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Charting a path for Vietnam to achieve its net-zero goals

By harnessing opportunities across sectors—particularly in power—Vietnam could potentially accelerate decarbonization to achieve net-zero emissions by 2050.

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Vietnam is more exposed to climate risk than nearly any other country in the world. By some estimates, it is one of the top five countries likely to be most affected by climate change.[1] Barring adaptation and mitigation measures, the country could face severe social and economic consequences.

Stakeholders across the country understand this reality and have begun making pledges and announcing policies aimed at reducing greenhouse-gas (GHG) emissions. At the UN Climate Change Conference in Glasgow (COP26) in 2021, Prime Minister Pham Minh Chinh announced the country's commitment to phase out coal power generation by the 2040s and achieve net-zero carbon emissions by 2050. Most recently, in its National Strategy on Climate Change, Vietnam announced a 43.5 percent emissions-reduction target by 2030, sector-specific emissions targets for 2030 and 2050, and qualitative suggestions for achieving these goals.[2]

While these are praiseworthy goals, they are unlikely to propel Vietnam to net-zero emissions by 2050 on their own. Carrying out that mission will require more detailed and specific actions. To sketch out one possible scenario for Vietnam to achieve its climate ambitions, we conducted a bottom-up analysis of the country's key economic sectors and the required emissions trajectory. Carefully focused and aggressive actions to reduce emissions across sectors of the economy, especially in power, could put Vietnam on a path to potentially achieve net-zero emissions by 2050.

This transition won't be easy. Vietnam faces structural challenges, and the transition will require considerable investment—as well as significant mindset and operational changes. Nonetheless, by building on existing efforts and engaging across sectors, Vietnam could realize its commitments and help keep global warming below key thresholds. Such actions would also improve health outcomes, provide access to new sustainable value pools, and grow GDP.

The net-zero imperative and progress to date

Vietnam faces twin threats. First are the physical risks posed by climate change, which could have an outsize impact on Vietnam's urban areas. Prior McKinsey research suggests that in Ho Chi Minh City (HCMC)—the country's largest city and an important hub for commerce and finance—flood depth could increase threefold by 2050, and a 100-year flood could affect 36 percent of the city.[3] Associated damages and losses could cost between $15 billion and $20 billion. A scenario in which the sea level rises 1.8 meters could put 66 percent of HCMC under water, potentially leading to blackouts and road and transit closures.

Second, Vietnam's GDP is at risk because of transition adjustments.[4] Vietnam derives a high proportion of its GDP from high-carbon sectors, and much of its capital stock is tied up in fossil fuel–based power. Vietnam has already struggled to attract financing for planned coal-fired thermal plants.[5]

Emissions reduction is thus essential for Vietnam to mitigate physical and economic risk. And that in turn will require substantial change. Vietnam's emissions could nearly quadruple by 2050 if the country's industries continue to grow at planned rates without technological change, industrial-base changes, and successful implementation of policy changes (Exhibit 1).[6]

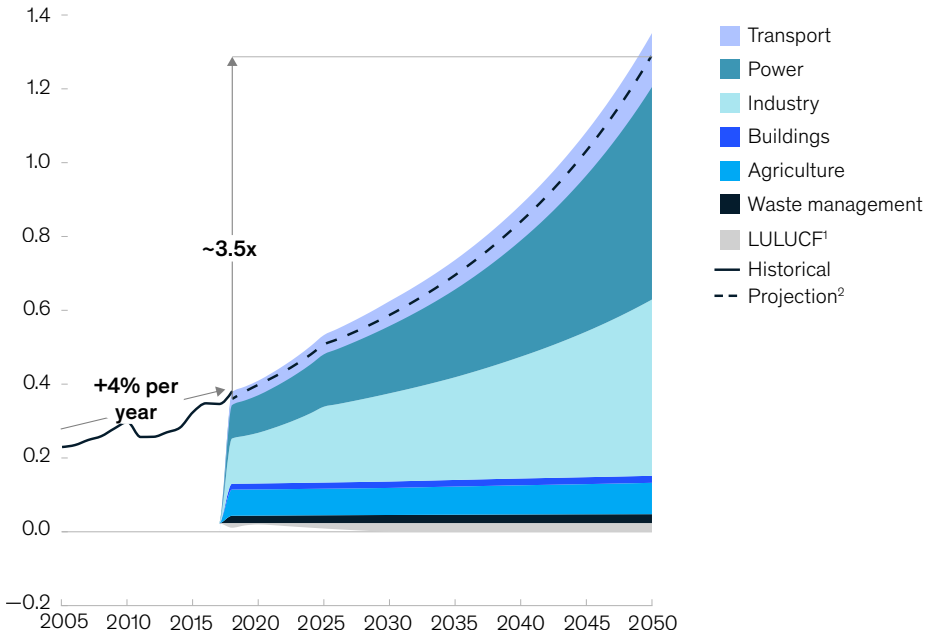
Vietnam's policy goals are in line with many of the country's Association of Southeast Asian Nations (ASEAN) peers that have also made net-zero commitments. As with other countries, Vietnam's

[1] "Country: Vietnam," World Bank Group Climate Change Knowledge Portal, 2021.
[2] "Decision No: 896/QD-TTg," National Strategy for Climate Change, July 26, 2022.
[3] "Can coastal cities turn the tide on rising flood risk?," McKinsey Global Institute, April 20, 2020.
[4] "How the net-zero transition would play out in countries and regions," McKinsey, January 25, 2022.
[5] Luu Huong, "Influential institutions look to wind down coal activities," *Vietnam Investment Review*, August 18, 2021.
[6] "Vietnam," CAIT 2018 data, Climate Watch; McKinsey Decarbonization Scenario Model, Vietnam.

Exhibit 1

Vietnam's emissions could quadruple by 2050 if the country does not successfully implement decarbonization policies.

Vietnam greenhouse-gas emissions trend, Gigatons of CO_2 equivalent ($GtCO_2e$)



[1]Land use, land-use change, and forestry. Some processes under LULUCF (such as forest fires and turning forest into agricultural land) emit CO_2, while the remaining forested areas serve as a carbon sink.
[2]The projected baseline scenario assumes technological adoption remains at the same level that it was in 2020.
Source: Climatewatch CAIT 2018 data; McKinsey Decarbonization Scenario Model output, Vietnam

emissions come from a range of energy and land-use systems. About 30 percent of total GHG emissions are from the power sector, a further 30 percent are from industry, and about 10 percent come from transport.

Multiple agencies within the Vietnamese government have outlined concrete CO_2 reduction policies. For example, the Ministry of Industry and Trade's Power Development Plan 8 (PDP8) aims to switch about 75 percent of generation capacity to renewables by 2045. Of this, about 100 gigawatts (GW) will be solar power and about 120 GW will be wind power (even higher solar targets are being discussed). The ministry also announced the use of hydrogen and ammonia in thermal generation plans, paving the way for green hydrogen to partially replace fossil fuels.

In transport, the prime minister has encouraged electric-vehicle (EV) adoption, EV-charging infrastructure, and the electrification of public transit. Public stakeholders have taken action accordingly. The Ministry of Finance has reduced EV registration fees. Hanoi, HCMC, and Da Nang all have metro projects under way, which may reduce the passenger share of personal vehicles. Hanoi and other cities have also talked about banning two- and three-wheel vehicles with internal-combustion engines (ICEs) and have already pedestrianized some neighborhoods on certain days. The Ministry of Transport is also planning high-speed rail, which could reduce the number of flights within the country.

Other government bodies have also made pledges. The Ministry of Agriculture and Rural Development

has pledged to stop deforestation by 2030,[7] and the Ministry of Construction has set requirements that promote green buildings.[8]

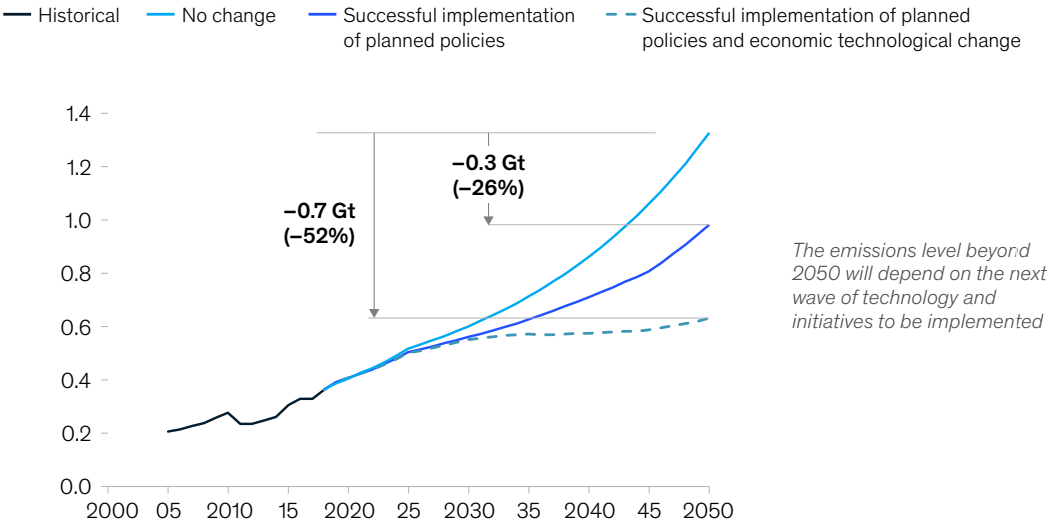
Beyond central-government agencies, some provinces have also emphasized decarbonization. Coastal provinces have been ambitious in setting high renewable-energy targets in the latest PDP8 draft. Others are explicitly pivoting away from high-emission industries to lower-emitting, higher-value-adding sectors. The province of Quang Nam has pioneered carbon-sink projects in Vietnam by protecting its forests in partnership with the World Wide Fund For Nature (WWF).[9]

If the government can successfully implement these policies, it will likely reduce emissions—but not to the extent required to reach net-zero emissions by 2050. Exhibit 2 highlights this gap with three scenarios. The least favorable is the scenario outlined previously, in which industries continue to grow at planned rates without technological change and without successfully implementing planned policies. The middle scenario in the chart shows the successful implementation of planned policy updates. In the best-case scenario, which combines the latest plans with economically viable technological changes—such as adopting EV powertrains for passenger cars and two- and three-wheel vehicles, improving agricultural efficiency, and pivoting to advanced manufacturing—the emissions curve drops even more. Under this scenario, Vietnam's emissions could flatten out around 2035. By 2050, emissions would approximate 0.6 gigatons, roughly the same level as in 2025.

Exhibit 2

An intermediate scenario demonstrates how current policies may still leave Vietnam falling short of its stated net-zero goal.

Pathways of Vietnam CO_2 emissions, gigatons of CO_2 equivalent ($GtCO_2e$)



Note: Figures are approximate.
Source: "Statistical yearbook of Vietnam 2018," General Statistics Office, June 29, 2019; McKinsey Decarbonization Scenario Model output, Vietnam

[7] "Vietnam forest facts and figures," UN-REDD, July 20, 2009.
[8] "Green building policies," Vietnam Green Building Council, accessed September 13, 2022.
[9] "Launching the Annamites Carbon Sinks and Biodiversity project – Quang Nam component," World Wide Fund For Nature (WWF), August 11, 2011.

Yet even under this best-case scenario, the country would get only about halfway to net-zero emissions. What does Vietnam need to do to close the gap? We outline a pathway in the following section.

Achieving net-zero emissions in Vietnam

We conducted detailed modeling of Vietnam's emissions across sectors and of several hundred specific decarbonization levers (and their cost) to assess what it could take to close the gap (see sidebar, "Our methodology"). We divided sources of GHGs into seven sectors—agriculture, buildings, industry, power, transport, waste management, and land use, land-use change, and forestry (LULUCF). A concerted effort across all seven sectors could reduce emissions to net zero by 2050 (Exhibit 3).

For this article, we focus in detail on three key sectors: power, industry, and transport.

Power

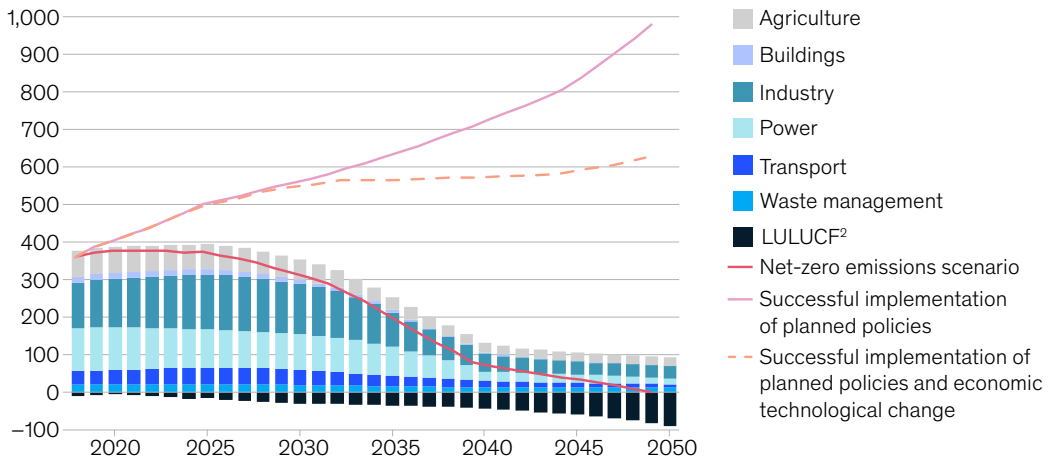
Power presents a significant opportunity for the country's net-zero emissions ambitions. It's also key to achieving those goals, given the critical importance of countrywide electrification for a range of other sectors. Vietnam is unique among its ASEAN peers in the extent of its physical potential to generate renewable energy.

Under our net-zero scenario, electricity demand will increase significantly as other sectors electrify—for example, switching from ICE vehicles to EVs. The country will need to invest in enabling infrastructure—such as transmission and distribution grids, as well as utility-scale storage—

Exhibit 3

Actions across seven sectors in Vietnam could result in net-zero emissions by 2050.

Projected pathway to reduce net emissions by 100%, megatons of CO_2 equivalent (CO_2e)



[1]Land use, land-use change, and forestry.
Source: McKinsey Decarbonization Scenario Model output, Vietnam

Our methodology

Vietnam has many potential paths to reach net-zero emissions by 2050. This report outlines one particular pathway that is feasible from a technology and supply chain perspective in the aggregate, based on current outlooks.

To arrive at this pathway, we used proprietary optimization models and data from our Sustainability Insights Decarbonization Scenario Explorer solution to evaluate several hundred decarbonization lever business cases across 42 subsectors and hundreds of discrete activities. In this optimization, we accounted for countrywide and regional constraints such as (but not exclusively) technical maximums for wind- and solar-power generation, maximum pumped hydro-energy storage potential, consumer willingness to switch to transport alternatives, and land available for reforestation. Because Vietnam recently released a new draft of the Power Development Plan 8 (PDP8), we paid particular attention to the power sector.

We did not account for the value of the nonmonetary benefits from reducing emissions, such as reduced air pollution, improved human health, and reduced physical risks from climate change. These benefits are significant for Vietnam and could be worth billions of dollars in improved societal outcomes.

We also did not constrain economic growth or consumption, and we assumed that production locations would not shift. The result is not a forecast but a pathway that outlines how national ministries, provinces, and corporate stakeholders could work together across sectors to reduce Vietnam's overall emissions 100 percent by 2050.

Finally, we do not investigate the specific challenges that the zero-emissions transition creates for individual companies. These can be significant. And while we explore some of the potential actions that key actors in Vietnam can take to navigate and shape the transition, providing a detailed perspective on how players in each sector can navigate the transition is outside the scope of our research.

to integrate renewables into the grid, bridge short-term supply shortages, and cover distances between power plant sites and demand centers.

Among sectors, power is best equipped to scale its decarbonization immediately. This is because of the ambitious targets set in the government's PDP8, the technical maturity of key renewables technologies, and investor interest in renewables in Vietnam. The government's strategy for net-zero emissions emphasizes power and even mentions nuclear power—a striking change for the country.[10] To reach net-zero emissions, Vietnam would have to pivot the bulk of its power generation capacity to wind and solar, installing about 150 GW of wind capacity, most of it offshore, and about 70 GW of solar capacity by 2050. The country would also need to shift the majority of what's left to hydropower and stop using coal after 2030 (Exhibit 4). We outline the capacity installed not just for generation but also for storage, reflecting global trends toward long-duration energy storage, which estimates suggest could reach 2.5 terawatts (TW) globally by 2040.[11]

In modeling this scenario, we considered significant demands during peak loading times and seasons (currently, the middle of the day and in the evening during June and July). The pathway thus requires Vietnam to maintain a sizable storage capacity for peak demand, as well as a small amount of thermal generation (about 10 percent) while incorporating carbon capture, utilization, and storage (CCUS) technology. As long-duration energy storage develops further, the country could move away from thermal generation altogether.

This pathway sets ambitious targets for renewables but captures just a fraction of Vietnam's overall

[10] "Decision No: 896/QD-TTg," July 26, 2022.
[11] "Net-zero power: Long-duration energy storage for a renewable grid," McKinsey, November 22, 2021.

renewable-power potential. For example, while it calls for the installation of about 150 GW of wind capacity, Vietnam's technical wind potential is between four and five times higher (Exhibit 5). Similarly, the pathway's solar target is less than one-fifth of Vietnam's economic solar potential. By harnessing its natural advantages and installing more wind and solar power than required for net-zero targets, Vietnam could become a net exporter of renewable electrons (for instance, to Singapore) and a green-hydrogen hub. This would satisfy internal demand for hydrogen gas and ammonia for cofiring and hydrogen for producing green metals, and it would supply rapidly growing export markets such as Korea and Japan.

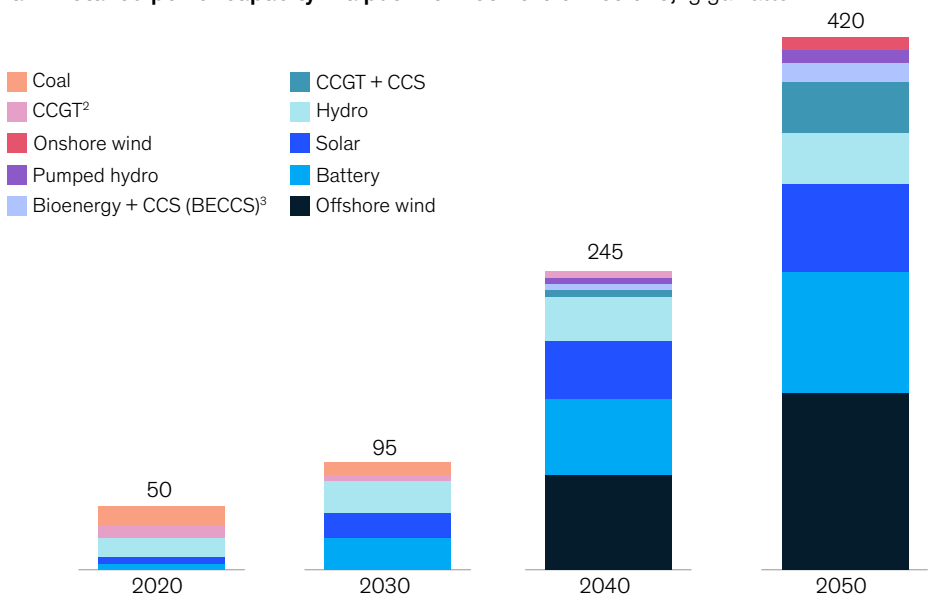
Provinces are already competing to attract offshore wind projects. For example, Binh Thuan has proposed more than 22 GW of offshore wind projects in its submission to PDP8. The Ninh Binh and Quang Ninh provinces have proposed more than 21 GW and more than five GW (of combined onshore and offshore wind), respectively.

Renewables are also the most effective source for meeting Vietnam's increasing power demand. Levelized cost of electricity (LCOE) forecasts for the country show that solar and onshore wind are already cheaper than all thermal generation sources, and offshore wind will be cheaper than gas by approximately 2030. These LCOE forecasts

Exhibit 4

Decarbonizing Vietnam could require a strong transition to renewable energy, as well as storage and grid investments.

Vietnam installed power capacity in a push for net-zero emissions,[1] gigawatts



Note: GW values are approximate.
[1]Based on the following capacity factors: 60% for gas; 36% for onshore wind; 54% for offshore wind; 70% for coal; 22% for solar; 50% for hydro; 66% for diesel; and 63% for bioenergy. To achieve emissions reduction aspiration, CCUS must cover thermal generation emissions; assume 90% emissions captured.
[2]Combined-cycle gas turbine.
[3]Bioenergy and carbon capture and storage.
Source: International Energy Agency; Institute for Sustainable Future; International Renewable Energy Agency (IRENA); McKinsey Decarbonization Scenario Model output, Vietnam

exclude carbon costs; if the carbon tax currently under discussion is implemented, renewables would be even more cost competitive and should displace thermal generation. Green-hydrogen production in Vietnam could become competitive with the lowest-cost producers worldwide.

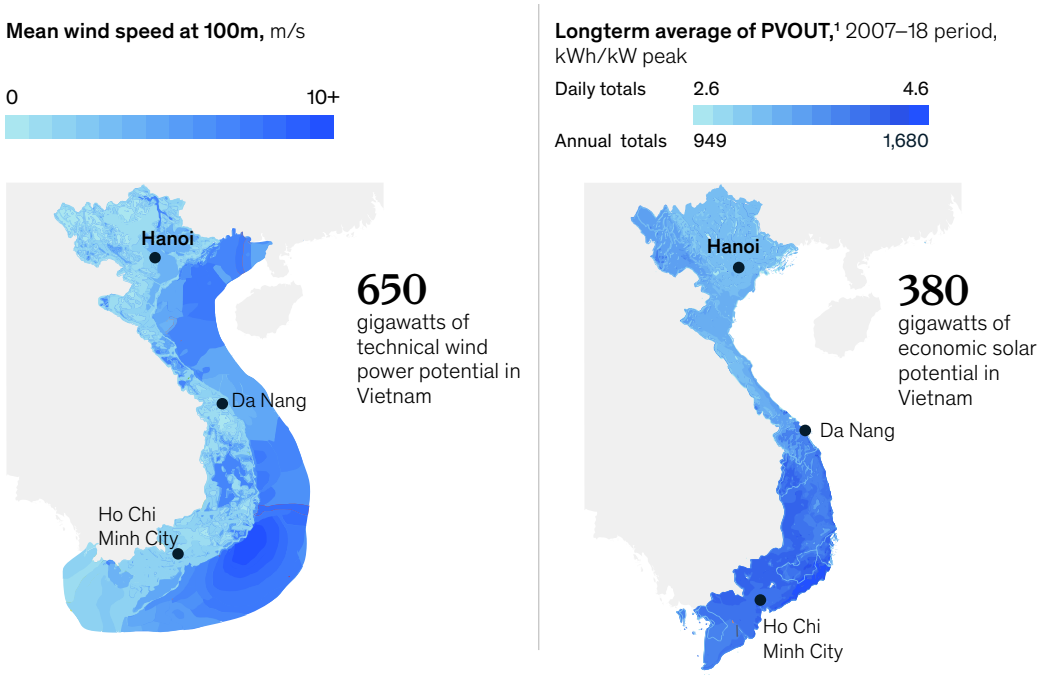
Industry

While the power sector will be the key to Vietnam's ability to achieve net-zero emissions, industry—as a major emitter of greenhouse gases—also has an important contribution to make. Vietnam will need to reduce the GDP contribution of basic low-value manufacturing and move up the value chain to high-value, electrified low-carbon segments.

Vietnam's steel industry provides one example. Under the net-zero pathway, the industry would need to plateau its growth by the late 2030s as the country pivots to higher-value manufacturing. Any additional new manufacturing capacity would deploy direct reduced iron and electric arc furnace (DRI-EAF) technology using green hydrogen and renewable electricity. By 2050, Vietnam would need to be producing more than 99 percent of its steel using DRI-EAF technology. Steel companies around the world are switching to DRI-EAF and have already planned 16 million tons of green-steel manufacturing capacity by 2030. Some Vietnamese provinces are already pioneering green metals: Dak Nong, for example, is considering how to implement

Exhibit 5

Vietnam has natural endowments with high potential for wind and solar power.



Note: The boundaries and names shown on maps do not imply official endorsement or acceptance by McKinsey & Company.
[1]Specific yield of photovoltaic power output.
Source: Global Solar Atlas 2.0; Global Wind Atlas; Institute for Sustainable Futures; *Vietnam energy outlook report 2019*, Electricity and Renewable Energy Authority and Danish Energy Agency, 2019

green aluminum manufacturing, incorporating renewable energy.[12]

Road transport

Road transport would also need to undergo major changes, such as a shift to bicycles, public transit, and EVs (including fuel cell EVs). This trend is already under way in Vietnam. Net-zero emissions would require changes in commuting and work habits specifically. For example, metro or bicycle would need to account for 40 percent of trips within HCMC and Hanoi by 2050, with increased teleworking reducing daily commuter trips in those cities by 6 percent. Electric motorcycles and scooters would need to have the majority share of two-wheel ridership by 2032 to 2035 and more than 99 percent market penetration by 2050. Rail transport, including high-speed rail, would begin to replace aviation and bus trips between Vietnam's major cities. To follow the net-zero pathway, Vietnam must implement high-speed rail by 2040. Next, high-speed rail must capture 20 percent of baseline domestic aviation passengers quickly, increasing to 30 percent by 2050.

Achieving ambitious decarbonization goals will be challenging and require investment

Some of the steps required to achieve net-zero emissions under this pathway would be difficult, but the experiences of other countries suggest they are doable.

Certain characteristics of Vietnam's geography and society will make decarbonization especially challenging. For instance, the long distance between Hanoi and HCMC—about 1,600 kilometers—makes implementing high-speed rail expensive. In contrast, Uzbekistan has successfully implemented almost 750 kilometers of high-speed rail and, with funding support from the Asian Infrastructure Investment Bank, is planning an additional 500 kilometers.[13] Vietnam's elongated geography creates challenges for grid infrastructure, and its underdeveloped grid limits the integration and expansion of renewable power generation. Chile, a similarly elongated country, has launched an effort to attract foreign companies to invest in Chile's pivot to a decentralized grid in support of the move to renewables.[14]

Capital projects in Vietnam have at times delivered behind schedule, but development of a public transport system would need to keep pace with required decarbonization efforts from the transport sector. This can be done: the first 350 kilometers of Uzbekistan's high-speed rail were operational in five months,[15] and the rapid metro line in Gurugram, India, was launched in two and a half years.[16] The high penetration of two-wheel ICE vehicles in Vietnam complicates the modal shift

To follow the net-zero pathway, Vietnam must implement high-speed rail by 2040.

[12] "Environmental protection – green growth," Vietnam Business Forum, March 30, 2020.
[13] "Asian Infrastructure Investment Bank provides $108 million loan to Uzbekistan for railway line electrification," *AKIpress*, April 1, 2022.
[14] *InvestChile Blog*, "Energy: Where are the investment opportunities in Chile?," May 24, 2021.
[15] "Uzbekistan's high-speed railways linking the past with the future," Emerging Europe, September 2, 2021.
[16] "India's first rapid metro begins operations in Gurgaon," *Business Today*, November 14, 2013.

to public transit, walking, or bicycling, but other cities have shown that this is also possible. For instance, Mexico City and Guadalajara (cities with rainy seasons and hot summer temperatures) have established bike-sharing programs as a key part of their transport mix.[17]

The investment required for these steps is an important piece of the puzzle. Our initial estimate suggests that between 80 and 90 percent of Vietnam's emissions across all sectors can be eliminated at a cost of $24 per ton of CO_2 equivalent or lower. Many of these levers are low cost. In fact, in less than a quarter of some cases, the cost of adopting a sustainable alternative is negative—that is to say, cheaper than continuing with the status quo.

For example, wind, solar, and hydro new builds are cost competitive with new thermal plants over their lifetime because they have lower operating expenditures and will have lower capital expenditures in the future. And electrifying road transportation is less costly than supporting ICE transportation due to significantly lower EV operating expenditures and the expected parity for total cost of ownership for EVs and ICE vehicles.

Still, significant public and private spending will be required to achieve net-zero emissions in Vietnam: a rough estimate based on our modeling of the net-zero pathway puts total investment at approximately $30 billion per year. Some projects are especially expensive: some estimates of Vietnam's high-speed rail plans place their cost at more than $55 billion.[18] But this does not account for the positive externalities of these changes, such as improved public health outcomes, greater economic activity, and access to new value pools.

Seizing the net-zero opportunity across sectors

Achieving net-zero emissions presents significant opportunities in the short and long term for government, businesses, and residents. Further socioeconomic modeling would more fully assess the societal impact of the transition, but residents would undeniably see significant improvement in health outcomes due to reduced emissions, especially in heavily polluted cities such as Hanoi. They would also benefit from reduced physical risk from climate change. And improved transit could reduce social isolation and increase equity by making employment and services more accessible.[19]

The public and private sectors have an important role to play in realizing these and many other opportunities promised by a successful transition.

In the public sector, the Vietnamese government could consider providing structured governance, regulatory support, and funding to accelerate demand for climate-friendly technologies in key industries. For instance, the government could ensure rapid commissioning of planned projects and update offshore wind regulations to ensure project bankability, clear site allocation, and transparency on future auction schemes. Given PDP8's ambitions for installed offshore wind capacity by 2030, and six- to eight-year development timelines, offshore wind projects should begin now—and this can happen only with regulatory guidance and support. As noted in a prior report, the government could set the rules and guidelines for green-bond market actors.[20]

Implementing the discussed carbon tax could help Vietnam decarbonize and raise revenues, thereby funding its climate goals. A carbon tax would also

[17] Arturo Balderas Torres et al., *Sustainable mobility for sustainable cities: Lessons from cycling schemes in Mexico City and Guadalajara, Mexico*, Coalition for Urban Transitions and University of Leeds, 2021.
[18] T. Du, "There will be a 300km/h high-speed railway from Hanoi to Ho Chi Minh City," Bao Dat Viet, December 30, 2019.
[19] "The benefits of public transport," Tourism & Transport Forum Australia, May 2010.
[20] Sarika Chandhok, Jonathan Deffarges, Bruce Delteil, and An Nguyen, "Can Vietnamese banks seize the green-bond opportunity?," McKinsey, August 3, 2022.

Funding the energy transition would represent a $1.5 billion revenue opportunity by 2025 for Vietnamese banks from issuing transition finance products.

help stimulate low-carbon industries targeting growing value pools while discouraging investment in sunsetting, emission-intensive ones. This would set the stage for Vietnam to eventually implement an emissions trading system.

More broadly, a national committee on climate change could allocate funding and support to industries and technologies that require a kick-start to create a base in Vietnam. In addition, a green-tech fund, investing in specific climate technologies to bring to Vietnam, could provide both positive returns and reduced emissions. By supporting climate-friendly technologies, Vietnam could help its industrial base access new value pools that will be worth between $9 trillion and $12 trillion by 2030, growing the country's GDP.[21]

The private sector can also access significant value pools by making strategic bets now on key decarbonization trends such as the following:

— *Renewable energy.* Vietnamese construction and real-estate players can use their expertise in developing large local capital projects to build renewable-energy installations. For instance, Fecon, a local construction company, has partnered with Corio Generation, Macquarie Green Investment Group's offshore-wind portfolio company, to develop offshore wind.[22] Local oil and gas companies could pivot to developing renewables, as many overseas players have done—for example, Equinor recently partnered with PetroVietnam to develop renewable power. In the future, a large renewable base could position Vietnam to become a leader in the growing green-hydrogen economy and to serve as a net exporter of green electrons. This is a time-sensitive activity; developers are already competing for the most economical sites.

— *Green steel.* There is significant commercial demand for green steel across industry sectors, and many leading steel manufacturers have launched green-steel plants. By making this shift, Vietnamese companies will avoid relying on high-emission manufacturing assets as regulations and shrinking demand eliminate markets for dirty steel.

— *Transport.* Vietnamese transport companies could follow early pioneers—from large-scale companies such as VinFast to start-ups such as Dat Bike—to participate in the EV value chain, from batteries to charging infrastructure.

— *Finance.* Funding the energy transition would represent a $1.5 billion revenue opportunity by 2025 for Vietnamese banks from issuing transition finance products.[23] Funding is most accessible to banks with local market expertise. Across sectors, opportunities exist for public–

[21] "Playing offense to create value in the net-zero transition," *McKinsey Quarterly*, April 13, 2022.
[22] Adnan Durakovic, "Corio and Fecon to jointly build wind farm offshore Vietnam," OffshoreWIND.biz, June 22, 2022.
[23] "Can Vietnamese banks seize the green-bond opportunity?," August 3, 2022.

private partnerships, especially for infrastructure projects with large benefits to cities.

While Vietnam has pledged to achieve net-zero carbon emissions by 2050 and has set sector-level targets as part of that objective, the country is not yet on a path to achieve its goal. Current efforts are meaningful, but Vietnam lacks a detailed decarbonization strategy. A pathway does exist, however. By harnessing opportunities across the economy—particularly in power—and coordinating across sectors to capture new value pools, Vietnam can meet its pledge, grow its GDP, and improve life for its residents.

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