
NetZero
Pathfinders
Delivering Net Zero
A Framework for
Policymakers
BloombergNEF

About NetZero Pathfinders

BNEF's *Delivering Net Zero: A Framework for Policymakers* is a handbook for governments to design and implement decarbonization strategies. It aims to serve as a fundamental resource for key stakeholders by outlining the policy actions needed to reach net zero. The public NetZero Pathfinders web platform displays a library of the most effective policies to date. These policies, known as best practices, can be replicated in other markets to accelerate progress to net zero.

Pathfinders best practices are powered by the expertise of hundreds of BloombergNEF analysts, who utilize clear metrics to identify and evaluate the most impactful climate solutions. By showing what really works, Pathfinders builds a community of decision makers and empowers them to drive the implementation of solutions and mitigate climate change. The initiative aims to serve municipal, regional, national and international policymakers, financiers, business leaders and others.

Pathfinders illuminates paths to net zero by:

Identifying the pillars of net-zero strategies.
The Pathfinders framework and pillars outline the most critical areas for policymakers to address in each emitting sector of the economy in the race to net zero.

Highlighting effective actions today.
Without immediate action, we are at risk of exceeding the carbon budget and committing the world to 1.5C of warming above pre-industrial levels. Policy and other measures that show historic or potential impact are thus critical to replicate. Pathfinders outlines actionable solutions to put the world on track for success this decade while laying the foundation for decarbonizing harder-to-abate sectors post-2030.

Telling success stories.
Through trial and error, governments and others have been testing potential decarbonization solutions for more than two decades. Pathfinders profiles field-tested measures that have been implemented internationally, nationally and locally, as well as newer measures with high potential for future impact. Pathfinders best practices can serve as inspiration for other markets formulating their own net-zero strategies.

Since there is no single path to decarbonization and solutions can vary widely by sector or jurisdiction, the NetZero Pathfinders platform is structured as a flexible framework that can continually evolve. We encourage engagement from all stakeholders and invite further examples of progress in the race to net zero. To learn more or to share your successes, please contact us at pathfinders@bloomberg.net.

NetZero Pathfinders

Pillars of Net-Zero Strategies

To help governments navigate potential policy paths to net zero, the Pathfinders actions are split into four pillars.

1
Accelerate deployment of mature climate solutions

Thanks to extraordinary progress achieved over the past decade, technologies that emit zero carbon dioxide already exist and are increasingly cost-competitive with their fossil-fueled rivals. This list includes wind and solar power projects in most of the world and electrified vehicles in a small but growing number of markets. Yet these climate-friendly technologies do not always flourish, in part due to policies that explicitly protect incumbents.

2
Support development of new climate solutions

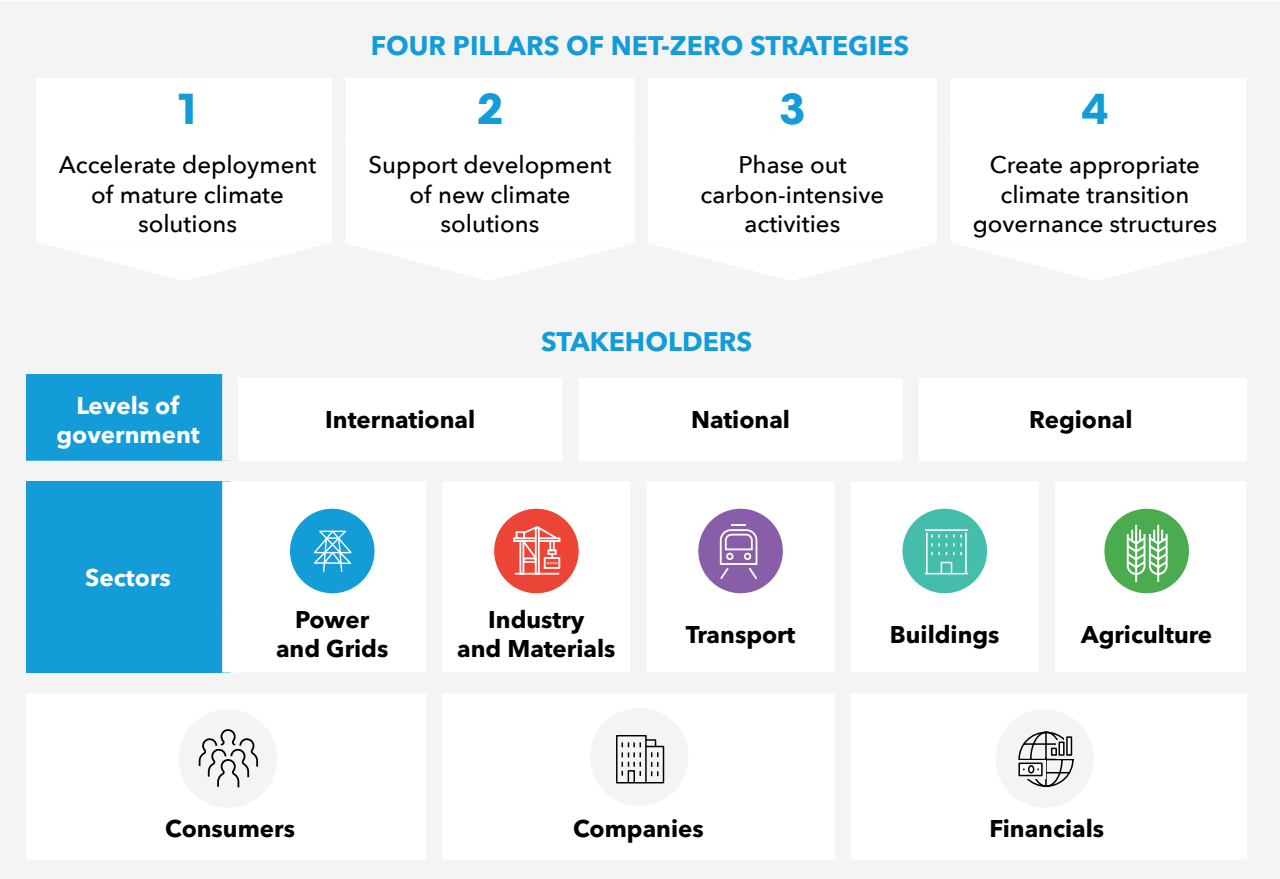
To zero out emissions entirely, more clean energy technologies will be required to provide around-the-clock, zero-carbon power; decarbonize industrial processes; cut emissions associated with livestock and agriculture; and meet other challenges.

3
Phase out carbon-intensive activities

Despite the immediate threat posed by climate change, governments continue to subsidize fossil-fuel production and consumption – whether directly or through state-owned companies and financial institutions. While such support should be phased out, scaling back subsidies that artificially cap consumer energy prices can be politically challenging. Nonetheless, policymakers and others have found innovative ways to phase out support for fossil fuels.

4
Create appropriate climate transition governance structures

The scope of the climate crisis is forcing governments to take a multidecadal view of the problem. But policies are only as good as the frameworks to devise, implement and enforce them. Policymakers must recognize that attracting investment in low-carbon technologies – and enjoying the associated economic benefits – requires constructing governance structures that are durable and long-lasting.



NetZero Pathfinders Framework

PILLAR 1 Accelerate deployment of mature climate solutions

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Speed up project deployment timelines	Promote the use of clean energy in industrial processes	Implement supply- and demand-side policies for electric vehicles to promote cost parity	Promote consumer incentives for heat pumps and efficiency measures, alongside penalties for fossil-fuel heating	Incentivize farmers to adopt precision technology
Ensure project bankability by mitigating offtaker risk and ensuring diversity and certainty of revenue streams	Foster the demand and supply of sustainable bio-based energy and feedstock in relevant industries	Speed deployment of charging infrastructure for passenger vehicles and trucks	Roll out company mandates to scale up low-carbon heating value chains	Promote soil and nutrient management that improves nitrogen use efficiency
Incentivize a diverse clean energy technology mix	Establish and enforce industrial energy efficiency standards	Boost walking, micromobility and public transportation in urban areas	Enforce efficiency performance standards in existing and new builds	Leverage carbon and clean-energy incentives to support deployment of manure management and anaerobic digestion projects
Proactively plan and build the power grid	Introduce circular economy requirements for producers and consumers of emissions-intensive materials	Accelerate access to finance for electric vehicles	Enable consumers to retrofit existing buildings through access to financing	Promote dietary shifts to low-emission sources of protein
Accelerate access to low-cost finance for clean energy projects and grids				

PILLAR 2 Support development of new climate solutions

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Support clean firm capacity and long-duration storage	Incentivize industrials to adopt zero-carbon processes and lower-carbon fuels	Stimulate the uptake of batteries and low-carbon fuels for heavy-duty vehicles	Support the deployment of alternative refrigerants with low or no global warming potential in heat pumps and air conditioning systems	Support the adoption of low-carbon nitrogen fertilizers
Support emerging grid technologies	Foster demand for low-emissions materials	Establish measures, such as blending requirements, to ensure the uptake of low-carbon aviation and shipping fuels	Encourage deployment of smart heating networks	Support development, commercialization and deployment of technologies that lower enteric methane released by ruminants
Ensure market design accounts for the integration of new demand and supply sources	Encourage shared hydrogen and CO2 storage and pipeline infrastructure	Support the development of clean propulsion technologies and low-carbon shipping fuels	Accelerate the development of innovative high-efficiency air conditioning systems and thermal storage technologies	Provide fast, low-cost and reliable soil carbon testing
Ensure sufficient, sustainable and traceable supply of energy transition metals				Provide incentives and regulatory pathways to promote alternative protein production and consumption
Promote consumer adoption of demand-side flexibility technologies				
Support research and development institutions and projects				
Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies				
Support low-carbon hydrogen production close to demand				

PILLAR 3 Phase out carbon-intensive activities

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Enable economic competition between renewables and fossil fuels	Phase out unabated coal-powered industrial facilities	Phase out sales of internal combustion engine vehicles through performance-, weight- and usage-based penalties	Phase out fossil-fuel heating, starting with the most emission-intensive systems	End harmful production subsidies and price supports resulting in over-application of fertilizers, land clearing and residue burning
Reuse grid capacity from retiring fossil-fuel plants	Switch to product and material pathways that abate or avoid process emissions	Tighten fuel economy standards for passenger and commercial road vehicles	Support the transition of fossil-fuel heating networks to technologies powered by sustainable fuels	Restrict international trade of goods produced on recently deforested land
Implement competitive price signals for capacity development and dispatch	Encourage all new industrial facilities and public buildings to be net-zero ready	Support scrappage programs for internal combustion engine vehicles	Establish net-zero standards and requirements for new buildings	Introduce land-sector offset mechanisms and develop agricultural carbon methodologies
	Ensure sustainable mining standards and traceability		Ban fossil-fuel boiler sales and installations in new builds while implementing boiler scrappage programs	

Remove fossil-fuel and other harmful subsidies

Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies

Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize

Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy

PILLAR 4 Create appropriate climate transition governance structures

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Establish clear ownership of the climate agenda within government				
Ensure clarity, continuity and stability of climate goals and initiatives				
Establish independent bodies to advise governments on climate goals and policies				
Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making				
Set up a mandatory green taxonomy				
Embed just-transition considerations into policy making				

NetZero Pathfinders

PILLAR 1
Accelerate deployment of mature climate solutions

While much of the climate-change discussion focuses on long-term goals decades away, achieving near-term and intermediate goals is also critical. Thankfully, due to the progress achieved over the past decades, zero-carbon technologies have reached – or are on the way to – cost parity with their fossil-fueled rivals. This list includes wind and solar power projects in most of the world and electrified vehicles in a growing number of markets and vehicle segments. Yet these climate-friendly technologies do not always flourish, in some cases because policies protect incumbents. This emphasizes the need for immediate, concrete policy action to accelerate the deployment of mature climate solutions today.

Power and Grids

- Speed up project deployment timelines
- Ensure project bankability by mitigating offtaker risk and ensuring diversity and certainty of revenue streams
- Incentivize a diverse clean energy technology mix
- Proactively plan and build the power grid
- Accelerate access to low-cost finance for clean energy projects and grids

Industry and Materials

- Promote the use of clean energy in industrial processes
- Foster the demand and supply of sustainable bio-based energy and feedstock in relevant industries
- Establish and enforce industrial energy efficiency standards
- Introduce circular economy requirements for producers and consumers of emissions-intensive materials

Transport

- Implement supply- and demand-side policies for electric vehicles to promote cost parity
- Speed deployment of charging infrastructure for passenger vehicles and trucks
- Boost walking, micromobility and public transportation in urban areas
- Accelerate access to finance for electric vehicles

Buildings

- Promote consumer incentives for heat pumps and efficiency measures, alongside penalties for fossil-fuel heating
- Roll out company mandates to scale up low-carbon heating value chains
- Enforce efficiency performance standards in existing and new builds
- Enable consumers to retrofit existing buildings through access to financing

Agriculture

- Incentivize farmers to adopt precision technology
- Promote soil and nutrient management that improves nitrogen use efficiency
- Leverage carbon and clean-energy incentives to support deployment of manure management and anaerobic digestion projects
- Promote dietary shifts to low-emissions sources of protein

Power and Grids

Actions to accelerate deployment of mature climate solutions

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- Accelerate access to low-cost finance for clean energy projects and grids

Decarbonizing the global power system is a foundational step toward ensuring that climate commitments are met. In the Net Zero Scenario of BNEF's *New Energy Outlook*,[1] more than half of all abatement in the power sector relies on scaling up wind and solar photovoltaic (PV) production. That, in turn, will require deploying increasingly mature flexibility solutions such as battery storage and demand-response technologies – and a significant scale-up of investment in the transmission and distribution networks.

Power-system decarbonization will also be crucial for cutting economy-wide emissions. Energy end-use sectors are expected be decarbonized in large part through the transition toward using clean electricity, thereby making technologies such as electric vehicles and heat pumps 'cleaner', too. Electrification of end-use sectors like transport and buildings also leads to efficiency gains in the energy system, due to the reduction in losses that occur when energy is converted from fuels to energy products, and then to end-use energy services.

The shift to a clean power system is well on the way thanks to the increased cost-competitiveness of zero-carbon electricity generation technologies and large, established supply chains. Either wind or solar PV is now the cheapest form of new-build electricity generation in countries accounting for over two-thirds of the world's population, more than three-quarters of global GDP, and 90% of all electricity generation. It is also now cheaper to build new renewables from scratch than operate existing coal and gas plants in a growing number of markets, including China, India and much of Europe.

1 *BloombergNEF's Net Zero Scenario describes a credible pathway to net-zero emissions by 2050 and limits global warming to 1.75C above pre-industrial levels. The methodology can be found in the New Energy Outlook 2024.*

Despite the increasing cost-competitiveness of wind and solar PV in many markets, however, these technologies do not always flourish. That's due to multiple causes, including fossil-fuel subsidies. Renewables deployment at scale remains mostly concentrated in high-income nations: members of the Organization for Economic Co-Operation and Development (OECD) have seen power-sector emissions drop by nearly one-third since peaking in 2007, while non-OECD emissions have experienced a net increase. The lack of robust clean energy policies and sufficient investment have limited growth in renewables in some developing economies.

One of the biggest barriers to renewables deployment, especially in developed economies, is bottlenecks in securing permitting and grid access. Together with land-use and zoning restrictions, and in some cases land ownership regulations, these permitting bottlenecks can cause significant project delays. **Speeding up project deployment timelines** is therefore pivotal to decarbonizing the power system.

One solution is for policymakers and regulators to implement measures to streamline processes for permitting and grid connection. In doing so, governments must provide enough resources to the bodies responsible for overseeing permitting and connection requests.

Policymakers should also exercise caution so as not to implement overly strict land-use regulations. Fast-tracking permits for projects on land deemed likely to be suitable can shorten permitting timelines, as can making relevant information – like geospatial data on local biodiversity – public. Establishing milestones that projects must hit to remain in the queue can reduce time spent on speculative or unlikely projects, thereby focusing assessors' efforts on permitting and connecting the most viable sites.

Beyond the more common permitting and connection bottlenecks, deployment timelines are sometimes hindered by supply-chain and labor constraints. Developers must ensure that the supply chains can deliver the necessary volumes of technology installations and respond to shocks as needed.

To maintain momentum on clean power project build in established markets, and unlock deployment in more nascent markets, it will be important to **ensure project bankability by mitigating offtaker risk and ensuring diverse and certain revenue streams**. Establishing revenue certainty for clean power sources can be spearheaded by both the public and private sectors.

Governments can establish well-designed competitive auctions for long-term offtake contracts. Such measures are among the most widely implemented climate-related policies and remain fundamental to ensure continued renewables uptake. An effective clean energy policy framework provides clarity to investors, minimizes bureaucracy and incentivizes construction of new clean power capacity. Typically, strong frameworks have included at the very least a bold but feasible clean energy target plus reverse auctions for clean power delivery contracts, or incentives for small-scale renewables deployment like feed-in tariffs or net metering.

Private offtakers like industrials, corporates, utilities and retailers can create demand for clean energy and sign power purchase agreements (PPAs) with generators, but governments must first ensure that clean power contracts are allowed. Policymakers and international financial institutions can also enact measures to bolster the depth of the private offtake market through PPA guarantees for clean power or standards on retailers requiring that a certain share of their energy supply is zero-carbon. Lastly, grid operators and regulators can play a role in ensuring clean power projects have access to a diverse source of revenue, including through standardized grid service and flexibility markets.

While wind and solar are key to power-system decarbonization, virtually every major electricity market is facing the challenge of adapting to increased shares of variable renewable supply. Therefore, it is fundamental that policymakers **incentivize a diverse clean energy technology mix** to ensure power system reliability. This means encouraging a resilient combination of low-carbon supply sources, as well as flexible energy storage capacity. A diverse portfolio of renewable energy sources is better for decarbonizing the global power mix than relying on just solar, for example, which has relatively low capacity factors and highly seasonal output. Wind power can be complementary to solar and has higher capacity factors.

Scaling up mature energy storage technologies will be key to allow deeper penetration of variable clean power and ensure diverse supply in all markets. Under BNEF's Net Zero Scenario, installed global battery

storage capacity must hit 4 terawatts (TW) by 2050. To help integrate additional renewables on the grid, battery annual installations grow more than threefold to provide energy shifting services. This is over 50 times the amount of battery storage available in 2023. However, many countries still lack policies to support battery storage development. By the end of 2023, there were around 71 gigawatts (GW) of behind-the meter and utility-scale storage systems installed, excluding pumped hydro, up from just 13GW in 2020. Still, over half of this is concentrated in the US and China. In other markets, especially developing economies, deployment of energy storage has been limited due to high technology costs and lack of adequate policy frameworks.

Market reform can help to overcome these barriers, for example by enabling energy storage for frequency regulation and ensuring there are clear rules for energy storage to enroll, bid and dispatch into markets given characteristics such as charging, discharging and limited energy availability. In markets that are more vertically integrated, utilities or network operators typically need a regulatory framework to direct them to consider energy storage when doing resource planning, such as energy storage targets, adjustment to models that feed into long-term planning to account for technical characteristics of energy storage, and new types of contract structures that are more appropriate for capacity rather than just energy output. In some cases, it may make sense to allow the utility to rate base[2] investments in energy storage assets (or part of the asset) in the same way it would pass through the costs for traditional network reinforcement.

The path to a net-zero power system hinges on collaboration between regulators, grid operators and policymakers. Global grid investment in BNEF's Net Zero Scenario more than doubles to about $800 billion by 2030, mostly to accelerate integration of new renewable energy supply. **Proactive, long-term planning and deployment of grid investment is needed** to upgrade networks, especially for system reinforcement and new connections over this decade. Grid plans can be designed to match the amount of renewables capacity targeted by policymakers. These plans can preselect corridors for new grid development, providing greater certainty for renewables site selection. Grid operators must work with policymakers to align on anticipatory spending (where network investment supports the connection of future power plants and future-proofing infrastructure) and robust needs-testing processes, especially as electrification of other end-use sectors such as transportation grows.

The development of inter-regional networks and coordinated planning between power markets can also be beneficial, both in island nations like the UK, Indonesia and Japan, and in regions with vast land masses like the US and China. Interconnected systems are more resilient to extreme events and supply energy more affordably to end-users.

Finally, it is critical to **accelerate access to low-cost finance for clean energy projects and grids**. As low-carbon projects have increasingly come to resemble traditional infrastructure investments rather than risky alternatives, a larger pool of investment capital has emerged. However, project developers and banks are still responsible for the majority of financial flows, and the cost to access this capital remains a limiting factor. As renewable power projects are capital-intensive at first, investments have become concentrated in wealthier nations.

One strategy to decrease the cost of capital is allowing developers to borrow on a portfolio basis, rather than borrowing from project to project. Renewable projects often have nearly no operating costs, meaning their profitability can largely be determined at the time of commissioning with virtually all costs related to capex. However, sometimes there are other factors at play beyond the cost of capital, such as high political risk, adding additional challenges for accessing private capital. Development institutions can help overcome this with concessional finance instruments – including loans, grants, and guarantees offered below market rate – to both decrease the cost of capital and improve access with longer repayment times and lower interest rates for renewables projects.

2 *A utility's rate base refers to its assets that provide energy service – such as generation, transmission and distribution infrastructure – on which it can earn a defined rate of return.*

NetZero Pathfinders

Industry and Materials

Actions to accelerate deployment of mature climate solutions

- Promote the use of clean energy in industrial processes
- Foster the demand and supply of sustainable bio-based energy and feedstock in relevant industries
- Establish and enforce industrial energy efficiency standards
- Introduce circular economy requirements for producers and consumers of emissions-intensive materials

Today, too many industrial processes still rely on unabated coal and gas. In the near future, these processes will need to quickly pivot to using mature cleaner energy sources such as clean power or bioenergy, or to emerging solutions like green hydrogen or synthetic fuels, as **promoting the use of clean energy in industrial processes** is one of the most effective ways to reduce industrial emissions.

The switch to clean energy and electrification are easiest where only low-temperature heat is required. Heat pumps that are tailored for industry, thermal batteries, and the greening of existing power demand for industry are the easiest to implement. In BNEF's Net Zero Scenario, global industrial energy consumption relies on electrification for a third of total emissions reductions by 2050. Policymakers and utilities could make it easier for industrial electricity consumers to procure clean power through new tariffs and lower-cost grid access.

However, over half of industrial demand is for high-temperature heat (above 500C), which is more challenging to electrify. Some heavy industrial processes such as aluminum smelting and steel recycling are already electrified processes, and we expect recycling to play a large role in the future of metals decarbonization. Some kinds of electric kilns, furnaces and boilers are also mature technologies that can be deployed in industrial processes that need temperatures above 400-500C. Not every industrial

process will electrify, however. We expect there to be a significant role for clean hydrogen, bioenergy and perhaps synthetic fuels where high temperatures and/or reducing agents are required. Almost half of all industrial abatement by 2050 in BNEF's Net Zero Scenario relies on bioenergy, low-carbon hydrogen and carbon capture and storage (for more, see Pillar 2: Industry and Materials). Governments can promote the use of these solutions in industry through incentives such as capex-based subsidies and regulations like carbon pricing.

Policy and regulation will be essential in **fostering the demand and supply of sustainable bio-based energy and feedstock in relevant industries**. Bio-based sources can provide a sustainable alternative to fossil-fuel-based feedstocks and fuels, and are often a 'drop in' solution, making them easy to adopt. Drop-in fuels are chemically identical to fossil fuels so can be used as a like-for-like replacement without the need for blending. Bio-based sources can include forms of woody biomass, agricultural residues or municipal solid waste. Bioenergy is a particularly critical energy source for decarbonizing cement and petrochemicals in BNEF's Net Zero Scenario. Concerns about the increasing use of unsustainable biomass, and the resultant detrimental land-use change, could be alleviated by government regulation and the support of sustainable forest management. Policymakers should also find ways to prioritize the use of forestry waste and agricultural residues.

Another mature solution for industry is energy efficiency, which can also reduce operating costs. For example, policymakers to **establish and enforce industrial efficiency standards** to cut energy consumption and emissions per unit of material produced. The most common such tool at regulators' disposal is energy performance standards, which set a minimum efficiency level for various products. However, standards must be sufficiently stringent and tighten over time to remain effective. An additional climate solution that could also cut costs is to **introduce circular economy requirements for producers and consumers of emissions-intensive materials**. Circular economy solutions often result in reduced lifecycle emissions due to the reduced use of virgin materials. Recycling also reduces the emissions from ore mining and transportation of new feedstock. For instance, the emissions intensity of recycled steel can be 86% lower than that of primary steel produced through basic oxygen furnaces.[3] Governments can therefore introduce circular economy requirements for producers and consumers of emissions-intensive materials to decrease virgin material in circulation. These policies can take the form of recycled content mandates for plastic packaging producers or extended producer responsibility requirements for cleaning up end-of-life waste.

3 *BloombergNEF, Decarbonizing Steel Technologies and Costs (2021).*

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Transport

Actions to accelerate deployment of mature climate solutions

- Implement supply- and demand-side policies for electric vehicles to promote cost parity
- Speed deployment of charging infrastructure for passenger vehicles and trucks
- Boost walking, micromobility and public transportation in urban areas
- Accelerate access to finance for electric vehicles

Global passenger electric vehicle (EV) sales continued to increase last year, but their higher upfront costs remain a significant hurdle for widespread adoption in some markets. Governments can help the sector clear this hurdle by **implementing supply- and demand-side policies for EVs to promote cost parity**. BNEF's Electric Vehicle Outlook (EVO) finds that internal combustion engine (ICE) vehicles and EVs will reach upfront price parity between 2024 and 2031, depending on the region and size of the vehicle. For example, large EVs and electric sport utility vehicles (SUVs) in Europe are expected to be the first segments to reach parity with their ICE counterparts. For markets with a longer timeline, like medium-size EVs in India, manufacturers can benefit from corporate tax exemptions and grants to help with the upfront hurdles of setting up shop or switching to EV manufacturing and scaling up production.

Accelerating EV adoption may also require policy support for the additional cost of batteries in regions and vehicle segments where ICEs remain cheaper. On the consumer side, governments can offer purchase subsidies, such as EV tax credits and grants, to vehicle buyers. In particular, incentives should be designed to make EVs accessible to low-income consumers. Governments can make best use of available funding, for example, by capping purchase subsidies if the vehicle value exceeds a certain amount. While many developed and mature

EV markets are winding down upfront subsidies, these measures can still play a valuable role in stimulating adoption in more nascent EV markets.

In tandem, **accelerating access to affordable finance for EVs** is crucial for spurring adoption, especially in the less mature EV markets. Interest-rate support through concessional loans to consumers could be introduced in geographies with high borrowing costs, and EVs could be included under priority sector lending, which would increase the pool of money allocated by banks for financing EV purchases. While electrification is the key pathway for passenger vehicles, it is also gaining traction as a solution for commercial trucks. BNEF's EVO finds that economics of battery-powered trucks improve toward 2030, as the supporting charging infrastructure develops. By that time, almost 10% of new sales of medium- and heavy-duty trucks are electric.

A successful scale-up of the electric vehicle fleet will have to be supported by **speeding deployment of charging infrastructure for passenger vehicles and trucks**. This can help mitigate 'range anxiety' – fear of running out of power before reaching a charging point – among consumers. Policymakers can accelerate the deployment of charging infrastructure by mandating or incentivizing charging stations in new building developments and working to simplify and streamline the permitting process. Extensive investments will be needed in high-powered charging for trucking fleets, including local grid network reinforcements. Governments should fast-track grid connection and permitting processes for these facilities wherever possible.

Electrification is crucial to decarbonizing the transport sector, but simply decreasing demand for individual or private road transport journeys can also have a significant impact on emissions. Around 2.2 billion metric tons of CO2 emissions could be avoided by a modest 10% reduction – compared with BNEF's base case driven by economic and technological trends – of total kilometers traveled by passenger vehicles between 2023 and 2050. **Boosting walking, micromobility and public transportation in urban areas** can decrease distances traveled by car and lower emissions – but to do so, policymakers must improve infrastructure and public transit networks to accommodate increased adoption. Policymakers can implement a range of measures to encourage modal shifts, from congestion charges to active travel incentives, as well as improving mass public transit and expanding walkable areas.

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Buildings

Actions to accelerate deployment of mature climate solutions

- Promote consumer incentives for heat pumps and efficiency measures, alongside penalties for fossil-fuel heating
- Roll out company mandates to scale up low-carbon heating value chains
- Enforce efficiency performance standards in existing and new builds
- Enable consumers to retrofit existing buildings through access to financing

Heat pumps are a mature, efficient heating technology with the potential to play a significant role in the decarbonization of heating in buildings. In BNEF's Net Zero Scenario, global heat pump installations reach a cumulative 507 million by 2050. However, in most of the world, they struggle to compete economically with gas-fired boilers and furnaces or coal-based heating on an unsubsidized basis. While they are often more competitive than oil boilers on a lifetime cost basis, high upfront costs can still lead to long payback periods.

As such, **promoting consumer incentives for heat pumps and efficiency while implementing penalties for fossil-fuel heating** are priorities to decarbonize buildings. Such policies can include grants, low-interest loans and tax breaks in combination with carbon pricing on fossil-fuel heating. These interventions can help lower the upfront cost of heat pumps while improving the ratio of fossil-fuel to electricity prices.[4] Policymakers should also be cautious when levying additional taxes on clean electricity, as they may distort the retail price or mute the impact of heat pump subsidies.

To ensure availability of low-carbon heating systems for consumers, governments should **roll out company mandates to scale up low-carbon heating value chains**. For example, regulators could mandate that manufacturers of heating systems have a quota of sales coming from low-carbon heating solutions. Such supply-side mandates worked well in Europe to transition automakers into scaling EV production and sales.

4 *The ratio of fossil-fuel to electricity prices is a reasonable proxy for the operational economics of a heat pump relative to fossil-fuel solutions, as a lower ratio indicates reduced cost for purchased energy. Another key factor is the effectiveness of the heating unit at converting a purchased megawatt-hour of energy into useful heat.*

Effective mandates should include a penalty for non-compliance and become more stringent over time, to provide a long-term signal for manufacturers to invest in low-carbon heating development and the associated value chains.

Buildings will likely require standards to lower energy consumption. Policymakers can start by **enforcing efficiency performance standards in existing and new builds**, usually via building energy codes. Putting in place a robust framework for energy performance certificates (EPCs), which score a property based on their efficiency levels, is important for transparency, monitoring and evaluation purposes. EPCs are usually a voluntary tool but could be used in combination with minimum efficiency performance standards as part of a mandatory framework, for example to ensure landlords maintain a certain efficiency level or risk facing penalties. Only a handful of markets today are considering and testing such measures.

Beyond minimum standards, **enabling consumers to retrofit existing buildings through access to financing** will be essential to increasing efficiency improvements across more buildings. Governments can enable financing for retrofitting through exemptions to property purchase tax, known in some markets as stamp duty, or subsidized programs for adding insulation or replacing boilers (see Pillar 3: Buildings). They can also directly intervene with scrappage programs, offering consumers financial incentives for replacing their fossil-fuel heating system with a low-carbon one.

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Agriculture

Actions to accelerate deployment of mature climate solutions

- Incentivize farmers to adopt precision technology
- Promote soil and nutrient management that improves nitrogen use efficiency
- Leverage carbon and clean-energy incentives to support deployment of manure management and anaerobic digestion projects
- Promote dietary shifts to low-emissions sources of protein

The manufacturing and use of synthetic fertilizers and pesticides accounts for 2.1% of greenhouse gases released globally – more than Japan's total emissions.[5] Policymakers can help mitigate these effects by **incentivizing farmers to adopt precision technology**, such as the use of data and analytical tools to increase crop yields and efficiency. Options include funding to support the development and deployment of new precision technologies, carbon pricing on agrochemical manufacturers, and regulations on farmers' use of inputs. In addition, governments can reform agriculture subsidies that encourage uncontrolled use of inputs (see Pillar 3: Agriculture). It will also be important for policymakers to incentivize low-carbon hydrogen to tackle fertilizer manufacturing emissions, and the use of enhanced-efficiency products, which control fertilizer release, and biostimulants (See Pillar 2: Cross-Sector).

These types of policies would **promote soil and nutrient management that improves nitrogen-use efficiency** and thus cut emissions from synthetic fertilizers. Governments can use regulations and incentives to encourage farmers to employ the 4R Nutrient Stewardship Framework, which promotes sustainable application of nutrients. In addition, they can implement schemes that provide regular 'green payments' to reward farmers for planting cover crops that reduce nutrient loss. Policymakers can also drive

5 *Stefano Menegat, Alicia Ledo, and Reyes Tirado, "Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture," Scientific Reports 12, no. 1 (2022): 1-13.*

decarbonization of the agriculture sector by **leveraging carbon and clean-energy incentives to support deployment of manure management and anaerobic digestion projects**. In total, manure management and its application to pastures as fertilizer contributes a similar share of global emissions as synthetic fertilizers and pesticides. Therefore, grants, feed-in tariffs and premiums, clean energy certificates and carbon pricing (see Pillar 3: Cross-Sector) can promote the construction of biogas plants on farms and in rural areas fueled by manure and agricultural residues. Another way to drive down agriculture emissions is to **promote dietary shifts to low-emissions sources of protein**. To kickstart this transition, governments can implement awareness-raising campaigns and carbon-footprint labeling systems to educate consumers on the link between animal meat and climate change. They can also require all public institutions like hospitals and schools to offer on their menus at least one option with lower-carbon animal protein such as chicken, or a vegetarian or vegan dish.

NetZero Pathfinders

PILLAR 2
Support development of new climate solutions

The current suite of cost-competitive zero-carbon technologies – wind, solar, batteries and electrified transport, among others – is poised to cut emissions meaningfully over the coming decades. But to zero out emissions entirely, more technologies will be required to provide around-the-clock clean power, to decarbonize high-temperature industrial processes, to cut emissions associated with livestock and to solve other challenges related to the energy transition.

In addition to deploying mature climate solutions, an acceleration in the development of new climate solutions is needed. The piloting and scaling of new technologies will be critical for decarbonization in harder-to-abate sectors and to complement clean electrification.

To achieve net zero globally, every sector of the energy economy needs to eliminate unabated fossil-fuel consumption completely by mid-century. Even the hardest-to-abate sectors will need to adopt CO2-free solutions, only turning to carbon removals where absolutely necessary, such as offsetting any final residual emissions. This underscores the need for stable, long-term policy signals to divert investment toward low-carbon solutions.

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Support clean firm capacity and long-duration storage	Incentivize industrials to adopt zero-carbon processes and lower-carbon fuels	Stimulate the uptake of batteries and low-carbon fuels for heavy-duty vehicles	Support the deployment of alternative refrigerants with low or no global warming potential in heat pumps and air conditioning systems	Support the adoption of low-carbon nitrogen fertilizers
Support emerging grid technologies	Foster demand for low-emissions materials	Establish measures, such as blending requirements, to ensure the uptake of low-carbon aviation and shipping fuels	Encourage deployment of smart heating networks	Support development, commercialization and deployment of technologies that lower enteric methane released by ruminants
Ensure market design accounts for the integration of new demand and supply sources	Encourage shared hydrogen and CO2 storage and pipeline infrastructure	Support the development of clean propulsion technologies and low-carbon shipping fuels	Accelerate the development of innovative high-efficiency air conditioning systems and thermal storage technologies	Provide fast, low-cost and reliable soil carbon testing
Ensure sufficient, sustainable and traceable supply of energy transition metals				Provide incentives and regulatory pathways to promote alternative protein production and consumption
Promote consumer adoption of demand-side flexibility technologies				
Support research and development institutions and projects				
Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies				
Support low-carbon hydrogen production close to demand				

Power and Grids

Actions to support development of new climate solutions

- Support clean firm capacity and long-duration storage
- Support emerging grid technologies
- Ensure market design accounts for the integration of new demand and supply sources

The power sector has several well-established and mature zero-carbon technologies. However, support for the deployment of emerging solutions, including those that are still unproven at scale, will be needed if the power sector is to stay on track to net zero. This is because deep decarbonization of the power system cannot be achieved economically with wind, solar and battery storage alone. New sources of flexibility and dispatchable technologies are needed to back up and balance variable renewable generation as the power system decarbonizes and more energy end-use sectors electrify.

In BNEF's Net Zero Scenario, increased demand-side flexibility as well as low-carbon thermal capacity – such as gas power plants abated with carbon capture and storage, or plants running on zero-carbon hydrogen – become important aspects of the power sector's transition. This is especially the case in power systems without abundant hydropower resources to handle seasonal lows in wind and solar output. Even markets with hydropower need to consider the drought resiliency of their systems. Long-duration storage technologies, such as thermal energy storage and compressed air energy storage systems, may also be able to compete and provide this critical role to the system. Virtually all dispatchable, zero-carbon solutions remain uneconomic compared with unabated fossil-fuel power plants today. Therefore, it is essential for policymakers and companies to **support clean firm capacity and long-duration energy storage**.

There are several market design mechanisms being used today to either incentivize new clean firm capacity build or ensure that existing lower-carbon firm capacity stays online, including:

- Energy-only markets linked to strong CO2 constraints. This may include a strategic reserve or capacity payment, in order to guarantee reliability and enable backup plants to keep in the money.
- Auctions for zero-carbon power with reliability criteria, or capacity markets or reserves with emissions thresholds. Some markets are also using direct capital subsidies or fiscal support measures to encourage clean backup capacity.
- Energy supplier obligations for decarbonization and resource adequacy.

Electricity network operators face the challenge of integrating new variable and distributed sources of renewable generation, while also ensuring the adequacy and reliability of supply. They may also need to expand the system rapidly to accommodate growing demand from electrification of buildings, industry and transport. However, there are limiting factors, such as supply constraints, power flow control and network congestion management.

Ensuring that the grid remains in constant balance between generation and demand requires new technologies that can react to rapid changes in renewable energy generation. Therefore, to maximize the use of existing grid infrastructure, regulators can incentivize network operators to embrace and **support emerging grid technologies**. They can do this by introducing new regulatory frameworks that stimulate investment on total costs or operational costs, not just upfront capital costs, to enable the adoption of grid-enhancing technologies. Supporting information-sharing through disclosure of completed projects and equipment standards can also help with adoption.

Transmission grids can use dynamic line-rating tools to help reduce congestion, or advanced conductor materials to increase transmission capacity.[6] In cold and windy conditions, these tools also give power lines an improved ability to safely transmit power without the risk of overheating. Distribution utilities can overhaul their management of the network, as many already are, moving from a static seasonal approach to active operations. This has been achieved by modernizing grid equipment, deploying advanced software and sensors, and using distributed energy resources as part of the solution to the challenges utilities face.

Transmission and distribution grid operators must continually extend and upgrade their infrastructure. Transmission utilities need to ensure their networks continue to transport electrons from centralized power plants to load centers, while expanding capacity to do so in new locations. Distribution utilities regularly upgrade their grids for two main reasons: as infrastructure ages or as demand in certain locations increases. They must also adapt to higher levels of distributed energy resources and shifting demand patterns.

Lastly, regulators should ensure **market design accounts for the integration of new demand and supply sources**. For example, policymakers can introduce financial incentives to promote deployment of hydrogen electrolyzers. These can soak up otherwise curtailed renewable generation, enabling a greater penetration of clean power. BNEF's Net Zero Scenario finds that by 2050, 16,500 terawatt-hours – or almost one-fifth – of global electricity demand can be flexibly used to produce 'green' hydrogen, but only at times when electricity is available from renewable sources. Market design and regulation will be key in determining if and how curtailed renewables are utilized.

It will be important for policymakers to ensure that energy storage technologies ranging from electrochemical and mechanical to thermal storage are not penalized by the market set-up. Today, they are often hindered because grid operations are typically designed to treat supply and demand separately, but storage assets do both (in charging and discharging) as co-related functions. Without coordination of supply and demand to account for energy storage technologies, it may be overly cumbersome if not impossible to participate in a market.

6 *Dynamic line rating includes various technologies for determining conductor thermal ratings, improving transmission efficiency and mitigating congestion through real-time data.*

Industry and Materials

Actions to support development of new climate solutions

- Incentivize industrials to adopt zero-carbon processes and lower-carbon fuels
- Foster demand for low-emissions materials
- Encourage shared hydrogen and CO2 storage and pipelines infrastructure

Building net-zero technologies for industry at commercial scale is an expensive and lengthy process. For most industrials, hydrogen, carbon capture and direct electrification have been trialed in a lab or at very small scale, but there is still little detailed information on capex costs, operating parameters and the energy or emissions intensity of these processes. Large pilot projects are needed to fill in these knowledge gaps and to demonstrate the viability of the technologies for producers and their lenders.

Low-emissions materials, such as green steel and aluminum, are already on the market; however, they remain economically uncompetitive with their traditional counterparts, and much of the policy support implemented to date has focused on the supply side. Demand-side policy can help stimulate the market for green products and enable producers of these materials to securely expand their climate-friendly operations. Governments can therefore **foster demand for low-emissions materials** by leveraging a combination of regulations and incentives. Such regulations could be green procurement mandates, which require specified entities to buy materials that do not exceed a certain embodied-carbon threshold (see Pillar 3: Buildings). Policymakers can also target upstream demand for low-emissions feedstock, such as mandating industrials that already use gray hydrogen switch to green hydrogen. On the incentive side, policymakers can enact direct subsidies to compensate for the green premium gap or the additional cost of procuring low-emissions materials, in combination with the penalties and quotas.

Governments may utilize the same suite of tools on the production side to **incentivize industrials and materials producers to adopt zero-carbon processes and lower-carbon fuels**. For example, this could take the form of a steel company procuring low-carbon hydrogen to produce green steel via output-based subsidies, or capex support. Operational subsidies such as contracts for difference support the additional cost of producing low-carbon technologies and materials. In markets with (or planning to introduce) a carbon pricing mechanism, CO2 contracts for difference can effectively do the same thing while reducing the subsidy bill for governments through carbon market revenues in the long run. Governments can target a specific technology or a range of technologies, and should award subsidies to projects via a competitive bidding process to help reduce subsidy costs and improve price discovery.[7]

Another reason why it is very expensive for industrials to move away from conventional fuels or implement carbon capture is the cost and technical challenges associated with transporting and storing hydrogen and CO2. Policymakers can thus **encourage shared hydrogen and CO2 storage and pipeline infrastructure** by supporting collaborative pilot projects and strategically awarding permits and funding. Carbon capture hubs, co-located with industrial clusters, are networks of CO2 transport and storage infrastructure enabling carbon capture applications to expand into cement, chemicals, hydrogen and oil and gas. Crucially, the progress made in deploying these hubs could go a long way toward increasing investor confidence along the carbon capture value chain, easing potential bottlenecks to scaling capacity. This is also the case for hydrogen hubs.

7 *BloombergNEF Pathfinders, Scaling Technologies for Greening Heavy Industry (2023).*

Transport

Actions to support development of new climate solutions

Stimulate the uptake of batteries and low-carbon fuels for heavy-duty vehicles

Establish measures, such as blending requirements, to ensure the uptake of low-carbon aviation and shipping fuels

Support the development of clean propulsion technologies and low-carbon shipping fuels

Heavy-duty vehicles, such as commercial trucks, are a challenging part of road transport to decarbonize due to their size and long-haul needs. Fully battery-electric vehicles (including those with battery swapping capabilities), hybrids, and hydrogen are all pathways worth further exploration to decarbonize this segment.[8]

To help this sector explore these pathways, governments can **stimulate the uptake of batteries and low-carbon fuels for heavy-duty vehicles** through subsidies and fiscal incentives, fuel economy regulations aimed at small fleets, and simplified funding processes. They can also vary operational charges for trucks, like road tolls, depending on a vehicle's CO2 emissions.

Blending mandates for on-road biofuels, such as ethanol and biodiesel, have long been the measure of choice for economies around the world to stimulate the uptake of alternative fuels in road transport. However, these fuels are better suited for heavy-duty vehicles because passenger vehicles can be more easily electrified.

Outside of road transport, governments should **establish measures, such as blending requirements, to ensure the uptake of low-carbon aviation and shipping fuels**. Some blending mandates for aviation fuel have already been rolled out, and more are in the pipeline. Yet new regulations tend to put a greater focus on lifecycle emissions reductions instead of simply defining the type of fuel to be blended, with new reward structures to match.

8 *For more, see BloombergNEF, Long-Term Electric Vehicle Outlook 2024.*

Furthermore, many markets are increasingly looking to incentivize adoption of 'drop-in' renewable fuels. These are seen as one of few solutions available to help decarbonize hard-to-abate sectors, like aviation, trucking and shipping, where cleaner options are currently limited or very costly. Blending mandates can be more effective when complemented with measures that reduce the burden on companies to procure clean fuels, such as financial support and incentives along the value chain. **Supporting the development of clean propulsion technologies and low-carbon shipping fuels** is key to innovate and decarbonize this mode of transport. The most viable near-term options consist of low- and net-zero-carbon fuels, such as biofuels, low-carbon methanol and ammonia, and other synthetic fuels. All these come with unique challenges related to availability, sustainability, cost and safety. Low-carbon methanol is a more readily available option than other alternative fuels and has been one of the main choices, alongside biofuels, in shipping companies' decarbonization plans.

Policymakers can offer more supply-side subsidies to tackle high feedstock costs, often seen as one of the biggest constraints. Other options such as retrofitting sails for large cargo ships and other propulsion modes remain at a far earlier stage of development, despite their long-term potential. Governments could therefore fund research and development (R&D) programs to accelerate deployment and commercialization. Overall, decarbonizing the shipping sector requires coordinated action among suppliers of low-carbon shipping fuels, vessel and engine manufacturers, ports and policymakers to establish clean shipping routes.

Buildings

Actions to support development of new climate solutions

Support the deployment of alternative refrigerants with low or no global warming potential in heat pumps and air conditioning systems

Encourage deployment of smart heating networks

Accelerate the development of innovative high-efficiency air conditioning systems and thermal storage technologies

New heating and cooling technologies can eliminate the need for harmful refrigerants, such as hydrofluorocarbons (HFCs), which are used in heat pumps to extract air from outside and concentrate it inside for indoor heating. They can also be used in reverse to cool air and act as an air conditioner. While heat pumps are more efficient and less emissions-intensive than traditional heating systems, the HFCs they use often leak and can have global warming potential over 3,000 times more potent than that of carbon dioxide.[9] As a result, there is a need to **support the deployment of alternative refrigerants with low or no global warming potential**, such as hydrofluorolefins, ammonia and propane, in heat pumps and air conditioning systems.

Climate treaties and government mandates are already playing a role. The Montreal Protocol, ratified in 1988, is an international agreement to protect the ozone later by phasing out ozone-depleting substances. Chlorofluorocarbons (CFCs) and halons, among other refrigerants, are all considered ozone-depleting substances and were essentially banned at the time of the Protocol.[10] However, HFCs continued to be used for heating and cooling. In 2016, signatories of the Protocol adopted the Kigali Amendment, which added the phaseout of HFCs to the Protocol. While the Amendment did not ban HFCs, it helped create demand certainty and interest in alternatives with lower carbon footprints. Since the ratification of the Kigali Amendment, several governments have set timelines to enforce HFC reduction mandates.

9 *HFC global warming statistics from the Climate & Clean Air Coalition.*
10 *For other banned refrigerants, see The Montreal Protocol on Substances That Deplete the Ozone Layer.*

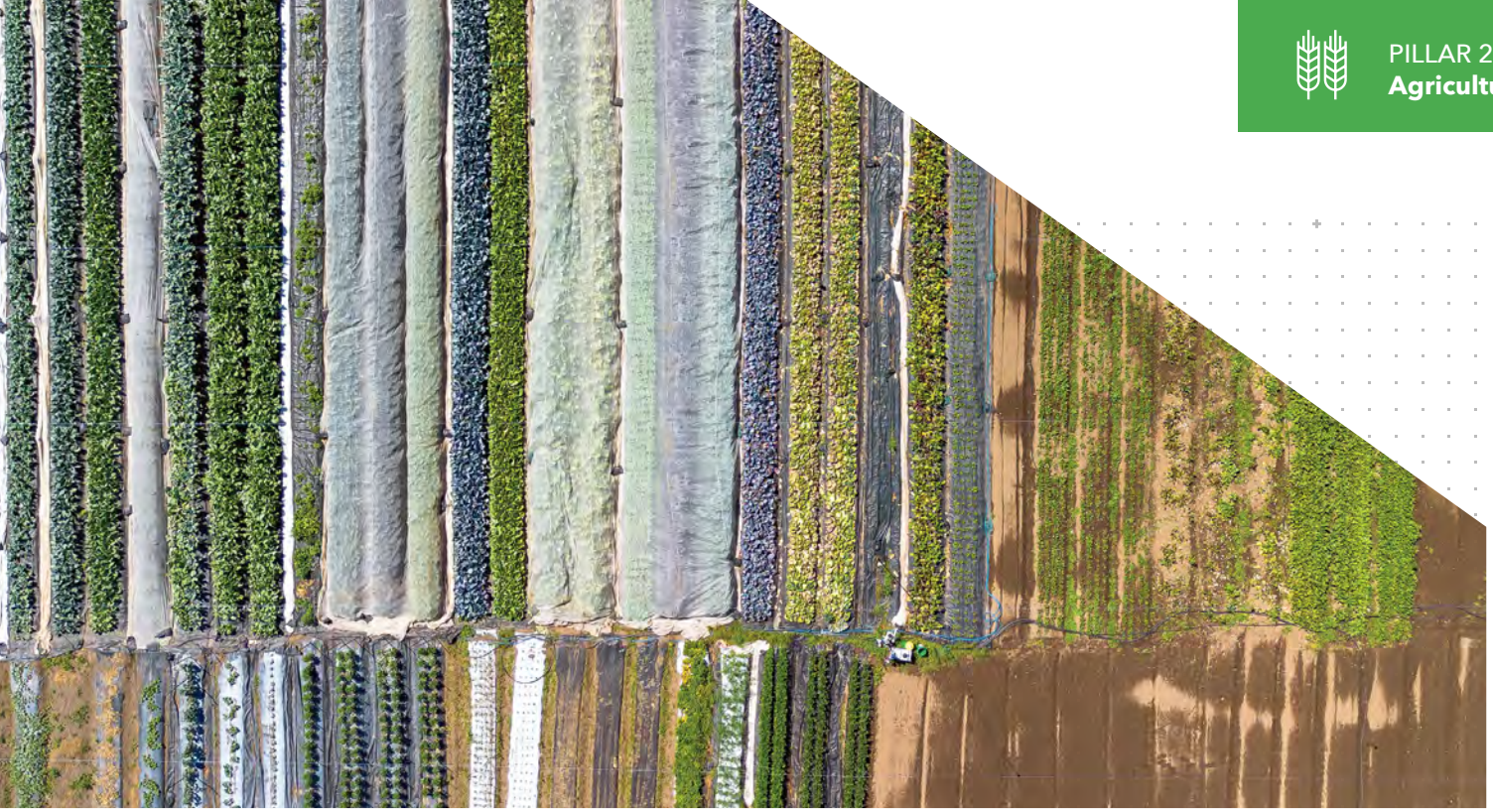
Heating is not the only energy-guzzling component of buildings. Air conditioners account for 4% of annual global emissions, resulting mostly from the indirect emissions associated with electricity generation required to power the air-conditioning system and remove the humidity from the air. Harmful refrigerants described above also contribute 37% of the global emissions associated with cooling.[11] The total share of emissions from cooling systems is expected to increase as temperatures and humidity rise around the globe, and as access to air conditioning systems becomes more commonplace. One study predicts the absolute emissions of cooling will increase five times from 2016 to 2050.[12] Therefore, policymakers must **accelerate the development of high-efficiency air conditioning systems** to reduce emissions from the dehumidifying and cooling process and from the refrigerants. Governments can regulate which refrigerants can be used in air conditioners as well as enact efficiency standards for cooling in new buildings to combat the circulation of the more energy-intensive units. They can also direct funding to research and development programs for more-efficient cooling technologies.

Other emerging low-carbon heating solutions, such as smart networks and thermal energy storage, will also play an important role in the buildings sector's path to net zero. Heat networks use underground pipes to transport hot water to a network of buildings by transferring heat generated from a centralized generation site to consumers. As a result, individual flats and buildings do not need to generate their own heat via on-site heat pumps or boilers.

To help decarbonize buildings, especially in urban areas, policymakers can **encourage the deployment of smart heating networks**, which rely on renewables or sustainable fuels and operate by optimizing energy consumption patterns and automatically distributing the heat supply. Smart heat networks can improve system flexibility through demand-side response to reduce the peak consumption load in subtle ways that do not disturb consumers, such as reducing the heat slightly while the hot water is being used. This has the potential to reduce both emissions and the cost of heating, thanks to the efficiency of a central heating source. (See Pillar 3: Buildings for more on heat networks.)

Accelerating the development of thermal storage technologies will also be important to support the decarbonization of heating in buildings. Governments can accelerate the development of these technologies through grant programs for research and innovation. Thermal energy storage works by heating or cooling a certain medium or material, such as rocks, phase-change materials or water tanks. The medium works by storing the energy so that it can be accessed at a later stage. This energy can be redirected to heating or cooling a tank of water, which can later be redistributed in heating networks or used as needed. Thermal storage can lower strain on the grid during periods of high demand in the winter, and store energy when it is cheaper and more abundant.

11 *See The Montreal Protocol on Substances That Deplete the Ozone Layer.*
12 *Jason Woods, et al., "Humidity's impact on greenhouse gas emissions from air conditioning," Joule 6, no. 4 (2022): 726-741.*



Agriculture

Actions to support development of new climate solutions

- Support the adoption of low-carbon nitrogen fertilizers
- Support development, commercialization and deployment of technologies that lower enteric methane released by ruminants
- Provide fast, low-cost and reliable soil carbon testing
- Provide incentives and regulatory pathways to promote alternative protein production and consumption

As well as improving soil and nutrient management, governments can decarbonize agriculture by **supporting the adoption of low-carbon nitrogen fertilizers**, which are the heaviest emitters of all synthetic plant nutrition products. Solutions include nitrogen fertilizers from ammonia produced using renewables rather than the conventional pathway of using natural gas, though the price of green ammonia is two to three times that of gray ammonia. The use of nitrogen fertilizers made with green ammonia does not directly reduce on-farm emissions because they behave the same as gray.[13] However, by incentivizing farmers to switch to low-carbon fertilizers, governments can reduce demand for gray products and thus the related manufacturing emissions. This demand can be bolstered by the introduction of financial incentives, agriculture subsidy reforms, mandates and/or carbon pricing for farmers.

These types of policy can also **support the development, commercialization and deployment of technologies that lower enteric methane released by ruminant animals** like cows, sheep and goats. Enteric fermentation is by far the biggest polluter in the agriculture sector, with a 6% share of global economy-wide emissions – equivalent to the EU's total for all sectors.[14] However, many of the existing climate solutions like feed additives and methane vaccines require government policy to kickstart deployment and reach commercialization. Some also need support to overcome challenges around delivering these solutions to livestock where they roam and graze over large areas. As well as financial incentives, governments can opt

13 *BloombergNEF, Scaling Up Hydrogen: The Case for Low-Carbon Ammonia (2024).*
14 *Food and Agriculture Organization (2024).*

for policy sticks, such as requiring livestock farmers that receive state subsidies to cut greenhouse gas release or obligate feed manufacturers to incorporate methane-inhibiting additives in their products.

In addition to policies targeted at upstream segments, countries can look at downstream incentives to **promote alternative protein production and consumption**, as well as implement the regulatory pathways to allow new food and drink products to come to market. As a first step, governments can ensure that alternative proteins compete on a level playing field with animal proteins – for example, by equalizing their tax treatment. On the regulatory side, governments can make transparent and streamline the lengthy and complex approval process for new food and drink products.

Soil is a key component of the global carbon cycle, holding 50% more CO2 than has ever been released from burning fossil fuels.[15] Storing more carbon in soils therefore holds huge potential for curbing climate change. But the volume of emissions sequestered is notoriously difficult to measure, report and verify, making it important that governments help to **develop and deploy fast, low-cost and reliable soil carbon testing**. For example, they could provide funding for devising a consistent measurement, reporting and verification approach; baseline surveys and benchmarking; and a common set of metrics.

Cross-Sector

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Ensure sufficient, sustainable and traceable supply of energy transition metals				
Promote consumer adoption of demand-side flexibility technologies				
Support research and development institutions and projects				
Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies				
Support low-carbon hydrogen production close to demand				

Many of the actions in the Pathfinders blueprint focus on mass deployment and commercialization of low-carbon technologies. But before this can happen, these climate solutions must be developed, tested and proved useful, impactful and safe. Governments therefore have a key role to play in **supporting research and development institutions and projects**. This could mean providing grants and low-interest loans to companies, think tanks, universities and other organizations. Alternatively, policymakers can set up dedicated research working groups within the government body or provide ongoing R&D programs for specified sectors.

Reaching net zero will see demand for energy transition metals exceed 240 million metric tons annually by 2050.[16] However, supply will struggle to meet the surging demand without new discoveries, higher capital deployment, technical advancements and growing recycling rates.

The current production of several energy transition metals is also heavily concentrated by region and/or by company, meaning there are high degrees of supply-chain risk across the entirety of their value chains.

15 *Christer Jansson, et al., "Crops for carbon farming," Frontiers in Plant Science 12 (2021): 636709.*
16 *BloombergNEF, Transition Metals Outlook (2023).*

Ensuring the sustainable and traceable supply of energy transition metals can play a central role in overcoming these challenges. Sound yet stringent policies – ranging from incentivizing exploration activity and enforcing transparent fiscal regimes to encouraging domestic value addition[17] and providing direct financial support – enable particularly resource-rich economies to simultaneously de-risk potential projects while building an attractive investment landscape for the wider sector. Governments in consumer-driven economies, however, often look to strengthen international partnerships and to maximize local production to drive diversification. Either way, any policymaking process should prioritize environmental, social and governance issues to ensure the sector progresses in line with evolving standards.

Demand-side flexibility solutions like smart EV charging and hydrogen electrolyzers will also be crucial for the decarbonization of multiple areas of the economy. In BNEF's Net Zero Scenario, such technologies are increasingly important for intraday balancing of the power system, by requiring consumers to behave in a more price-responsive way – to use power when it is cheap and abundant and avoid expensive peaks. More price-responsive demand can lower supply-side flexibility costs. As the power system grows, smart EV charging becomes one of the largest sources of demand-side flexibility in the future energy system. As a result, policymakers, regulators and industry players should collaborate on **promoting consumer adoption of demand-side flexibility technologies**. This means allowing customers to access dynamic or real-time energy tariffs, encouraging them to shift usage to periods of low prices and alleviate network constraints. It will be important to encourage the roll-out of technology – such as smart meters and appliances – to help consumers to respond to price signals. Policymakers also need to tackle barriers to smart EV charging such as a lack of suitable charging stations.

Additionally, electricity market design should evolve to enable and encourage consumers to provide flexibility, which can offset the need to build new power assets and grid infrastructure. Utilities and retailers can provide incentives like bill reductions in exchange for a consumer changing its energy consumption behavior or activating a resource like a battery on site.

Wholesale markets can also create rules to enable 'virtual power plants', in which a company aggregates many smaller individual assets or sites that can shift demand, which it can then bid into the specific market services like energy, capacity and ancillary services. Examples of how consumers can help the grid include adjusting energy consumption at specific times of day, either during peak demand events like very hot summer days, or more regularly by using technologies like batteries and EV charging or adjusting temperature controls.

Another cross-sector solution needed to reach net zero by mid-century is carbon capture, utilization and storage, or CCUS, which usually refers to the retrofits made to fossil energy or industrial materials production to decarbonize operations by capturing the carbon at the point source of emissions. With broad applications in industry, the power sector and hydrogen production, CCUS plays a key role in BNEF's Net Zero Scenario, as do carbon removal technologies such as direct air capture, which captures carbon from the air. Without these solutions, all things being equal, the world would be on track for 1.9C of warming by 2050 compared with a 1.75C outcome, based on BNEF analysis. Governments therefore need to **provide support for CCUS projects and infrastructure and carbon removal technologies** to tackle one of the biggest barriers to their deployment – the upfront costs for building such projects. Such support could include tax credits, contracts for difference, grants and/or carbon pricing (see Pillar 3: Cross-Sector). Governments must also ensure that these projects have easy access to the infrastructure needed to transport and store the CO2.

Lastly, an essential technology for power and industrial decarbonization is low-carbon hydrogen. Governments and companies can mitigate the technical challenges associated with transporting and storing hydrogen by supporting low-carbon hydrogen production close to demand. This helps reduce the resources and investments required to build out transport pipelines and storage hubs. Strategic placement of production can help secure demand and lower the costs for both the producer and the industrial procuring hydrogen. At times, this is not possible, due to space constraints or high costs, but it's a good principle to strive for.

17 *Value addition in this context refers to metal-producing countries maximizing the benefit of their resources by extending their presence along the mining value chain, such as building refineries alongside mining operations to create additional jobs and economic value.*

NetZero Pathfinders

PILLAR 3
Phase out carbon-intensive activities

Despite the immediate threat posed by climate change, governments continue to build thermal power plants, subsidize the burning of fossil fuels and underwrite their extraction through state-owned companies. Phasing out high-emitting sources and scaling back subsidies on fossil-fuel prices can be politically challenging. However, these are fundamental measures for limiting global warming.

Many assets in the real economy are long-lived, ranging from around 15 years for cars and buses, to 50 years for fossil-fuel power plants and 100 years or more for buildings. However, getting the world on a 1.5C trajectory will require retiring or retrofitting these assets on an accelerated timeline. This will require a transformation of the corporations, utilities and communities that have historically relied on their operation.

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Enable economic competition between renewables and fossil fuels	Phase out unabated coal-powered industrial facilities	Phase out sales of internal combustion engine vehicles through performance-, weight- and usage-based penalties	Phase out fossil-fuel heating, starting with the most emission-intensive systems	End harmful production subsidies and price supports resulting in over-application of fertilizers, land clearing and residue burning
Reuse grid capacity from retiring fossil-fuel plants	Switch to product and material pathways that abate or avoid process emissions	Tighten fuel economy standards for passenger and commercial road vehicles	Support the transition of fossil-fuel heating networks to technologies powered by sustainable fuels	Restrict international trade of goods produced on recently deforested land
Implement competitive price signals for capacity development and dispatch	Encourage all new industrial facilities and public buildings to be net-zero ready	Support scrappage programs for internal combustion engine vehicles	Establish net-zero standards and requirements for new buildings	Introduce land-sector offset mechanisms and develop agricultural carbon methodologies
	Ensure sustainable mining standards and traceability		Ban fossil-fuel boiler sales and installations in new builds while implementing boiler scrappage programs	
Remove fossil-fuel and other harmful subsidies				
Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies				
Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize				
Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy				

Power and Grids

Actions to phase out carbon-intensive activities

Enable economic competition between renewables and fossil fuels

Reuse grid capacity from retiring fossil-fuel plants

Implement competitive price signals for capacity development and dispatch

Alongside boosting the share of clean energy on the grid, phasing out fossil-fuel-fired generating capacity will be central to decarbonizing the global economy. Under BNEF's Net Zero Scenario, the world must retire 979GW of coal-fired generating capacity over 2025-2030. However, fossil-fuel power-generating capacity grew by more than 1.2TW over 2010-2023, with coal accounting for over half the total.[18] While the number of government pledges to shut down coal plants is rising, significant additional effort from policymakers, utilities and investors will be needed to ensure follow-through.

The first step to phasing out carbon-intensive activities in the power sector is to **enable economic competition between renewables and fossil fuels**, as well as promote grid-enhancing technologies (for more on technologies, see Pillar 2: Power and Grids). A priority should thus be reforming fossil-fuel subsidies, starting with aid targeted at producers and utilities (See Pillar 3: Cross-Sector).

With government subsidies for renewables fading, clean power plants rely more and more on straight sales of electricity to be profitable. Where there is a wholesale market, the influx of low-marginal-cost wind and solar power plants pulls down realized electricity prices, increasing the risk that these generators cannot turn a profit. As such, policymakers should **implement competitive price signals for capacity development and dispatch**. As well as encouraging an open and liquid market (see Pillar 1: Power and Grids), options include introducing subsidy-free auctions[19] and enabling renewables generators to participate in security-of-supply mechanisms.

18 *BloombergNEF capacity and generation data.*

19 *Subsidy-free auctions are competitive bidding rounds awarding sites and permits for wind or other renewables, but do not offer subsidized capex (upfront) or opex (operational) benefits.*

As fossil-fuel power plants retire over time, valuable grid connection infrastructure will become available. Coordination across companies, governments and grid operators could help to increase the **reuse of grid capacity from retiring fossil-fuel plants** for clean energy supply. This can support local job creation in areas that are economically dependent on carbon-intensive activities (for more on workforce development, see Pillar 3: Cross-Sector and **Pillar 4**). Regulators could ensure competitive processes are run to award access to the grid as the existing power plant winds down production, or create an enabling environment for utilities with grid access points to transition their production activities.

Industry and Materials

Actions to phase out carbon-intensive activities

- Phase out unabated coal-powered industrial facilities
- Switch to product and material pathways that abate or avoid process emissions
- Encourage all new industrial facilities and public buildings to be net-zero ready
- Ensure sustainable mining standards and traceability

Reaching economy-wide net zero by 2050 will require some emission-intensive assets to be retired early. It will also require enabling companies that are heavily invested in these assets to smoothly transition to cleaner ones.

Policy-based frameworks, incentives and penalties for owners and operators of carbon-intensive assets to **phase out unabated coal-powered industrial facilities**, including all units that are not retrofitted with CCUS capabilities, should thus be a priority. This process can look like introducing and gradually tightening CO2 standards for existing assets and setting a clear and mandatory phaseout timeline. Such measures can be designed to offer a path for investors to decommission or retrofit emission-intensive assets and avoid uncertainty for owners and operators as facilities are retired.

'Process emissions' – or emissions that occur during industrial manufacturing processes – can be extremely difficult to abate and account for a substantive share of industrial greenhouse gas emissions. Process emissions can be reduced by deploying solutions such as CCUS (in cement manufacturing) or hydrogen (for steel). In some cases, alternative pathways can be explored. For example, anode emissions from aluminum smelting can be reduced by using inert anodes, while limestone substitutes for cement could lower this sector's process emissions. Governments can therefore encourage companies to **switch to product and material pathways that abate or avoid process emissions**. In particular, policies should help tackle the still-high costs of available climate solutions including electrification, green hydrogen or CCUS. (For more on CCUS and hydrogen, see Pillar 2: Industry and Materials).

Policymakers can also **encourage all new industrial facilities to be net-zero ready** by enforcing efficiency standards and regulations that require companies to plan for future decarbonization efforts. Given that many industrial assets often last for over 50 years, governments should ensure that the new factories built today are capable of deploying net-zero technologies with minimal disruption in the future. For example, new gas-based furnaces must be built to allow an easy switch to cleaner fuels such as hydrogen or biogas. Similarly, new industrial facilities must plan for sufficient space and infrastructure to install CCUS or hydrogen equipment in the future. Since many industrial processes could be electrified, grid operators should also consider a potential future increase in electricity demand and peak load when planning transmission and distribution cables and substations.

Metals and minerals are imperative for a successful transition to a low-carbon economy; however the sector accounts for both significant emissions and land degradation. For example, almost 15% of the land used in producing raw materials today falls within a protected area. BNEF estimates that this land disturbance could more than triple as existing mines expand to meet growing demand. Meanwhile, several mining projects are facing pushback because of their impact on local communities.

The mining sector must adopt more-sustainable practices as it expands and responds to energy-transition-related demand. Policymakers should urge the sector to reduce its carbon footprint by **ensuring sustainable mining standards and traceability**. One way this could be done is by holding the sector accountable through the enforcement of compulsory emissions reporting and global greenhouse-gas benchmarks. Other options include encouraging the use of renewable electricity and low-carbon fuels in powering operations, or introducing targets for secondary production, which refers to recycling metals from end-of-life products. The close proximity of several mining activities to highly biodiverse areas means that policymakers should consider measures that mitigate any damage or disruption to natural ecosystems. Given the mining sector's unique intersection with social and governance issues, governments should also enforce effective traceability requirements across the sector. This transparency permits end-users to ensure that the metals and minerals used in products are sourced responsibly and ethically.

Transport

Actions to phase out carbon-intensive activities

Phase out sales of internal combustion engine vehicles through performance-, weight- and usage-based penalties

Tighten fuel economy standards for passenger and commercial road vehicles

Support scrappage programs for internal combustion engine vehicles

In addition to demand-side policies, like the purchase incentives outlined in Pillar 1: Transport, many mature EV markets have implemented supply-side mandates targeting automakers. For instance, fuel economy thresholds have accelerated automakers' scale-up of electric vehicle manufacturing and sales. Yet to remain a decarbonization driver, **fuel economy or tailpipe CO2 emissions standards should be tightened for passenger and commercial vehicles** and stretch further in time than current rules. Policymakers should not show leniency for non-compliance.

Governments can implement penalties based on vehicle performance, weight and use to phase sales of internal combustion engine vehicles. Such policies drive decarbonization while remaining less contentious among industry and consumers than a wholesale ICE sales ban. These penalties can take the form of additional taxes on heavy vehicles or a required level of emissions performance in new vehicles sold. Additionally, phaseout timelines give automakers a deadline to work toward. Governments should therefore stick to their original timeline to maintain investor certainty and hold automakers accountable. Interim targets should be set, however, with progress reviewed regularly.

Governments can also mitigate potential opposition to an ICE phaseout by pairing it with consumer incentives. For example, they can **support scrappage programs for ICE vehicles** that offer a monetary reward for turning in old vehicles.

NetZero Pathfinders

Buildings

Actions to phase out carbon-intensive activities

- Phase out fossil-fuel heating, starting with the most emission-intensive systems
- Support the transition of fossil-fuel heating networks to technologies powered by sustainable fuels
- Establish net-zero standards and requirements for new buildings
- Ban fossil-fuel boiler sales and installations in new builds while implementing boiler scrappage programs

As economics alone will not drive the transition to using low-carbon heating sources in the short term, policymakers should **phase out fossil-fuel heating, starting with the most emission-intensive systems**. The approach needed will vary significantly between markets, but regions with high dependency on coal, peat or oil for heating can focus decarbonization measures on those sources, as a first step. This could mean designing incentives for low-carbon heating in such a way that they prioritize displacing the highest-emitting sources first. In markets with rapidly growing building stocks, it is equally important to regulate new builds and prevent locked-in dependency on high-emitting energy sources.

Policymakers can also consider **bans on the sale and installation of boilers that burn fossil fuels, particularly in new builds**, to ensure that the use of these boilers dwindles. In tandem, **boiler scrappage programs**, in which consumers receive a monetary incentive for trading in their fossil-fuel-fired equipment, help complement the stick with a carrot and facilitate a faster phaseout. However, in doing so it is important to consider an equitable transition: the ban on fossil fuels must be done in a way that does not raise energy costs for consumers who can least afford it. Subsidies for heat pumps, like those discussed in Pillar 1: Buildings, are key – as are progressive tax systems that reduce the cost of electricity relative to gas and other fossil fuels, thereby reducing the operating costs for those using electric heating units.

Some markets have a relatively high share of heating needs met by heat networks. While some of these networks can be fuel-agnostic, coal and gas have remained the dominate fuel source globally, supplying the vast majority of buildings. For this reason, policymakers should consider **supporting the transition from fossil fuels in existing heating networks toward technologies that use sustainable fuels and/or waste heat**. Policymakers can facilitate the transition through carbon pricing or by providing grants to fund the switch to low-carbon technologies.

Furthermore, **establishing net-zero standards and requirements** is one of the most effective tools at regulators' disposal to ensure that new buildings are designed with emissions reduction in mind.

These regulations can include design considerations, construction material specifications, operational efficiency requirements and embodied carbon limitations. For example, procurement mandates specify the embodied carbon limits of materials that can be procured by developers for new buildings. Governments can also mandate that all new builds developed after a certain date meet a stringent set of net-zero requirements related to embodied carbon and efficiency capabilities. Some governments have introduced green public procurement mandates as a first step in testing these requirements for new buildings in the public sector. This is also a useful strategy in markets where it is more difficult to regulate private buildings or phase out older buildings relying on fossil-fuel heating.

NetZero Pathfinders

Agriculture

Actions to phase out carbon-intensive activities

End harmful production subsidies and price supports resulting in over-application of fertilizers, land clearing and residue burning

Restrict international trade of goods produced on recently deforested land

Introduce land-sector offset mechanisms and develop agricultural carbon methodologies

Countries provide hundreds of billions of dollars per year in agriculture subsidies that encourage activities with environmentally detrimental side effects. In particular, it is imperative that governments **end harmful production subsidies and price supports resulting in over-application of fertilizers, land clearing and residue burning**. They should identify these types of support and devise a reform plan, beginning with phasing out subsidies targeted at producers. They can, for example, require that support recipients undertake activities to curb emissions such as reducing synthetic fertilizer use. They can also fund new incentives for low-carbon activities using the savings from reducing environmentally harmful subsidy programs.

With deforestation accounting for 40% of global emissions from agriculture, forestry and land use,[20] another way for governments to promote the phaseout of carbon-intensive activities is to **restrict international trade of goods produced on recently deforested land**. Tropical forest loss and damage is the second-largest cause of man-made climate change, and nearly 90% of global deforestation is caused by the expansion of cropping and livestock grazing, according to the UN Food and Agriculture Organization.[21] Policymakers can therefore require that companies importing certain products into their jurisdiction prove that these goods are deforestation-free. In particular, they could target the agricultural commodities that are leading drivers of global tree-cover loss, such as cattle, oil palm, soy, cocoa, rubber, coffee and wood.

20-21 *UN Food and Agriculture Organization of the United Nations, "COP26: Agriculture Expansion Drives Almost 90% of Global Deforestation" (2021).*

In addition, a potentially significant way to spur the phaseout of domestic carbon-intensive activities is to **introduce land-sector offset mechanisms and develop agricultural carbon methodologies**. Offset programs enable farmers and landowners to undertake low-carbon projects in order to generate carbon credits; these credits can then be sold to governments or companies looking to realize voluntary sustainability targets or comply with a regulated carbon market or tax.

However, such schemes remain relatively rare and have had a modest impact, with high upfront costs and complex processes and hefty fees for listing and validation two notable hurdles to their adoption. An alternative to an offset program is an ecosystem service market whereby farmers and landowners are paid for undertaking an ecosystem or environmental service such as biodiversity protection.

Cross-Sector


Power and Grids


Industry and Materials


Transport


Buildings


Agriculture

Remove fossil-fuel and other harmful subsidies
Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies
Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize
Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy

An early priority in the efforts to phase out carbon-intensive activities is to **remove subsidies for fossil fuels and other environmentally harmful practices**.

In 2022, G-20 governments and state-owned enterprises provided a record $1.3 trillion in support to coal, natural gas, oil and fossil-fuel power, according to BNEF analysis.[22] Of this amount, 65% went to consumers and the overall sector, while 35% went to producers and power generators, many of which saw their profits skyrocket that year. Support for fossil fuels slows down the climate transition by distorting energy prices and encouraging potentially wasteful use and production of fossil fuels. It also leads to investment in long-lived, emissions-intensive equipment and infrastructure. Even subsidies intended to help low-income households and other vulnerable consumers tend to disproportionately benefit the wealthy because these households tend to consume more fuel per person. Subsidy changes can be contentious, but identifying distortive fossil-fuel support and issuing a reform plan with a clear timeline is a good first step.

In addition, lawmakers can deter carbon-intensive activities by **implementing carbon-pricing mechanisms and integrating environmental considerations into trade policies**. Carbon taxes and emissions-trading schemes need careful design, as most existing programs are ineffective at driving companies and consumers to decarbonize. This may be due to low CO2 prices, and generous concessions to participants, such as tax-free allowances and free permits. By introducing trade policies like carbon border tariffs, policymakers can eliminate these concessions without the risk that companies relocate to regions with lower carbon prices or weaker environmental standards by introducing trade policies like carbon border tariffs. Both fossil-fuel subsidy reform and carbon-pricing mechanisms can raise government revenue that can then be reinvested in low-carbon support programs.

Furthermore, policymakers can **implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize**. Emissions performance standards are a widely used policy mechanism that can be modified for any emitting sector. These standards can take the form of vehicle exhaust limits for passenger and commercial vehicles with which manufacturers must comply (for more on Transport, see Pillar 3: Transport). For buildings, developers must comply with net-zero standards or requirements in new buildings. Standards should be implemented with timelines that give producers sufficient runways to make necessary arrangements, such as readying their supply chain and securing demand for low-carbon or efficient products and materials (for more on Buildings, see Pillar 3: Buildings)

Because many assets in the real economy last for decades, the financing decisions of the past can lock in carbon emissions well into the future. "Committed" emissions from existing fossil-fuel-based assets in the power, industrial, and transport sectors are already incompatible with a 1.5C trajectory. Consequently, some carbon-intensive assets will likely need to be retired early, requiring a transformation of the corporations, utilities, and communities that have historically relied on their operation. Thus, policymakers and civil society organizations will need to implement initiatives that **manage the impact of the transition on jobs and businesses**.

22 *BloombergNEF, Climate Policy Factbook: COP28 Edition (2023).*

As new technologies emerge fast, all nations around the globe will also need to **train workers** for the low-carbon economy. This is fundamental to ensure that new technologies can be implemented quickly and safely. Over the coming years, policymakers and civil society will need to prepare younger professionals and reskill workers from high-emitting sectors to install and operate green technologies. See **Pillar 4** for more on ensuring a just transition.

PILLAR 4
Create appropriate climate transition governance structures

Tackling the climate crisis requires policymakers to devise a low-carbon strategy spanning decades and involving numerous sectors and stakeholders. But policies are only as good as the frameworks that exist to design, implement and enforce them. Governments must also recognize that to attract the required significant investment in low-carbon technologies – and enjoy the associated economic benefits – they must build governance structures that are durable for the long term. Financial institutions as well as companies are therefore integral to the clean energy transition. Yet few policymakers have introduced the measures to encourage and subsequently mandate these players to disclose and address their climate-related risks and impacts.

As market forces or regulatory interventions transition the global economy from high-carbon assets to low-carbon alternatives, workers and communities that rely on these assets must be supported, in what has been coined a 'just transition'. Investors, corporations and civil society all have key roles to play in ensuring that the transition is fast but does not leave anyone behind. This will require targeted economic diversification in regions formerly reliant on fossil fuels, as well as a strong, coordinated action among governments, communities, investors and businesses.

Power and Grids	Industry and Materials	Transport	Buildings	Agriculture
Establish clear ownership of the climate agenda within government				
Ensure clarity, continuity and stability of climate goals and initiatives				
Establish independent bodies to advise governments on climate goals and policies				
Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making				
Set up a mandatory green taxonomy				
Embed just-transition considerations into policy making				

NetZero Pathfinders

Cross-Sector

Establishing clear ownership of the climate agenda within government is an important first step to driving the shift to a low-carbon economy. Without a clear mandate assigned to a particular team, policymaking progress and the energy transition can be slowed by cross-department disagreements and uncertainty over decision making. However, the energy transition will require economy-wide efforts. Therefore, when devising new policies, the owner of the climate agenda should consult other departments to gather sector-specific input and build intra-government support.

In addition, to support, inform and advise on policy, lawmakers should **establish independent bodies to provide objective advice to governments on climate goals and policies**. Composed of climate and energy experts, these organizations can ensure alignment between policy and the latest science, and enable better scrutiny over progress toward low-carbon targets and government decisions. Ongoing research and analysis by these entities can also help to hold policymakers to account for short-term progress toward longer-term goals. They can also contribute to target-setting and identifying optimal pathways to achieving these commitments.

In addition, it is crucial that governments **ensure clarity, continuity and stability of climate goals and initiatives**. This means establishing and maintaining robust processes for policymaking, with clearly communicated timelines for changes, and actively consulting with industry and experts. Continuity in policies supporting clean energy and other climate-related projects is vital, because sudden or retroactive changes damage investor confidence in a market and constrain progress toward green goals.

Climate change poses ever-growing risks to banks, investors and insurers, as well as companies. Yet few policymakers have taken effective actions to require financial institutions and corporations to mitigate their exposure to these risks. The first stage should be to mandate generic environmental disclosures and then to **mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making**. The ultimate goal is for financial institutions to price the impact of climate change into their investment or lending activities, to mitigate the risk of an economic crisis and progressively shift financial portfolios away from activities not aligned with a low-carbon economy.

Governments should also **set up a mandatory green taxonomy** that sets out which economic activities are considered environmentally sustainable. A science-based classification allows companies and investors to assess their exposure to activities aligned with the low-carbon transition. A green taxonomy should spur these entities to increase their share of green revenue and capital expenditure. A growing number of jurisdictions are introducing these mechanisms. But to be impactful in the energy transition, policymakers will have to promote cross-regional alignment and turn them into regulations, rather than voluntary frameworks that can be brushed aside if they prove too challenging.

Although the benefits of the low-carbon transition will far outweigh the costs, it will be important to **embed just-transition considerations into policymaking**. This should ensure that workers and communities that rely on emission-intensive assets are supported and the benefits created by the energy transition are inclusive. The physical effects of climate change are often disproportionally felt by the world's poorest countries, impacts which are exacerbated by existing economic disparities. Just-transition decision making also applies to inter-regional policies and international climate agreements to identify the effects on the rest of the world and ensure that high-income countries are mitigating their fair share.

BloombergNEF

BloombergNEF (BNEF) is a strategic research provider covering global commodity markets and the disruptive technologies driving the transition to a low-carbon economy.

Our expert coverage assesses pathways for the power, transport, industry, buildings and agriculture sectors to adapt to the energy transition.

We help commodity trading, corporate strategy, finance and policy professionals navigate change and generate opportunitites.

NetZero Pathfinders

NetZero Pathfinders Framework

The Pathfinders framework and policy actions are designed around the four pillars of net-zero strategies, but sometimes it is helpful to visualize the policy actions structured by sector, as well. The following five diagrams show our policy actions flipped and restructured by each emitting sector. The colored dots in the cross-sector actions indicate the other sectors to which each action applies.

LEGEND

- Power and Grids
- Industry and Materials
- Transport
- Buildings
- Agriculture
- Cross-Sector

Power and Grids

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Speed up project deployment timelines	Support clean firm capacity and long-duration storage	Enable economic competition between renewables and fossil fuels	Establish clear ownership of the climate agenda within government
Ensure project bankability by mitigating offtaker risk and ensuring diversity and certainty of revenue streams	Support emerging grid technologies	Reuse grid capacity from retiring fossil fuel plants	Ensure clarity, continuity and stability of climate goals and initiatives
Incentivize a diverse clean energy technology mix	Ensure market design accounts for the integration of new demand and supply sources	Implement competitive price signals for capacity development and dispatch	Establish independent bodies to advise governments on climate goals and policies
Proactively plan and build the power grid	Ensure sufficient, sustainable and traceable supply of energy transition metals	Remove fossil-fuel and other harmful subsidies	Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making
Accelerate access to low-cost finance for clean energy projects and grids	Promote consumer adoption of demand-side flexibility technologies	Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies	Set up a mandatory green taxonomy
	Support research and development institutions and projects	Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize	Embed just-transition considerations into policy making
	Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies	Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy	
	Support low-carbon hydrogen production close to demand		

Industry and Materials

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Promote the use of clean energy in industrial processes	Incentivize industrials to adopt zero-carbon processes and lower-carbon fuels	Phase out unabated coal-powered industrial facilities	Establish clear ownership of the climate agenda within government
Foster the demand and supply of sustainable bio-based energy and feedstock in relevant industries	Foster demand for low-emissions materials	Switch to product and material pathways that abate or avoid process emissions	Ensure clarity, continuity and stability of climate goals and initiatives
Establish and enforce industrial energy efficiency standards	Encourage shared hydrogen and CO2 storage and pipeline infrastructure	Encourage all new industrial facilities and public buildings to be net-zero ready	Establish independent bodies to advise governments on climate goals and policies
Introduce circular economy requirements for producers and consumers of emissions-intensive materials	Ensure sufficient, sustainable and traceable supply of energy transition metal	Ensure sustainable mining standards and traceability	Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making
	Promote consumer adoption of demand-side flexibility technologies	Remove fossil-fuel and other harmful subsidies	Set up a mandatory green taxonomy
	Support research and development institutions and projects	Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies	Embed just-transition considerations into policy making
	Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies	Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize	
	Support low-carbon hydrogen production close to demand	Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy	

Transport

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Implement supply and demand side policies for electric vehicles to promote cost parity	Stimulate the uptake of batteries and low-carbon fuels for heavy-duty vehicles	Phase out sales of internal combustion engine vehicles through performance-, weight- and usage-based penalties	Establish clear ownership of the climate agenda within government
Speed deployment of charging infrastructure for passenger vehicles and trucks	Establish measures, such as blending requirements, to ensure the uptake of low-carbon aviation and shipping fuels	Tighten fuel economy standards for passenger and commercial road vehicles	Ensure clarity, continuity and stability of climate goals and initiatives
Boost walking, micromobility and public transportation in urban areas	Support the development of clean propulsion technologies and low-carbon shipping fuels	Support scrappage programs for internal combustion engine vehicles	Establish independent bodies to advise governments on climate goals and policies
Accelerate access to finance for electric vehicles	Ensure sufficient, sustainable and traceable supply of energy transition metals	Remove fossil-fuel and other harmful subsidies	Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making
	Promote consumer adoption of demand-side flexibility technologies	Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize	Set up a mandatory green taxonomy
	Support research and development institutions and projects	Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy	Embed just-transition considerations into policy making
	Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies	Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies	
	Support low-carbon hydrogen production close to demand		

Buildings

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Promote consumer incentives for heat pumps and efficiency measures, alongside penalties for fossil-fuel heating	Support the deployment of alternative refrigerants with low or no global warming potential in heat pumps and air conditioning systems	Phase out fossil-fuel heating, starting with the most emission-intensive systems	Establish clear ownership of the climate agenda within government
Roll out company mandates to scale up low-carbon heating value chains	Encourage deployment of smart heating networks	Support the transition of fossil-fuel heating networks to technologies powered by sustainable fuels	Ensure clarity, continuity and stability of climate goals and initiatives
Enforce efficiency performance standards in existing and new builds	Accelerate the development of innovative high-efficiency air conditioning systems and thermal storage technologies	Establish net-zero standards and requirements for new buildings	Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making
Enable consumers to retrofit existing buildings through access to financing	Ensure sufficient, sustainable and traceable supply of energy transition metal	Ban fossil-fuel boiler sales and installations in new builds while implementing boiler scrappage programs	Embed just-transition considerations into policy making
	Promote consumer adoption of demand-side flexibility technologies	Remove fossil-fuel and other harmful subsidies	Establish independent bodies to provide objective advice to governments on climate goals and policies
	Support research and development institutions and projects	Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies	Set up a mandatory green taxonomy
	Support carbon capture, utilization and storage projects and infrastructure and other carbon removal technologies	Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize	
	Support low-carbon hydrogen production close to demand	Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy	

Agriculture

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Incentivize farmers to adopt precision technology	Support the adoption of low-carbon nitrogen fertilizers	End harmful production subsidies and price supports resulting in over-application of fertilizers, land clearing and residue burning	Establish clear ownership of the climate agenda within government
Promote soil and nutrient management that improves nitrogen use efficiency	Support development, commercialization and deployment of technologies that lower enteric methane released by ruminants	Restrict international trade of goods produced on recently deforested land	Ensure clarity, continuity and stability of climate goals and initiatives
Leverage carbon and clean-energy incentives to support deployment of manure management and anaerobic digestion projects	Provide fast, low-cost and reliable soil carbon testing	Introduce land sector offset mechanisms and develop agricultural carbon methodologies	Establish independent bodies to advise governments on climate goals and policies
Promote dietary shifts to low-emission sources of protein	Provide incentives and regulatory pathways to promote alternative protein production and consumption	Remove fossil-fuel and other harmful subsidies	Mandate companies and financial institutions to report their climate risks and impact, and integrate them into decision making
	Ensure sufficient, sustainable and traceable supply of energy transition metals	Implement carbon-pricing mechanisms and integrate environmental considerations in trade policies	Set up a mandatory green taxonomy
	Promote consumer adoption of demand-side flexibility technologies	Implement emissions performance standards and regulations that give a clear, long-term signal to producers to decarbonize	Embed just-transition considerations into policy making
	Support research and development institutions and projects	Manage the impact of the transition on jobs and businesses and train workers for a lower-carbon economy	
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NetZero Pathfinders

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