand has thus far outstripped additions of new renewable resources.

The adoption of clean technologies is changing the nature of energy security and introducing new external dependencies – particularly on China, which dominates nearly all parts of the clean tech supply chain. With this, macroeconomic resilience increasingly relies on diversifying supply chains and the ability to capture market share in new electric technologies, such as electric vehicles.

The EU's uptake of clean energy technologies since the Paris Agreement has helped cushion the region from more severe energy impacts caused by Russia's invasion of Ukraine and, more recently, from this year's volatility due to restricted supplies from the Gulf.

China's on-road fleet of electric vehicles (EVs), the world's largest, lowered the country's exposure to this year's oil shock by providing consumers low-carbon optionality in the face of higher oil prices. Meanwhile, China is enabling resilience-building outside its borders — with nearly 2.5 million EVs exported in the first half of 2026 alone. We estimate EVs on the road globally will displace 1.9 million barrels per day of oil demand this year.

Investments in decarbonization are frequently motivated by the need to mitigate climate change. However, this focus overlooks a potentially critical benefit of a transition to clean energy: enhancing national strategic resilience and energy security. In other words, a country's adoption of clean energy technologies (such as wind, solar, energy storage and hydrogen electrolyzers, but also conventional and next-generation nuclear, biofuels and more broadly including demand-side equipment like EVs) could pay a "resilience dividend" — or benefits beyond climate objectives that help reduce economic and geopolitical exposure to global fossil fuel shocks.

At a macro level, clean tech does not seem to have yet reduced fossil fuel use globally, as overall energy demand has been increasing faster than renewable resources deployment. But resilience stories are starting to emerge in which clean energy investments have displaced fossil fuels, diversified the energy supply, and reduced economic sensitivity to fuel supply shocks. Digging deeper into sector-level dynamics, particularly investments in renewable power generation and the adoption of EVs, resilience gains emerge more clearly, demonstrating how the energy transition reaches beyond climate policy as a purely environmental endeavor into a cornerstone of national economic and geostrategic security. These gains, however, come with new dependencies to manage, particularly with China, as reliance on concentrated clean-tech supply chains grows.

## Linking the energy transition to macroeconomic resilience is complex

**Our model suggests that a faster reduction in countries' oil use has contributed to resilience to oil supply shocks over time.**

Investing in clean power generation, biofuels and more energy-efficient technologies should strengthen countries' macroeconomic resilience by reducing dependence on fossil fuel imports and exposure to fossil fuel supply shocks. Energy-importing countries are particularly vulnerable to global energy supply disruptions, which can raise inflation, erode consumers' purchasing power, raise production costs for firms, and weaken the balance of payments, all contributing to a growth slowdown. But the line connecting the adoption of clean technologies to macroeconomic resilience is complicated.

### Lower oil-import dependence is associated with greater resilience to oil supply shocks

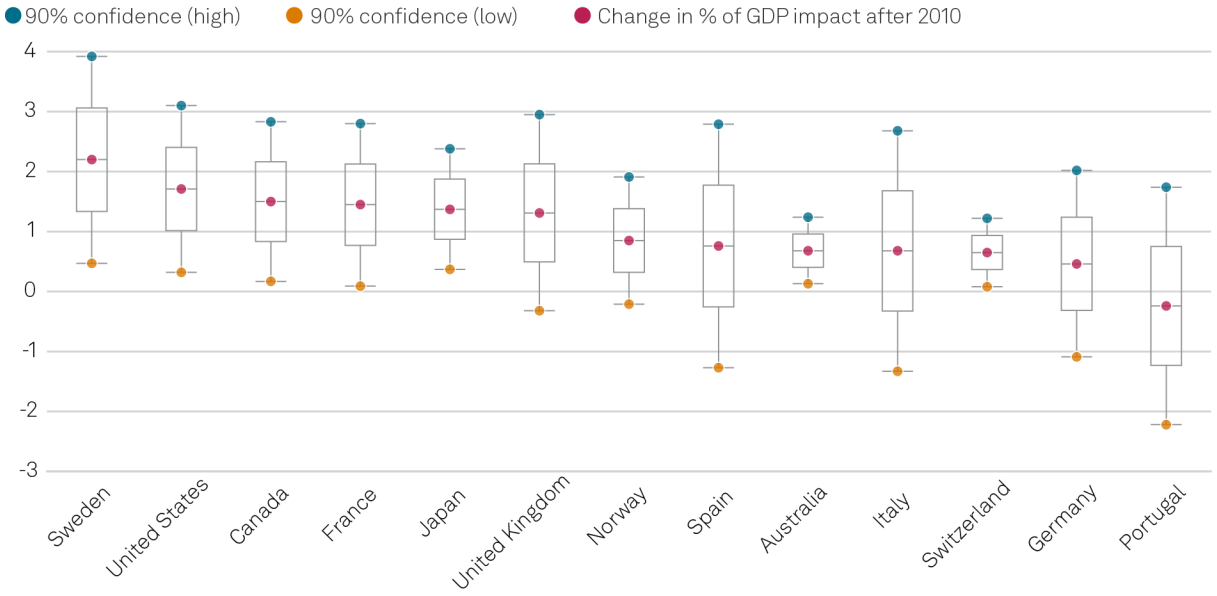
There are two primary avenues for a country to decrease its reliance on external sources of fossil fuels: increase domestic production of energy, or lower energy use, for example, via improvements in energy efficiency. Both should enhance economic resilience to fossil fuel supply shocks and price volatility. To test whether either of these approaches can make a country more resilient to fossil fuel shocks, we estimate the response of GDP to exogenous oil supply shocks for a selected group of advanced economies.

Our results suggest that economic activity in our sample countries has become less sensitive to oil supply shocks over the past 15 years (see Figure 1). This seems to be more pronounced in economies that have increased domestic production and their net energy exports, such as the United States and Canada, or that have combined improvements in energy efficiency with clean-tech deployment without creating new energy dependencies, such as Sweden. Post-2010 those economies no longer experience a contraction in domestic economic activity following a global oil supply shock. However, the resilience displayed during the most recent period cannot be fully attributed to energy resilience strategies, as country-specific fiscal measures and the post-pandemic recovery — elements missing from our model — also provide important buffers.

Figure 1

**GDP responses to oil supply shocks have become more muted In several advanced economies since 2010**

Improvements in GDP responses to an oil supply shock comparing the 2010-2025 period to 1990-2009 period (cumulative impacts)




As of September 2026.
The model uses a Global VAR to disentangle oil supply shocks from demand and precautionary shocks on oil prices; those innovations are then used to identify countries' GDP impulse responses via Jorda local projections. The sample is split in two periods — 1990-2009 and 2010-2025 — to isolate more recent shifts in energy dependencies. We exclude the Covid period, Q1 2020-Q2 2021, from the sample to avoid data distortion, but results also hold when using dummies instead. Data includes real oil prices, oil inventories, oil production and global Industrial production for the GVAR, GDP, CPI, and short rates for countries' local projections, which also enter the regression as controls.
Sources: Fred database; S&P Global Ratings.
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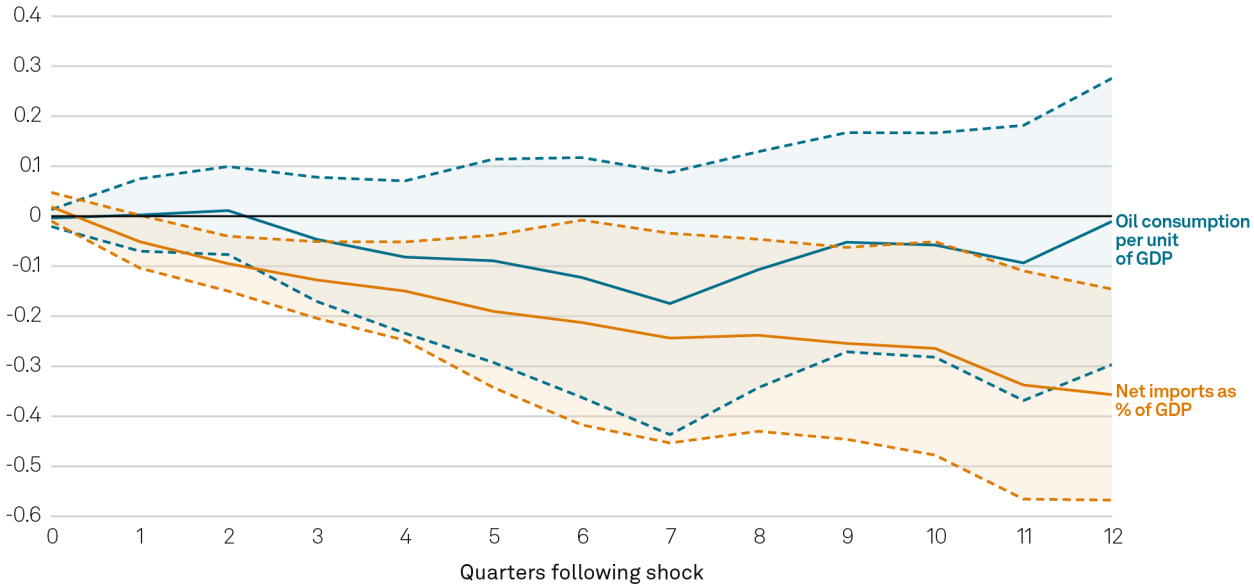
**Adding countries' energy profiles in a panel regression suggests lower net oil-import dependence has been the main resiliency factor.** In our sample, countries that import a larger share of their oil experience a stronger slowdown in economic activity after an oil supply shock. For countries with oil import dependence one standard deviation above the sample mean, this leads to a 0.25-percentage-point additional loss in GDP after two years (see Figure 2). This points to the potential benefits of clean tech deployment and energy efficiency, if they help lower countries' net energy imports.

But to date, the strongest relationships between decreased oil-import dependence and economic resilience are not necessarily due to energy efficiency improvements and renewable power deployment. Rather, it reflects a reduction of net import dependence that occurred through rising domestic fossil fuel energy production in our sample (including Australia, Canada and the US).

Adding to that, the model does not identify a statistically significant effect from oil intensity (i.e. oil consumption relative to GDP), likely because the reduction in oil intensity follows a similar gradual downward trend across the sample of countries included in the model. As such, if we look at the oil intensity reduction within countries (and not across countries), our model suggests that a faster reduction in countries' oil use has contributed to resilience to oil supply shocks over time.

Figure 2

**Higher net oil-Import dependence is associated with larger GDP losses following oil supply shocks**
Impulse Response Function - Cumulative % GDP impact associated with oil supply shocks driven by oil import and intensity characteristics




As of September 2026.
We run the model as in Figure 1, for a panel of countries for which we can add energy characteristics (oil consumption relative to GDP and the ratio of net oil imports to oil consumption and to GDP) to see whether those influence the GDP response to oil supply shocks. Energy-characteristic interactions are estimated on a smaller sample of nine countries with oil-intensity and trade data: Japan, Australia, Canada, the US, UK, Italy, France, Germany, Spain. Each characteristic enters a separate regression; effects are per one standard deviation of the standardized characteristic. We exclude the Covid period (Q1 2020-Q2 2021) from the sample to avoid data distortion but results also hold when using dummies instead.
Sources: Fred database; S&P Global Energy; S&P Global Ratings.
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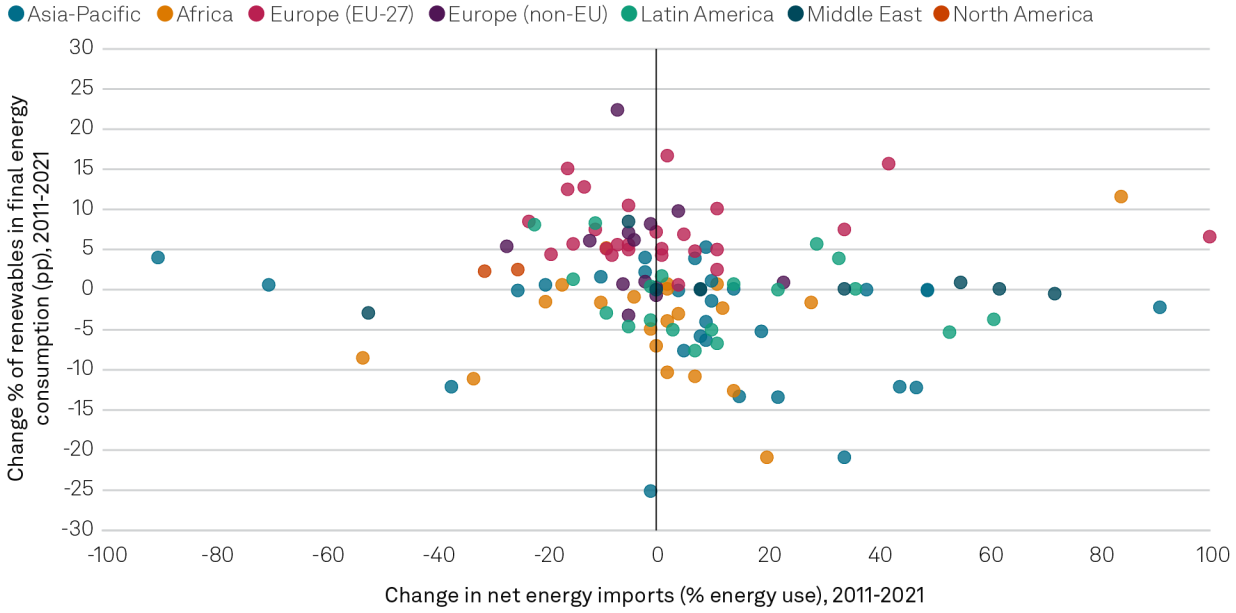
**Further complicating the picture linking the energy transition to resilience gains, however, is the reality that clean tech deployment does not seem to have reduced energy import reliance globally** (see Figure 3). Even though clean tech deployment has been one of the ways importers in the Asia-Pacific region and Europe have sought to diversify their energy portfolios and reduce their **greenhouse gas** emissions, most countries have seen their energy import dependence (i.e. net energy imports as a share of energy use) increase, not decrease, in recent years.

This is because, in many countries, especially emerging markets, fossil fuels continue to meet growing energy demand (see Table 1), and existing transport, industrial and building infrastructure remain heavily dependent on them. Electricity only accounts for a fifth of final energy consumption, and S&P Global Energy estimates fossil fuels will still supply around half of global energy supply by 2060 (see In Search of Resilience: A scenario-based assessment of energy and environmental security).

Figure 3

**An increasing share of renewable power in final consumption has not necessarily reduced energy importers' reliance as a share of energy use**

Change in the share of renewables in final consumption compared to the change in the share of net energy imports in total energy use between 2011 and 2021




As of September 2026.
Energy imports include all types of energy.
Sources: World Bank; S&P Global Ratings.
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Table 1

**Fossil fuels continue to satisfy rising energy demand needs globally**

Changes in fossil fuel demand across regions, 2005-2025

| Region | Coal | Gas | Oil |
|---|---|---|---|
| North America | -63% | 55% | -1.20% |
| Europe (non-EU) | -27% | -9% | 1% |
| Europe (EU-27) | -60% | -22% | -18% |
| Middle East | -52% | 151% | 58% |
| Africa | 2% | 93% | 67% |
| Latin America | 35% | 26% | 33% |
| Asia-Pacific | 94% | 134% | 62% |

As of September 2026.
Source: S&P Global Energy.
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**Broader energy security strategies, domestic resource endowments and climate policy choices ultimately shape the prevalence of fossil fuels across energy systems and the relative importance of clean tech in the resilience equation.** In the EU, for example, where clean tech deployment is aiming to reduce both external dependencies and emissions, countries such as Finland and Sweden have succeeded in reducing energy imports by 50%-60% over the past 20 years thanks to deployment of renewables and improvements in energy efficiency. Yet others, such as Denmark and the Netherlands, have seen energy import exposure increase despite clean tech adoption, due to declining domestic oil and gas production. Meanwhile, the US and Brazil have become net energy exporters thanks to rising

domestic oil and gas production, which makes them more sheltered, and potentially benefiters, from physical supply disruptions, although still exposed to higher prices. And a shift to domestic sources of power generation to enhance resilience does not necessarily mean a shift to clean energy sources (see Türkiye's continued reliance on coal as part of its energy strategy What the world can learn from Türkiye's energy transition strategy heading into COP31, Sept. 15, 2026).

## Case studies in Europe and China illustrate the strategic benefits of clean tech investments

While the evidence presented above suggests that improved resilience to fossil fuel shocks can at least partly be attributed to higher domestic fossil fuel production and not necessarily clean tech adoption, the cases of Europe following Russia's 2022 invasion of Ukraine and China's uptake of EVs ahead of the current oil shock illustrate how investment in clean technology deployment can provide an alternative way to lower exposure to fossil fuel imports and enhance geostrategic resilience.

### Europe's renewable energy uptake offers a buffer against natural gas shocks

Europe's overall dependency on imported energy had been rising in the years immediately after the 2016 Paris Agreement — staying at levels considerably higher than the import reliance of China or India, even as US net energy imports turned negative. Both total European natural gas supply and the volumes provided via Russian pipelines continued to rise following the Paris Agreement. Both total natural gas supply and Russian pipeline imports peaked in 2019, at 503 billion cubic meters and 168 Bcm, respectively, with the drop in 2020 partly reflecting lower activity from the start of the pandemic. By 2021 — the year before Russia's invasion of Ukraine — total gas demand had slipped and Russian pipeline volumes had dropped by 27 Bcm, as Gazprom started reducing storage supply ahead of the crisis.

Meanwhile, EU power generation since the Paris Agreement has reflected strong investment in clean tech (see Figure 8). This resulted in EU non-hydro renewable generation growing by more than 200 terawatt-hours between 2016 and 2021, led by onshore wind and solar generation. Notably, however, natural gas-fired generation also increased by nearly 100 TWh, as coal-fired power was dropping off strongly.

Europe's total wind and solar renewable generation in 2022, totaled nearly 800 TWh — the equivalent of nearly 140 Bcm of natural gas, assuming the average efficiency of Europe's 2022 gas-fired fleet (~57%). In terms of magnitude, this calculated equivalent volume of gas is comparable to the 141 Bcm of gas supplied to the EU via Russian pipelines in 2021. To be sure, however, renewable generation displaces not just gas, but a mix of gas, coal, lignite, hydro and imports depending on the power dispatch stack.

The EU's policy response and its resulting market disruptions was focused on sourcing alternative energy supply and reducing demand. The EU had previously committed to reaching net-zero GHG emissions by 2050, which meant that policies already existed for encouraging domestic clean energy (renewables) production and reducing gas demand through energy efficiency and electrification. Building on this, the 2022 crisis led to increased EU targets for renewable energy through the RED III and REPowerEU policy efforts. Retirement of zero-emitting nuclear reactors, however, complicated the push toward curtailing natural gas-fired generation. Germany retired its final three nuclear reactors

in April 2023, only slightly delayed from the planned schedule, following a number of nuclear plant retirements at the end of 2021.

**Notably, a meaningful share of the pivot away from Russian pipeline supply was met by increased dependency on LNG imports** — which jumped from 86 Bcm in 2021 to 149 Bcm in 2022. In this way, resilience in Europe is not solely a story of transitioning to renewable energy. Out of necessity, diversification of the supply of gas (without clear climate benefits) is being done in conjunction with a move toward cleaner energy. Elevated LNG import levels from sources such as the US and Qatar have meant that EU gas markets continue to be exposed to external dependencies.

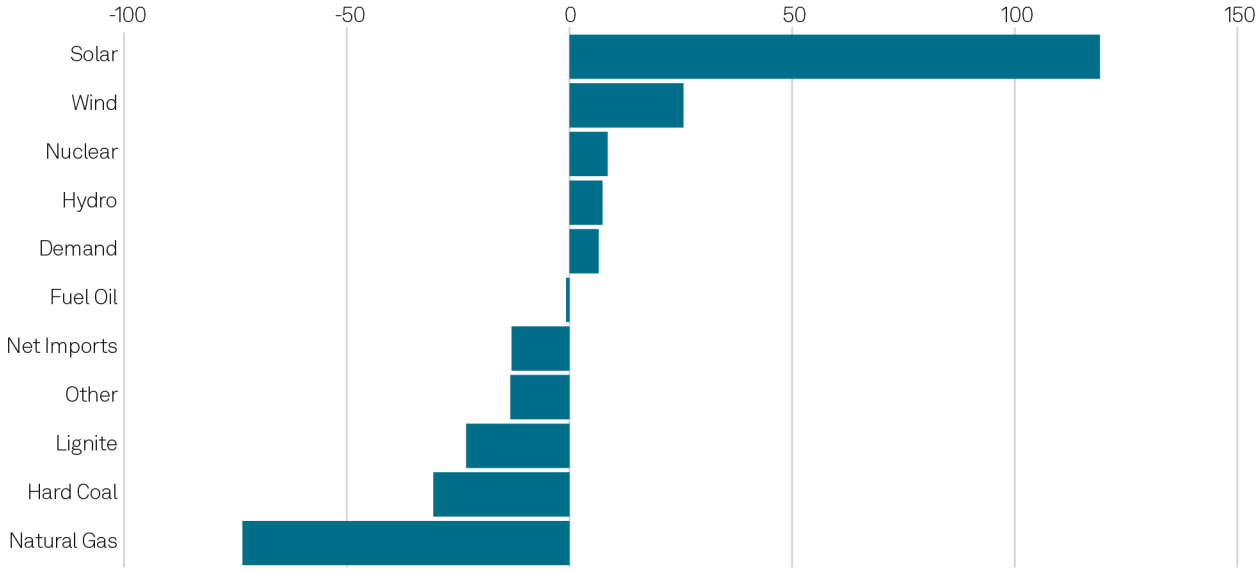
**Clean energy deployment has accelerated since 2022, with European clean tech investment in 2026 expected to more than double 2021 levels.** Since 2022, European policy has seen a stronger push for renewables, most recently evidenced by the European Commission's publication of the Electrification Action Plan, which aims to transform Europe into the "first electro-powered continent" by accelerating the shift from fossil fuels. The commission is looking to double its share of power in total energy in part to reduce its vulnerability to geopolitical shocks, aggressively targeting cuts in gas imports of more than 70% and crude oil imports by 40% by 2040. Already, total EU non-hydro renewables generation has risen nearly 340 TWh since 2021, 70% greater than the increase in renewable generation seen from 2016 to 2021. Meanwhile, over the same period, overall gas demand has dropped considerably, including marked reductions in the power sector gas burn. However, the bolstering of the push for renewables in power has not been mirrored with sustained and larger-scale efforts to substitute for gas in the buildings or industrial sectors.

**This has left the EU power sector, and its economy more broadly, less exposed to this year's market turmoil and supply issues in the Gulf, both in terms of absolute volumes and resulting power prices** (see Figure 4). Wholesale power prices are set by the supplier of the marginal megawatt-hour, and are now seeing a relatively smaller share of hourly prices being set by natural gas-fired generation. That said, higher electricity demand from extreme heat, combined with low hydro reserves and reduced nuclear generation, played a role in driving Spanish power prices back up over the summer. In terms of European natural gas, while TTF gas prices in August 2022 rose to nearly 275% of the start-of-year level, July 2026 TTF prices were at 177% of start-of-2026 levels. Notable will be the translation and timing of the dynamics of wholesale power price changes to more sticky retail prices for end users, who have been increasingly expressing concerns around affordability.

Figure 4

**Relative to 2022, higher renewables generation in 2026 has eroded markets' exposure to gas prices**

Estimated Western European supply and demand change 2026 vs 2022 (April – September, TWh)

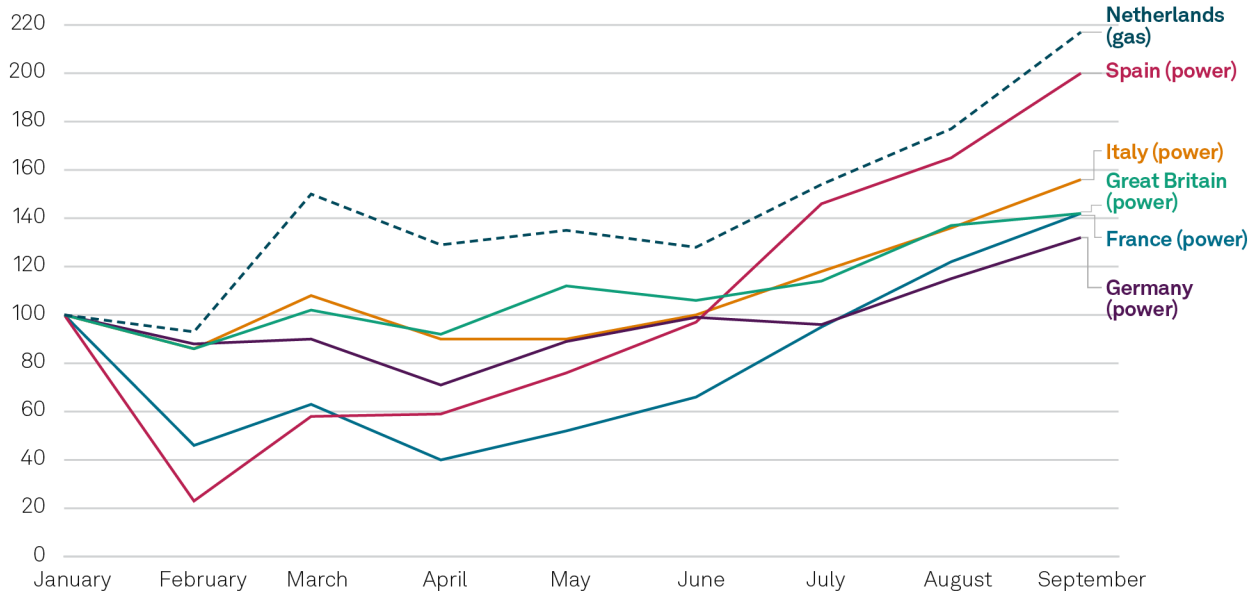



As of September 2026.
Source: S&P Global Energy.
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Figure 5

**The impact of the war in the Middle East has been significantly stronger on wholesale gas markets than on wholesale power markets**

Indexed day-ahead power and gas prices (100 = Jan. 26 average)




As of September 2026.
Source: S&P Global Energy.
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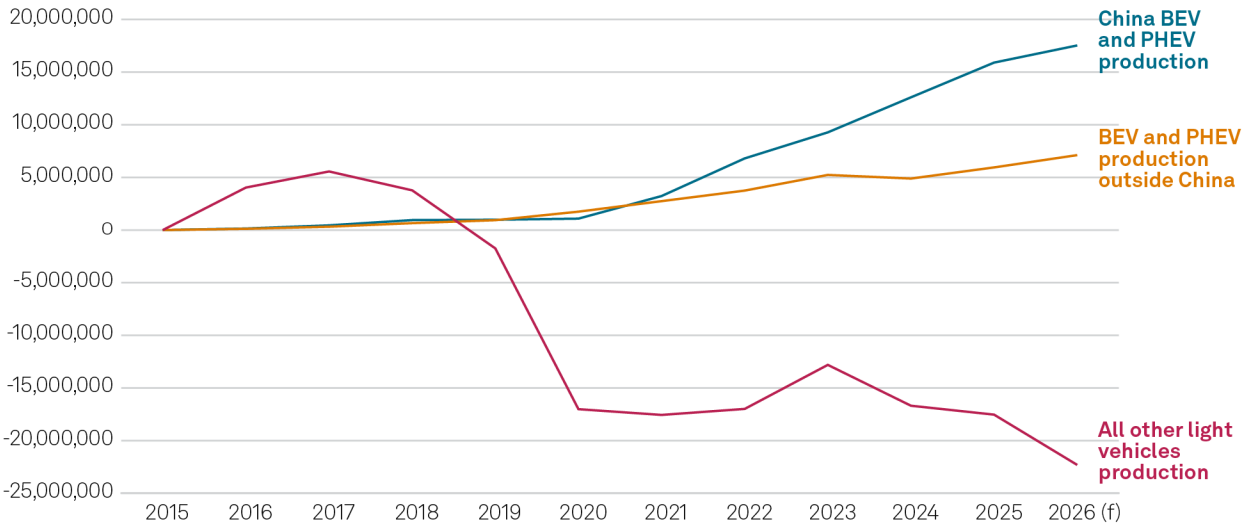
### China's adoption of electric vehicles provides another window into the contribution of clean technology to resilience

Resilience through decarbonization is not only a story of renewable power generation. Adoption of EVs can also provide a buffer, particularly in the face of higher and more volatile oil prices, such as those resulting from the ongoing reduction in oil flows through the Strait of Hormuz. Today, we observe that elevated oil prices are prompting consumers across markets, though to differing degrees, to move up the "fuel-efficiency ladder," the top rung of which is battery electric vehicles (BEVs).

**Unlike in past oil shocks, affordable EVs — primarily those manufactured in China — are now a lower-hanging fruit available for consumers to reduce oil consumption.**
While annual production of conventional internal combustion engine vehicles globally is estimated to have dropped by more than 20 million units since 2015, global annual EV production — including BEVs and plug-in hybrid electric vehicles (PHEVs) — is estimated to have increased by about 25 million, with Chinese EVs accounting for more than two-thirds of that total, according to Mobility Global data (see Figure 6).

Figure 6

**Production of EVs is rising at the expense of conventional ICE vehicles**
Global light vehicle production, change from 2015 (units)




Data compiled Aug. 17, 2026.
ICE = internal combustion engine. EV = electric vehicle. BEV = battery electric vehicle. PHEV = plug-in hybrid vehicle.
2026 is a forecast. PHEVs include range-extended electric vehicles.
Sources: Mobility Global; S&P Global Energy.
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**Along with the country's high-speed rail network, China's EV fleet — the world's largest — is providing the country's consumers low-carbon optionality in the face of an oil shock.**
Today in China, BEVs and PHEVs account for roughly 15% of all the light vehicles on the road. In terms of new sales, the share reached about 60% in the second quarter of 2026. In recent months, EV charging data suggest that Chinese consumers have been driving their PHEVs more in electric mode and, for multi-car households, driving their EVs (BEV or PHEV) more in place of their conventional internal combustion engine vehicles. It also appears that consumers in China have been leaning more on the country's heavily electrified ride-hailing fleet, and more often opting for high-speed trains over cars for inter-city travel.
These options and their scale are helping insulate China from the current oil shock.

**At the same time, China is, in some senses, is enabling lower oil dependencies in export markets through its high-scale production of economically priced EVs.** An acceleration in Chinese EV exports is a signpost for higher fuel prices spurring greater global interest in EVs. In the first half of 2026, China exported nearly 2.5 million BEVs and PHEVs — more than double the year-earlier period. This is more than all BEVs and PHEVs sold in the US in 2025 and the first half of 2026 combined.

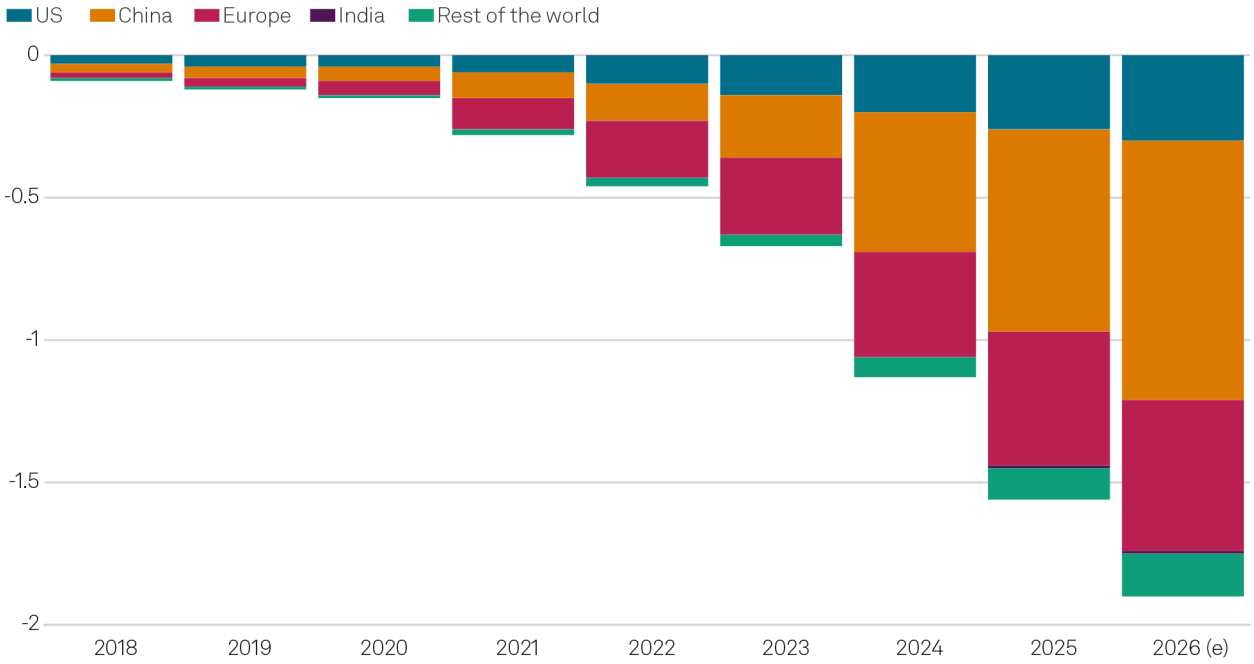
**Markets with no or limited domestic vehicle production, are more likely to be more open to Chinese vehicle imports than those with large domestic vehicle manufacturing sectors, as their local industries will be put at less (or no) risk.** In Australia, a country with no domestic vehicle production, the BEV and PHEV share of new light vehicle sales surged from an estimated 13% in the second quarter of 2025 to 32% in the second quarter of 2026, fueled by greater availability of competitively priced EV models from Chinese brands in addition to, in recent months, higher oil prices. In the latter period, more than two-thirds of the EVs sold were brands from automakers based in China.

**Each additional EV that enters the on-road fleet in a given market bolsters that market's resilience during periods of elevated gasoline and diesel prices.** S&P Global Energy estimates that battery electric and plug-in hybrid electric light vehicles on the road globally will displace 1.9 million barrels per day of oil demand in 2026 (roughly the amount that Germany consumes annually and nearly 2% of global oil demand; see Figure 7). This is equivalent to avoiding use of more than 25 billion gallons of fuel in a year, a financial dividend to drivers, all else being equal, including electricity prices, in a higher oil price environment.

Figure 7

**EVs are estimated to displace nearly 2 million b/d of oil demand in 2026**

Indicative global oil demand displaced by light BEVs and PHEVs (million b/d)




Data compiled Aug. 17, 2026.
BEV = battery electric vehicle. PHEV = plug-in hybrid vehicle.
Figure shows displacement as a negative number. Oil includes gasoline and diesel. 2026 data is an estimate.
Sources: S&P Global Energy; Mobility Global.
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To be sure, greater sales of more fuel-efficient vehicles — notably but not exclusively EVs — will have only a slow-motion impact on oil demand and will introduce new supply chain dependencies, notably including those related to China. Yet the current oil shock will end, and when the next one inevitably comes around, EVs — both those from Chinese automakers and their peers responding to an acute business threat — will be more competitive still.

**S&P Global Energy estimates that battery electric and plug-in hybrid electric light vehicles on the road globally will displace 1.9 million barrels per day of oil demand in 2026 (roughly the amount that Germany consumes annually and nearly 2% of global oil demand).**

### Projected investments in clean tech highlight how energy importers are looking to bolster their resilience

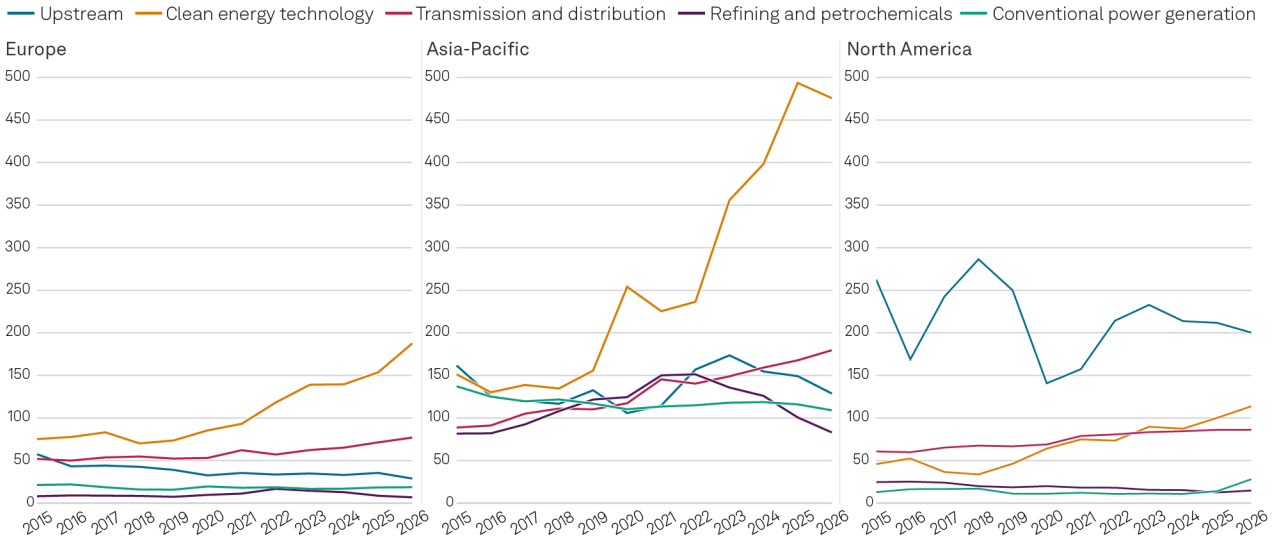
The ongoing turmoil in the Middle East will likely further drive renewable energy and EV adoption, and not primarily as a way to meet climate objectives. As we have highlighted, this is likely to improve economies' resilience to fossil fuel shocks by reducing external dependence on imported energy.

Diverging approaches to driving clean energy adoption, however, show that it is just one way to manage energy security. Traditional energy importers like China, other Asia-Pacific countries and Europe are investing significantly more than other regions to accelerate clean tech adoption and electrification, to reduce both emissions and exposure to fossil fuel shocks (see Figure 8). By contrast, North America, Latin America, the Middle East and Africa continue to invest relatively more in domestic fossil fuel production, reflecting the current resilience benefits amid increased geopolitical uncertainty, together with the long-term challenges of decoupling economies from domestic fossil fuel production.

Figure 8

**Energy geopolitics evolve**

Energy supply side spending by region, USD real 2025




As of September 2026.
Source: S&P Global Energy.
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**However, even among fossil fuel producers and countries without top-down strategies promoting the energy transition, clean tech deployment is increasingly driven by competitive pricing and potential investment returns.** With decentralized energy systems becoming more affordable, consumers and companies can choose to shield themselves from fossil fuel shortages, energy price volatility, or unreliable grids by adopting solar PV and battery systems, as well as electric vehicles and other higher efficiency end-use products. S&P Global Energy analysis suggested that over 90% of the incremental power generated in 2024 was in countries where the costs of renewable power, on a levelized per megawatt-hour basis, was below that of the benchmark fossil fuel power costs.

**As a result, markets are increasingly mobilizing capital toward the energy transition.** Private finance for climate mitigation is increasing everywhere, even in emerging markets where a lack of capital was an initial barrier to transition. Private investors drove 60% of mitigation finance outside China in 2024, up from 50% just two years earlier, according to Climate Policy Initiative data. In the US, while the production of domestic fossil fuels has risen, renewables are set to dominate electricity generating capacity additions this year and in years to come as the most immediate source of energy available to supply data centers' rising power needs (See US Grid Outlook 2026: Renewables Add Over 90 GW as Data Center Demand Tests Reliability).

## Looking forward: New dependencies emerge as the nature of energy risk shifts

Clean tech adoption does not mean countries' strategic vulnerabilities will be eliminated, rather that the source and nature of those vulnerabilities will change.

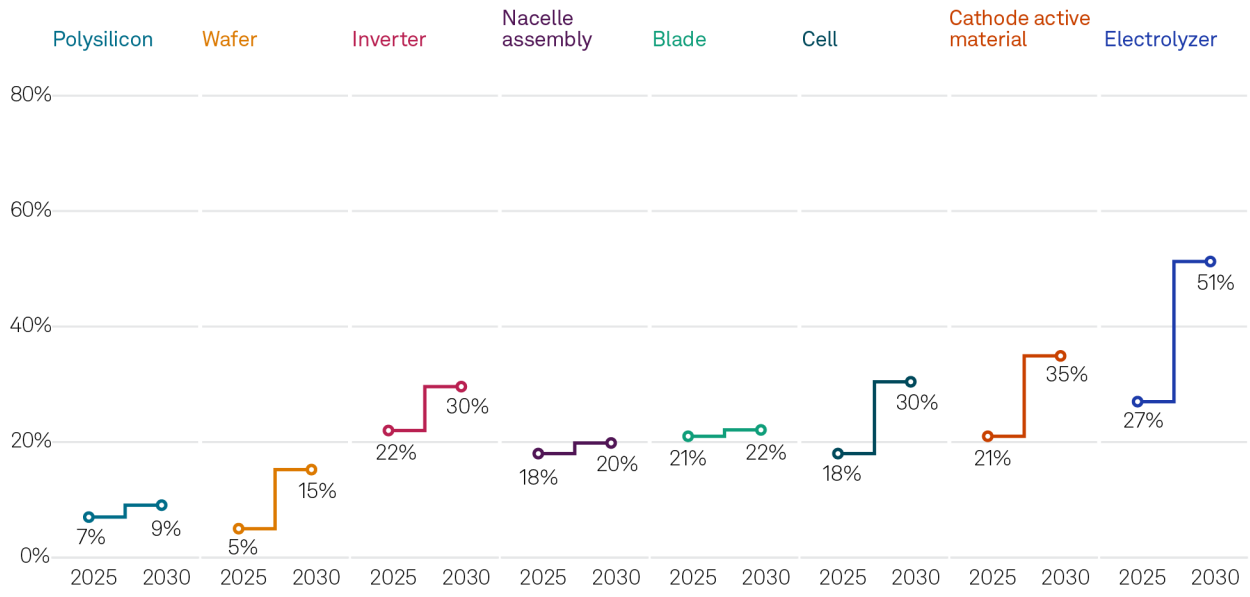
**Where clean technologies do displace imported fossil fuels, resilience benefits mainly stem from a transition to greater reliance on domestic power sources, sheltering countries from external fossil fuel supply and price shocks.** However, the manufacturing of clean technologies is already dependent on highly concentrated supply chains. Notably, China has come to dominate nearly all parts of the clean tech supply chain, from the mining and processing of key metals and minerals to the production of componentry and technologies. Countries investing in renewable technologies are, in effect, trading old dependencies for new ones.

**The vulnerabilities associated with concentrated supply chains for clean tech, which are typically operated over a longer lifetime, are fundamentally different than those stemming from a continuous need to access spot-priced fossil fuels.** Governments are already responding to this by diversifying sourcing of critical minerals and supply chains, supporting domestic production capacities and sometimes even scaling back on their GHG emissions goals to secure access to key resources and preserve jobs (see Figure 9).

Figure 9

**Certain nodes of clean tech supply chains are localizing — responding to government policies and the need for resilient supply chains**

Share of manufacturing capacity located outside of China for different cleantech components




As of September 2026.
Source: S&P Global Energy.
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**In other words, building resilience through clean tech adoption is complicated by a changing network of dependencies, ever-rising energy demand and fossil fuels remaining critically embedded in energy systems.** Irrespective of the climate and resilience benefits, replacing one energy system with another will take time, particularly as global energy needs have so far risen more quickly than renewables capacity additions. And transitioning to clean tech is creating a new set of trade-offs to balance the energy trilemma — energy security, sustainability and affordability.

Even though it may not eliminate vulnerabilities, the case for clean technologies to strengthen economic and geostrategic resilience by reducing exposure to imported fossil fuels is clear. And even where countries do not explicitly integrate clean tech investments into their national strategic planning, the markets may well do the job for them.

## Learn More

- In Search of Resilience
- What the world can learn from Türkiye's energy transition strategy heading into COP31
- US Grid Outlook 2026: Renewables Add Over 90 GW as Data Center Demand Tests Reliability
- Multidimensional Global Energy Pathways
- Sustainability Quarterly Third-Quarter 2026 Edition

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