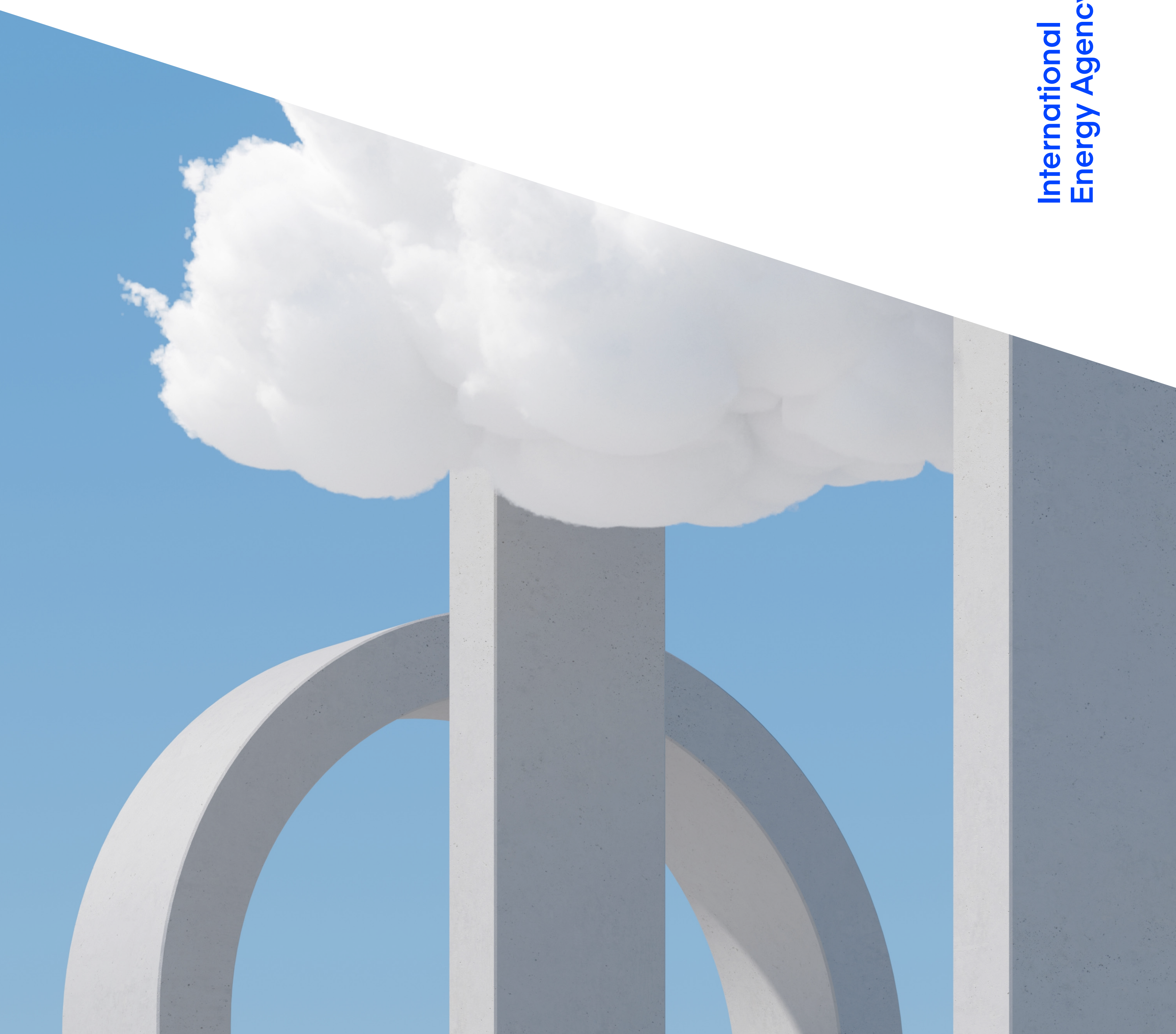
Advancing Clean Energy Demonstration Projects

International Energy Agency



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Abstract

In the 2023 update to the Net Zero Roadmap, the IEA noted that while in the near term almost all emissions reductions can be delivered by technologies and measures that are already known and available, innovation will be needed through to 2050. About 35% of the CO_2 emissions reductions needed in 2050 in a scenario consistent with the energy sector reaching net zero in the same year come from technologies that are still at the pre-commercial stage today. This includes technologies in emission-intensive sectors such as heavy industry and long-distant transport. While there has been progress in recent years, more innovation is needed to demonstrate these technologies and accelerate their paths to market.

The demonstration step on the innovation journey can be particularly difficult, especially for large-scale projects, because of the significant risk and capital required to test out certain technologies. This report provides an update on clean energy demonstrations worldwide based on project-level information featured in the IEA Clean Energy Demonstration Projects Database. It draws on the latest available information on funding and development status for projects across segments including hydrogen and hydrogen-based fuels, power generation and storage, industry, transport and CO_2 management. The report also looks at examples of government support and funding instruments for demonstration projects that could potentially help accelerate the innovation journey.

Highlights

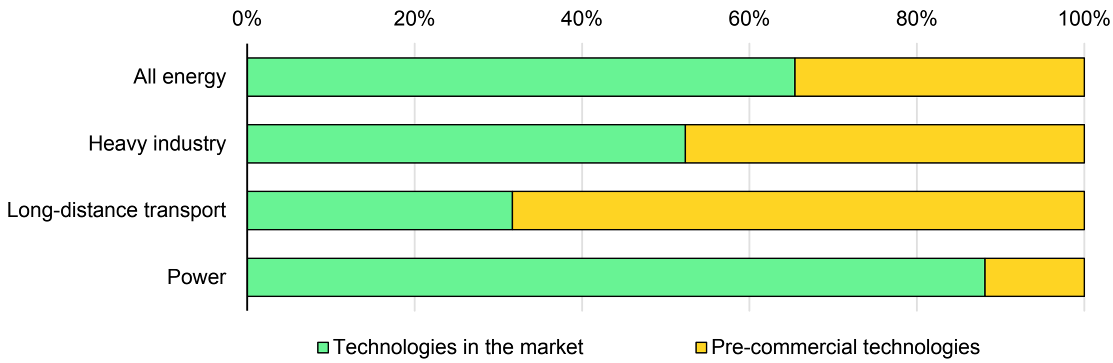
- **Clean energy innovation plays an important role in meeting long-term energy and climate goals.** In the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario), technologies that are not yet commercial today deliver 35% of the emissions reductions in 2050. In heavy industry and long-distance transportation, where fewer clean technologies are available, this share is 50% and 70%, respectively. On the innovation journey, the demonstration step is particularly challenging, given its intrinsic duration, risks and capital requirements.
- **The IEA Clean Energy Demonstration Projects Database tracks more than 580 projects to support decision-making on innovation.** In 2021, we estimated that around USD 90 billion is needed as soon as possible to set up a global pipeline of clean energy demonstrations before 2030 to deliver on the NZE Scenario. In the 2024 edition of the Database, total funding – public and private – for active projects over 2022-2035 stood around USD 60 billion, although limited available data means that the value could be higher.
- **Governments play an important role in supporting demonstrations.** Across selected projects, each dollar invested by government was matched equally by industry. Policy support is increasing, notably in North America, Europe and China, which accounted for 95% of total funding. Examples include the US Office for Clean Energy Demonstrations and the EU Innovation Fund. However, 60% of total funding is for projects that are not yet under construction.
- **Current trends indicate much greater emphasis on supply-side rather than demand-side technology.** Around half of the total funding was for projects focusing on hydrogen and hydrogen-based fuels production, and another quarter on power generation, such as for advanced nuclear designs and floating offshore wind. In comparison, sectors such as aluminium, cement, steel, aviation and shipping attracted much less funding. Carbon capture, utilisation and storage (CCUS) technologies accounted for a third of total funding, cutting across sectors. These trends suggest that there are still many funding opportunities in hard-to-decarbonise sectors on the demand side.
- **Financing demonstration projects requires dedicated instruments and many of these are already well-known.** Debt, equity, guarantees and blended mixes thereof are already widely used in the financial community to support infrastructure projects in and outside the energy sector. International collaboration among governments, financial institutions including multilateral development banks, and industry, can help set up financing facilities for clean energy demonstrations and potentially accelerate the innovation journey.

The need for clean energy demonstration projects

Meeting the climate goals agreed by many countries worldwide will require using a wide range of measures to reduce emissions. In the near term, almost all emissions reductions can be delivered by technologies and measures that are already available, scalable and cost-effective. However, the outlook to 2050 changes, with innovation playing a greater role: about 35% of the CO_2 emission reductions needed in the NZE Scenario in 2050 come from technologies that are still pre-commercial today. In 2022, we identified pressing demonstration needs in specific segments of the energy sector, such as heavy industry, long-distance transport, hydrogen and synthetic fuels production, advanced biofuels, advanced renewables, small modular reactors and CCUS applications in situations that had not yet been demonstrated.

Despite significant progress in recent years, more innovation is needed to bring these technologies to market, notably in emission-intensive sectors such as heavy industry and long-distance transport. In these sectors, the share of emissions reductions delivered by pre-commercial technologies is even greater, at 50% and 70%, respectively. Large-scale demonstration projects are particularly important given the significant risk and increase in capital required to learn about the effectiveness, affordability and market-fit of certain technologies at full commercial size. Such projects can be hard to finance and can take many years from inception until they accumulate sufficient operating experience, a period often characterised as the "valley of death" because promising technologies sometimes fail to make it to the other side without robust support.

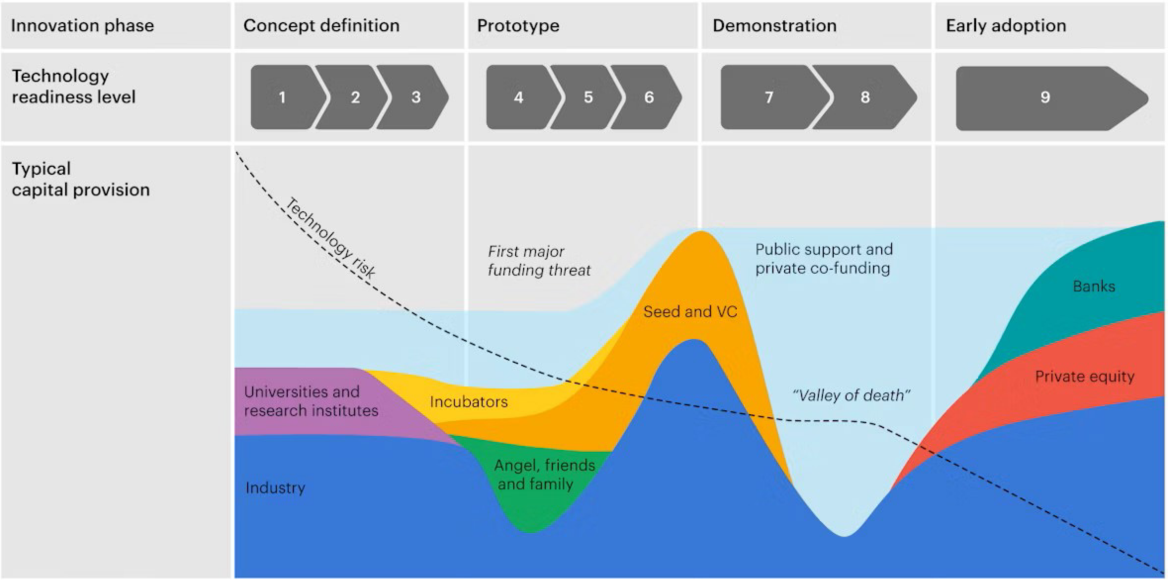
CO_2 emissions reductions in 2050 relative to 2022 in the Net Zero Emissions by 2050 Scenario, by sector and Technology Readiness Level



Notes: "Pre-commercial" refers to prototype and demonstration stages. Heavy industry includes aluminium, cement, chemicals and steel production. Long-distance transport includes aviation and maritime shipping but excludes trucks.
Source: Adapted from IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach.

It is vitally important to bring a global portfolio of clean energy demonstration projects to fruition, with particular emphasis on ensuring effective government support. International collaboration is important as the aggregated learnings from projects across different countries and regions are key to accelerate progress. For each major technical challenge, a balanced set of projects that covers different technological, geographical, regulatory and market contexts would be an ideal outcome to minimise total costs. International sharing of the arising findings from experiences with project design, funding and operation can support this goal. Governments have major stakes in the success of large-scale clean energy demonstration projects because the whole of society will share in the economic and environmental benefits of faster commercialisation, and real-world projects will help hone the accompanying regulations and standards.

Representative capital provision, public funding gaps and ownership pathways for clean energy technologies under development



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In 2022, recognising this need for public support, 16 governments committed USD 94 billion by 2026 to set up a pipeline of clean energy demonstration projects. Many high-level policy and strategy documents now explicitly mention demonstration projects, and financial institutions are developing new mechanisms to fund them.

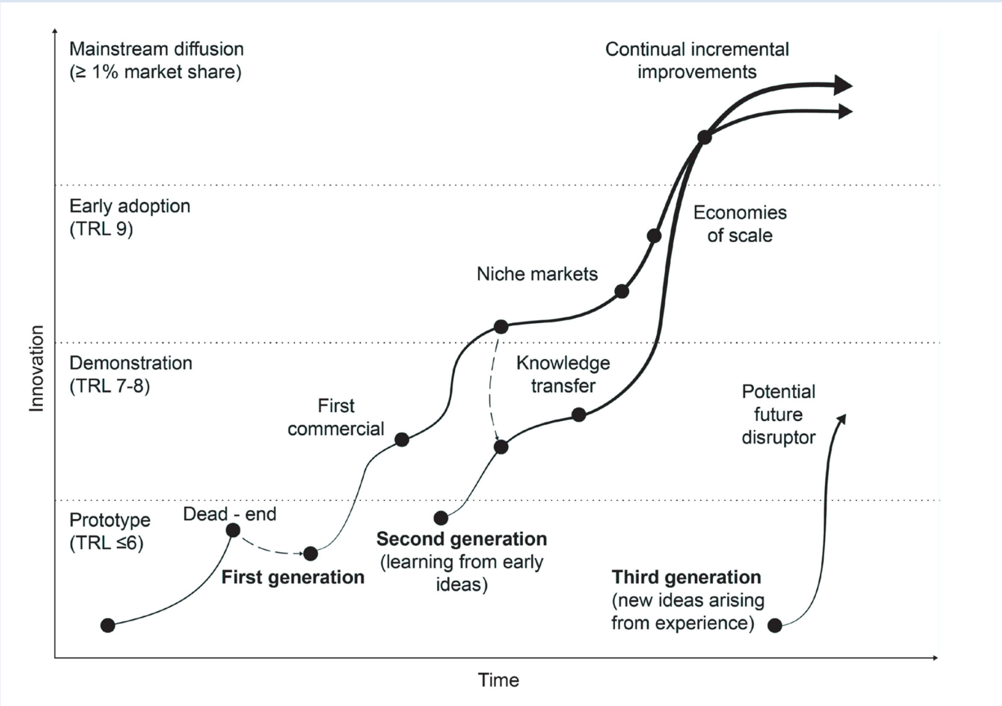
This report provides an overview of the global landscape based on project-level information drawn from the IEA Clean Energy Demonstration Projects Database, and a compilation of policy and financing instruments used to support those projects.

What is a clean energy demonstration project?

A commercial demonstration project is a large-scale example of a new technology that still carries technological risk. Demonstration projects are designed to demonstrate technical feasibility and commercial-scale operations, as well as provide a regulatory stress-test and build social licence. They also reduce the perception of risk for financiers and insurers, and facilitate investment in subsequent installations. A demonstration project does not have to be first of its kind, but does need to be the first that demonstrates its goals in a relevant environment (a new regulatory regime or geographical region, for example).

In ETP's Clean Energy Technology Guide, "first-of-a-kind commercial", or Technology Readiness Level (TRL) 8, refers to the commercial demonstration of a full-scale technology, deployed in final conditions. It is important to distinguish this step from field trials and other initiatives aiming to pilot the deployment of a technology that has already been demonstrated. While the notion of first-of-a-kind can be open to interpretation, we define it as the first project operating at the scale of a full commercial unit utilising a given technology, within a given sector, or in a new type of market and regulatory environment. If several projects meeting these criteria are simultaneously under development, they may all be considered as potential first-of-a-kind facilities. We also include projects currently at TRL 7 that are starting the journey towards TRL 8.

The innovation journey from prototype to market



Notes: TRL = Technology Readiness Level. See also: ETP Clean Energy Technology Guide.
Source: IEA (2020), Energy Technology Perspectives 2020: Special Report on Clean Energy Innovation.

Demonstration projects involve far more time, cost and risk than a prototype. The sheer size of the capital at risk – which can easily surpass USD 1 billion in some sectors – and the fact that they are usually loss-making investments when considered in isolation, make the business case challenging.

Governments across the world might use different criteria to categorise demonstration projects, which might better reflect the specific situation within each country. The list of projects included in this report fit a common definition that allows a common set of results to be generated across different countries.

Funding for clean energy demonstration

Global funding and data availability

We compiled over 1000 projects related to the development of technologies required to reach net zero emissions, of which 583 fall within the IEA's definition of Demonstration projects, and 350 are relevant to the period between 2022 and 2035.[1]

Projects were collected from submissions from six governments that provided information on projects that they classify as demonstration projects. This was then complemented with the IEA's own research. The selection of projects on the short-list was based on the IEA's definition of demonstration projects, which considers the TRL of the technology being tested, its significance in terms of technology development and the regional distribution of existing projects. Data availability with respect to funding, timing, and current status was often sparse, which led us to select only subsets of this demonstration project list for various pieces of analysis presented in this report.

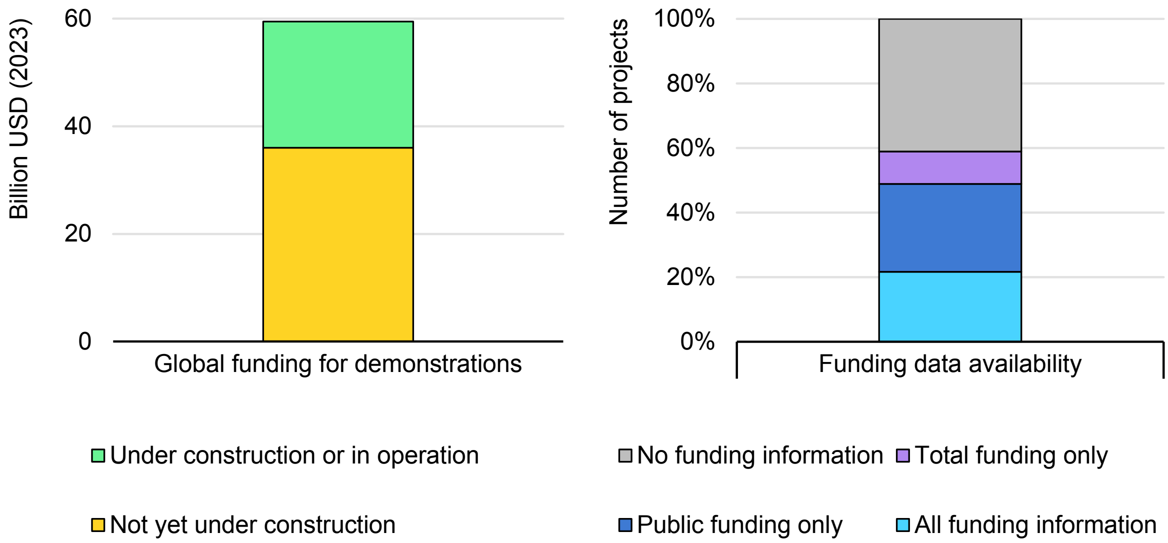
As of November 2024, we estimate that there were around 200 active projects, aggregating to nearly USD 60 billion in total funding, in the IEA Clean Energy Demonstration Projects Database over the 2022-2035 period.

This estimate includes public and/or private funding – depending on data availability – for projects that have either been announced or for which funds have already been committed after a final investment decision (FID). Of this total, we could track around USD 31 billion in public funding. In many cases, funding is

[1] The 2022-2035 period includes any project that was announced or started in 2022 or before, or between 2022 and 2035, and is expected to start operating or to end between 2023 and 2035. For example, a project spanning over the 2019-2025 period is included, as are projects from 2022-2030, but not those from 2016-2022, nor 2030-2050. Projects that were announced or that started before 2022, but for which timeline information was lacking, are not counted, such as projects announced in 2021 but without a clear target date for construction or operation.

disbursed in successive tranches as the project evolves and reaches certain milestones, but our aggregate includes the maximum possible envelope for the entire project for which information is currently available (e.g. for a project allocated USD 50 million in total but currently at the feasibility study stage, the whole envelope would still be counted in the aggregate).

Total global funding for clean energy demonstrations, 2022-2035



Notes: Total funding refers to both public and private. Analysis of around 350 projects selected over the 2022-2035 period, of which around 200 projects have at least some funding information available (either total funding or public funding).
Source: IEA analysis based on IEA's Clean Energy Demonstration Projects Database as of November 2024.

Most of this funding has not yet translated into projects under construction. Of the 350 selected entries over the 2022-2035 period, around 200 were projects still active with available status and funding information. Of those, 60% of the funding was for projects not yet under construction, which means that they have been announced by government or company officials, but that they are at the concept stage, or that discussions, negotiations or feasibility studies are ongoing, but that the FID has not yet been made. The other 40% of the funding was for projects that had reached FID, which means that funds have been committed, construction has started, or that the demonstration is already operational.

Our estimate excludes projects for which funding data was available but information about the status of the project was lacking, and projects that have been suspended or discontinued, for example due to technical or financial reasons. There were more than 40 such projects over 2022-2035 in the database, of which suspended or discontinued ones aggregated to a total of USD 13 billion. Further research focusing on projects that have been cancelled – and the underlying reasons leading to discontinuation – could generate important policy learnings and lessons for future planning and project design.

For every dollar that governments invest in clean energy demonstrations, the private sector invests another dollar. In most cases, budgets for demonstration projects combine both public and private money (see following section on financing instruments). Of all projects over the 2022-2035 period (i.e. including discontinued ones), we could gather data points for both public and private budgets for only 20% of them. For those projects, we estimate that public funding accounted for around 55% of total funding, with slight variations across sectors. In cases where demonstrations are carried out by incumbent industrial players, the share of private funding can be greater. In some cases, companies may even fund the entire project without use of public money. For demonstrations carried out by new entrants, such as start-ups or smaller innovative companies, public funding helps leverage private co-financing (e.g. through grants or concessional loans backed by public guarantees).

A significant share of total funding is concentrated in just a few large-scale clean energy demonstrations. In certain technology areas such as nuclear, CCUS, low-emissions fuel production, or offshore wind turbines, clean energy demonstrations are even more capital-intensive than average. There can be several reasons for such high costs, including heavy regulatory and safety requirements, greater technology risks or uncertainty, the sheer scale of the project, the need to integrate or tailor technology to a broader supply chain, and long construction times. Such "megaprojects" – projects for which over USD 1 billion is allocated – have an outsized influence on the global total. Less than 15 active projects selected over 2022-2035 accounted for over half of the total USD 60 billion estimate.

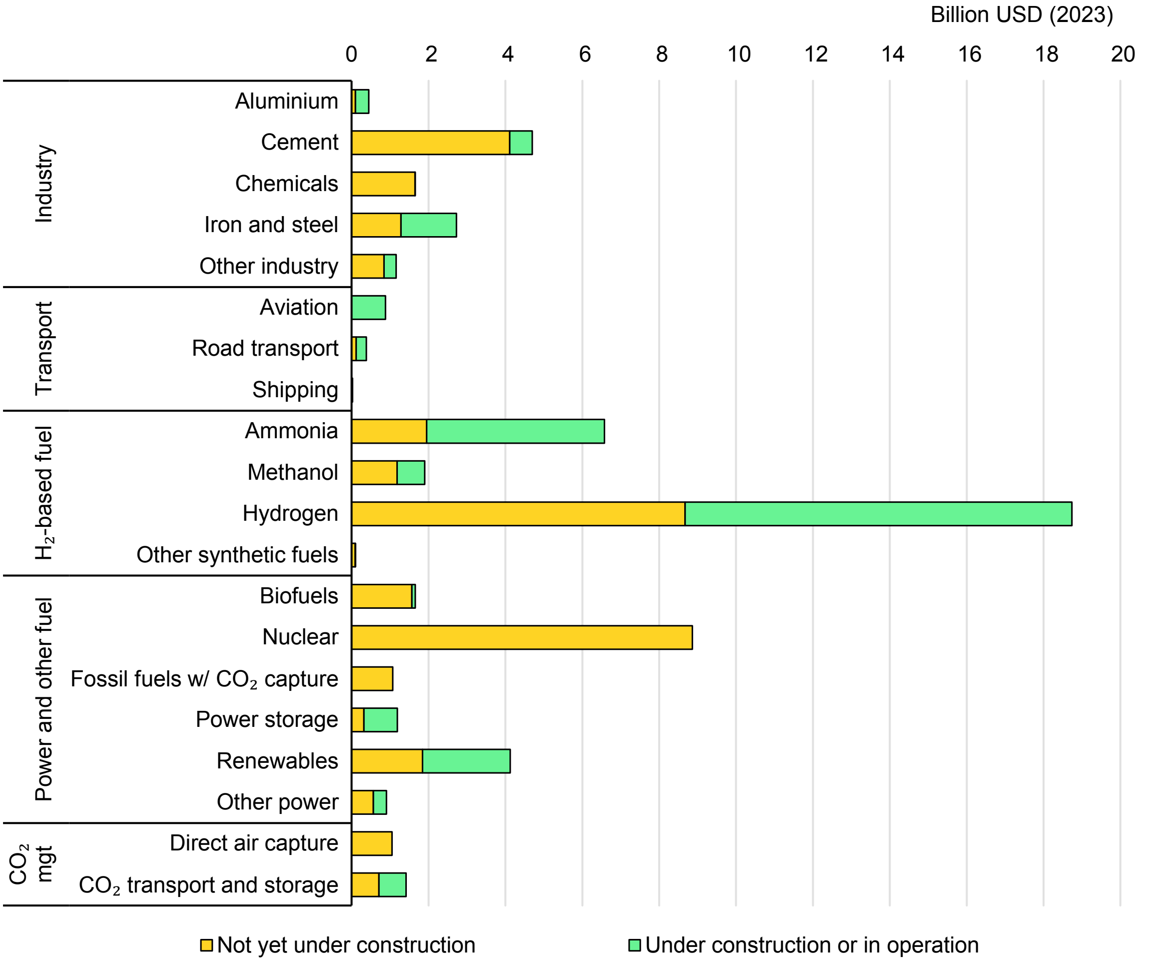
Our aggregate could be an underestimation of actual total funding, given data limitations. First, there are significant data gaps regarding funding information. Of the 350 projects pre-selected in the database over the 2022-2035 period, we were able to collect funding information for around 200 projects. Gathering information for larger projects is typically easier than for smaller projects, notably because of the publicity around them relayed by government, companies and the media. Secondly, information about timing and status is often challenging to gather and can be inconsistently reported. For example, a project may be announced for 2026 but without a clear indication of whether this means that concept, FID, construction, operation, or completion is expected for 2026. In some cases, no information on timing is available. Of the nearly 600 projects featured in the whole database (i.e. not filtered over 2022-2035), timing information is missing for 20% of them, and in most cases only a single year – instead of a period – has been collected. Of the 270 projects in the whole database for which we collected at least one funding data point, 10% lacked information on timing.

There is an opportunity to increase transparency, if governments make more data available about the projects they support. Without effective tracking mechanisms, it can be challenging for decision makers to identify underserved areas, measure the progress of previous investments, and adequately set priorities for future programmes. While the IEA Clean Energy Demonstration Projects Database is an important first step, collecting reliable data is challenging and resource-intensive. In many cases, projects are part of broader research programmes, which makes it harder to identify the exact envelope allocated to a single project. Many demonstrations are co-led by corporate actors, which limits the availability of public data due to confidentiality. Public reports do exist in some cases, such as for the US Office for Clean Energy Demonstration or for projects funded under the EU Innovation Fund that have dedicated fact sheets. Another good example of internationally coherent clean energy innovation data tracking is in the IEA's Energy Technology RD&D Budgets Data Explorer, which has provided reliable data on public R&D budgets for over five decades, since 1974, and would not be possible without efforts from IEA Member countries to standardise data-reporting. These mechanisms provide useful templates that can be used and enhanced for better global tracking, transparency, collaboration and knowledge-sharing.

Sectoral funding

Funding for clean energy demonstration projects is unevenly distributed across segments. One notable finding is that there is greater focus on supply-side technology, such as the production of hydrogen, nuclear, renewables and biofuels, than on demand-side technology, such as electrification equipment or hydrogen use in heavy industry, or the use of synthetic fuels in aviation and shipping. It is also notable that much more funding is flowing to projects focusing on the production of hydrogen and hydrogen-based fuels than to any other clean energy technology sector. In terms of further action, there is an opportunity for decision makers to strengthen support for demonstrating demand-side technology, equipment and infrastructure, especially in industry and transport.

Total funding for clean energy demonstrations by sector and status, 2022-2035



Notes: "H_2" = hydrogen. "CO_2 mgt" = CO_2 management. Hydrogen projects with exclusive application in a specific end-use sector (e.g. use of hydrogen in steelmaking) are reported in the corresponding end-use sector, and otherwise under "Hydrogen".
Source: IEA analysis based on the Clean Energy Demonstration Projects Database as of November 2024.

Hydrogen and hydrogen-based fuels

Nearly half of the estimated total funding on clean energy demonstration projects in the period 2022-2035 was for hydrogen or hydrogen-based fuel production. Hydrogen production via water electrolysis is a uniquely cross-cutting process with the potential to provide many co-benefits, including absorbing otherwise curtailed renewable electricity, and providing grid balancing services and large-scale energy storage. Low-emissions hydrogen can also be produced from biomass or from fossil fuels with CCUS. On the demand side, hydrogen can support decarbonisation efforts either when used directly, or when used to produce low-emissions fuels; however, technologies using hydrogen were not included in this category. Of the active clean energy demonstration projects selected over the 2022-2035 period in the database, more than USD 27 billion in funding – nearly half of the total – was for hydrogen or hydrogen-based fuel production and infrastructure. Of these, around 45% was for electrolysis-based technology. Hydrogen production alone accounts for nearly USD 19 billion, ammonia for over USD 6 billion, and methanol for nearly USD 2 billion.

Many more projects – beyond demonstrations – are in development, underscoring the strong focus on hydrogen in recent years. As the individual components of these systems are most often mature, we do not include all of them in the database of demonstration projects. In many cases, these projects seek to address complex combinations of existing technologies, improve performance and scale, and reduce risks. If the integration of existing components and technologies leads to novel concepts or processes, and if their primary focus is to push the frontier of knowledge or technology development for at least one component or technology combination never previously demonstrated, such projects are considered as demonstrations. Of course, many of the 2 500 production projects in the hydrogen database[2] are innovative – from seeking to ramp production up and down to match variable renewable power generation, producing renewable fuels, decarbonising industry, or supplying a fleet of fuel cell vehicles – but few of them are considered demonstration projects.

Power generation and storage

Power generation demonstration projects attracted most funding after hydrogen and hydrogen-based fuels. These accounted for around USD 16 billion, or a quarter of total funding from active demonstration projects analysed over the period of study. Projects in nuclear power, such as for advanced large-scale designs and small modular reactors, gathered USD 9 billion. Projects focusing on renewables gathered USD 4 billion, such as for floating offshore wind turbines, biomass with CCUS, ocean wave energy, and advanced solar PV. Nuclear power projects are typically lengthy, risky, highly regulated and capital-intensive infrastructure projects, and a considerable amount of funding is therefore concentrated in only a handful of projects – just four in our sample. In comparison, there were 40 projects for renewables. Projects in power storage, and in fossil fuel-based power with CCUS, attracted USD 1 billion each, spread over around 15 projects in each segment. Hydrogen-based power generation gathered around USD 600 million.

There are important data gaps on funding in this sector. Nearly a third of the selected demonstrations do not have any funding information in the database at time of writing, which suggests that we are underestimating total funding. Of those

[2] The IEA's Hydrogen Production and Infrastructure Projects Database tracks data on projects for the production of hydrogen for energy or climate change-mitigation purposes and the development of hydrogen infrastructure and is regularly updated.

that do have funding information, a third are floating offshore wind projects, which could be skewing the sectoral distribution towards this specific technology area.

Industry

Around 20% of total funding was allocated to clean energy demonstration projects in industry. While the database features many – more than 100 – projects across industrial segments, totalling nearly USD 11 billion in funding, this is much less than the funding announced or allocated to projects on the supply side, such as for hydrogen and power. Examples of priorities that decision makers could explore further include demonstration activities to address the pressing innovation needs in industry for which only limited funding is currently available (e.g. industrial heat in different segments).

Funding for demonstrations in industry was unevenly distributed. Projects focusing on cement production attracted 45% of total industrial funding, steelmaking 25%, chemicals production 15%, and aluminium production just 5%. Cement production projects often focus on integrating CCUS technologies to reduce emissions or on exploring alternative raw material options. For iron and steel production, most listed projects focus on hydrogen-based routes, such as direct reduced iron with high levels of electrolytic hydrogen, or switching from coal to electrolytic hydrogen in a blast furnace. For aluminium, projects typically seek to electrify alumina refining or use inert anodes for primary smelting. While we were able to collect information for more than 30 active projects over 2022-2035 in cement production, the database features less than 10 for each of the other segments.

International collaboration can help pool resources to set up new demonstration projects quickly. More efforts are needed to move pre-commercial technologies in the industry sector past the demonstration stage. Co-operation can potentially shorten the time needed to identify, fund and scale such projects, and reduce the need for duplication across multiple jurisdictions. There are already existing mechanisms that could be further leveraged to focus on technology demonstration, such as the high-level G7 Industrial Decarbonisation Agenda, the IEA Working Party on Industrial Decarbonisation, the Net Zero Industries Mission under Mission Innovation (MI), and the Industrial Deep Decarbonisation Initiative under the Clean Energy Ministerial (CEM).

Transport

Less than USD 1.5 billion was allocated to demonstration projects in transport, or just 2% of the total funding over the 2022-2035 sample. This is a stark contrast with the pressing innovation needs for the demonstration of designs that can make use of alternative fuels and technologies in aviation or shipping, as well as heavy road transport. Within the sector, much of the funding was for aviation (close to

70%), road transport including battery production and recycling (30%), and shipping (less than 2%). Projects in aviation are typically more capital-intensive than in road transport – over USD 200 million per project compared to around USD 20 million.

In aviation and shipping, technology focus varies based on weight and size. For lighter aircraft or ships, electrification can be relevant, but for larger ones, projects more typically focus on synthetic fuels, such as ammonia and methanol for shipping and kerosene for aviation. Constraints on space and weight increase the difficulty of this task for aviation, while for shipping, the cost remains comparatively low as technologies are based on existing internal combustion engines, modified for the properties of the alternative fuels.

Current trends suggest project developers and investors are betting on synthetic fuels to decarbonise aviation and shipping. The lifetime of aircraft and ships typically spans several decades, and they rely on dedicated refuelling infrastructure. Each new generation of aircraft or ship therefore locks in technology, equipment and emissions over the long-term. Today, few projects focus on developing *end-use* equipment such as alternative powertrains, while many more focus on the *production* of alternative fuels such as hydrogen-based drop-in fuels or biofuels, which attracted more than USD 1.5 billion in funding. For example, the database features several projects focusing on methanol or ammonia production at a port for direct use in shipping, or on hydrogen production as feedstock to produce synthetic kerosene for aviation, as well as several advanced biofuel facilities.

Rapid electrification of cars, vans, buses and trucks is changing innovation needs in road transport. While few heavy-duty trucks sold today are electric in comparison to the rapid market penetration of electric cars, sales are increasing and technology is maturing, even if further innovation efforts are needed to improve battery performance and decrease costs for long-distance truck freight. Additionally, electric buses are more widely adopted, especially in urban settings. Hydrogen fuel cell vehicle technologies are also maturing, even as applied to heavier trucks and buses. As a result, road transport demonstration projects largely focus on hydrogen refuelling and electric vehicle charging infrastructure, such as fast charging, battery-swapping for trucks, and electrified roads.

CO_2 management

Many CO_2 management technologies have been used for decades and can therefore be considered as already demonstrated. CO_2 management refers to a range of sub-technologies and equipment used for the capture, transport, utilisation and storage of CO_2. CO_2 capture through chemical absorption in gas processing and chemicals production and CO_2 transport in pipelines date back to the 1970s, and CO_2 injection in dedicated storage sites to the 1990s. This legacy of technology development provides learning for decision makers today in terms of demonstration project design in this sector.

First-of-a-kind CO_2 capture plants are yet to be built in many applications, such as in cement production, steelmaking, hydrogen production from methane reforming at high CO_2 capture rates, and direct CO_2 capture and removal from the air (Direct Air Capture, or DAC). With regards to CO_2 transport and storage infrastructure, CO_2 terminals and shipping are also not yet operating at commercial scale. In addition, advanced capture technologies with lower energy intensities and higher capture rates still need to be demonstrated at scale.

The IEA CCUS Projects Database endeavours to track these advances by collecting information on all large-scale projects, i.e. over 100 kt/CO_2 per year, across the CCUS value chain. These can include large-scale capture pilots and demonstrations, first- and nth-of-a-kind commercial capture plants, and CO_2 transport and storage networks. In the IEA Clean Energy Demonstration Projects Database, we seek to identify a subset of these projects that specifically target the demonstration or the first-of-its-kind application of CCUS technologies.

We estimate that around USD 20 billion in total funding was allocated to CCUS demonstration or first-of-a-kind projects in the sample.[3] Projects in low-emissions hydrogen received most of this funding (50%), followed by hard-to-abate industry (20%), CO_2 removal through bioenergy with CCUS and DAC (15%), CO_2 transport and storage infrastructure (7%), and fossil power generation (5%). Around two-thirds of the funding was for projects located in North America, and the remainder for projects located in Europe. Funding for demonstration projects is just a subset of total funding for CCUS projects. In 2023 alone, nearly USD 20 billion in public funding was allocated to CCUS projects.

Around half of this funding was for first-of-a-kind CCUS plants that are currently under construction. These include the Heidelberg Materials Norcem cement plant and the Northern Lights CO_2 shipping terminal and storage site, both of which received funding from the Norwegian Government as part of the Longship project. This also includes the Orsted biomass-fired power facilities which received funding from the Danish Government, and Air Products low-emissions hydrogen facilities in Canada and the United States, which both reached FID in 2023. The financing structures of these projects, as well as the funding instruments, vary greatly by country. While the Norwegian Government committed to fund around 85% of the Longship project to demonstrate the first full CCUS value chain, the Air Products USD 7 billion investment in the United States was mostly privately funded and

[3] This amount stands much higher than the funding displayed for the CO_2 management segment of the sectoral breakdown figure because CCUS is a cross-cutting technology used in other sectors. The CCUS estimate flows from the definitions laid out in this subsection and is based on publicly available information for the selected projects over 2022-2035.

relies on the 45Q tax credit to provide operational subsidies (see later subsection on financing instruments). The other half of the funding helped fund pilots, feasibility, and front-end engineering and design (FEED) studies. These are needed to test and estimate the cost and feasibility of new technologies and applications before reaching the construction stage, and typically require large amounts of funding given the scale of CCUS projects.

As with other sectors, there are important data gaps for demonstration and first-of-a-kind CCUS projects, such as the amount of private funding, as the data is often not disclosed by companies and/or the project has not yet reached FID. We also exclude public funding announcements that do not disclose project-level funding. This is the case for Stimulation of Sustainable Energy Production and Climate Transition (SDE++) funding in the Netherlands, which earmarked EUR 8.8 billion in funding for CCUS projects in 2021 and 2023, and for a recently confirmed GBP 22 billion funding package allocated to several CCUS and low-emissions hydrogen projects as part of two industrial clusters in the United Kingdom, most of them first-of-a-kind CCUS facilities. Certain regions might also be underrepresented because of a lack of funding data. This is the case for China, for example, where several large-scale CCUS demonstration projects were selected in 2024 as part of the Implementation Plan for Demonstration Projects on Advanced Green and Low-Carbon Technologies, or have only recently reached an FID. As such, our current aggregate could underestimate the total funding going to CCUS demonstration and first-of-a-kind projects, and may therefore increase as further project-level information is made available.

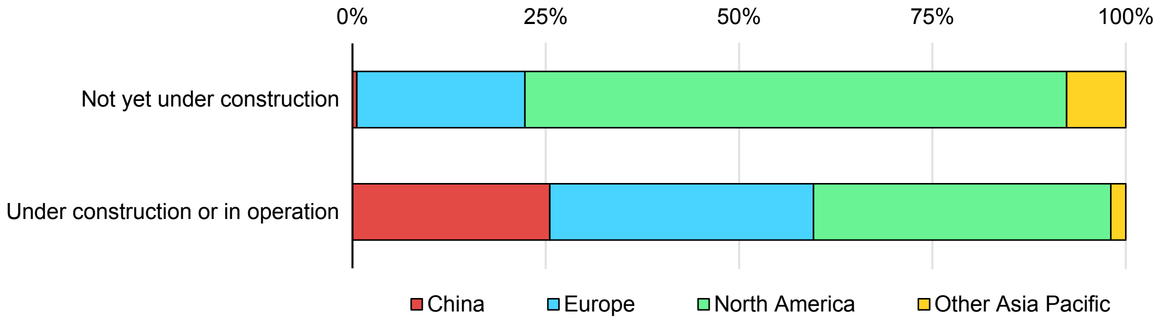
Regional funding

Clean energy demonstrations are concentrated in North America, Europe, China, and a few other advanced economies in the Asia Pacific region, such as Australia, Japan and Korea. Of the selected active projects over 2022-2035, nearly 60% of the total funding announced or allocated to them was in North America (primarily in the United States), 25% in Europe, and 10% in China. In comparison, we were not able to track much funding flowing to projects in emerging markets and developing economies (EMDEs), even in large economies such as Brazil, India, Indonesia, Mexico, Morocco or South Africa. While capital-intensive projects are harder to finance in EMDEs, more focused research could improve the comprehensiveness of our database in the future.

The United States features the largest pipeline of upcoming clean energy demonstrations. There are notable variations in funding distribution across regions depending on the status of clean energy demonstrations. When looking at projects already under construction or in operation, distribution is relatively even: North America accounts for around 40% of total funding, Europe for 35%, and China for 25%. The picture changes radically when looking at forthcoming projects in the pipeline and not yet under construction. For those projects, Europe accounts for only 20% of total funding and China for less than 1%, while North America's share jumps to 70%. In the case of Europe, we tracked roughly the same amount of funding pre- and post-FID, at USD 8 billion. To compare, we tracked around USD 9 billion for projects in North America already under construction or in operation, and nearly USD 35 billion for forthcoming projects in the pipeline.

This shift is largely a reflection of strengthening policy support for demonstration projects in the United States, which established the Office for Clean Energy Demonstrations in 2021. As of November 2024, billions in funding are pending FID from award negotiations, and new calls are opening on a regular basis. As some of these projects move past the critical FID step – which can take months or even years in some cases – construction will get under way.

Total funding for clean energy demonstrations by region over 2022-2035



Notes: "North America" includes the United States and Canada. "Other Asia Pacific" includes Australia, India, Indonesia, Japan, Korea, New Zealand, Chinese Taipei, and Viet Nam.
Source: IEA analysis based on the Clean Energy Demonstration Projects Database as of November 2024.

Data availability limitations may be skewing this regional breakdown, particularly for Chinese projects. The public availability of funding information and links to clean energy demonstration projects by the US Government greatly facilitate data collection and analysis. Publicly available information on EU funding streams also helps with tracking progress at the project level, even if not compiled specifically for demonstrations.

In comparison, we were not able to identify many forthcoming projects in China, which, considering the country's quickly increasing clean energy R&D budgets, suggests we are underestimating Chinese funding in clean energy demonstrations. Public information on key national R&D programmes is available for each five-year plan cycle, but data on project-level funding and technology focus is harder to collect. There are many examples of breakthrough technology development in China. In some technology areas, such as battery-swapping for heavy-duty electric trucks, China has reached commercial-scale deployment (i.e. these are not included as demonstrations in the database), whereas such projects could be considered as first-of-a-kind demonstrations in any other region. More research focusing on identifying China's current demonstration frontiers could help improve comprehensiveness and balance the regional breakdown for the forthcoming pipeline.

Government support for clean energy demonstrations

Governments have an important role to play in supporting clean energy demonstrations. Given the high risks associated with demonstration projects, policy measures can target all pillars of the innovation system, from providing funding to creating markets. Here are specific examples of ways governments can support clean energy demonstrations, based on the IEA innovation framework:

- **Resource-push.** Governments can allocate public budgets for demonstrations in technology areas of national importance and set priorities where there are pressing innovation needs. They can also create incentives for the private sector to co-finance demonstrations, including start-ups and small and medium enterprises. In addition, governments can engage with global partners (e.g. other governments, multilateral development banks) to pool resources around large-scale projects.
- **Knowledge management.** Governments set the general rules for intellectual property, knowledge-sharing, and collaboration across public, private and academic networks. They can also engage with other countries to learn from global practice through existing international collaboration platforms such as the IEA Technology Collaboration Programme (TCP) and MI.
- **Market-pull.** Governments can support the demand for clean energy products and services to improve the business case for pre-commercial technologies, thereby decreasing the risks associated with near-market concepts at the demonstration stage. Demand-side schemes can include public procurement, operational subsidies, standards or mandates, and demand aggregation across sectors.
- **Socio-political support.** Governments are responsible for setting the long-term vision for clean energy and innovation in the country, and for engaging with stakeholders, including civil society, to build collective acceptance. Governments can also set rules to ensure the outcomes of demonstrations are fairly distributed in society.

High-level support for clean energy demonstration is increasing. Important funding schemes have been announced in recent years, including the notable 2022 Pittsburgh commitment by 16 governments to allocate USD 94 billion by 2026 to a pipeline of projects. In most cases, however, support is not limited to demonstration but rather covers the entire innovation journey. There are a few exceptions, such as the US Office of Clean Energy Demonstration, and the EU InnovFin Energy Demonstration Projects (retired in 2022). International collaboration is also increasing, either through bilateral country co-operation, or through multilateral fora such as the TCP and MI.

Selected examples of government strategy or policy documents mentioning support for clean energy demonstration

Country	Policy	Description
Australia	National Energy Performance Strategy	Published in 2024, the strategy explicitly mentions clean energy demonstration. Under the Powering the Regions Fund, set up in 2022 with AUD 1.9 billion Australian dollars (USD 1.3 billion) to support industrial decarbonisation, the Australian Renewable Energy Agency (ARENA) provides support to trials, demonstration and first-of-a-kind commercial projects through the Industrial Transformation Stream, for up to AUD 400 million. The fund allocated another AUD 200 million to Critical Inputs to Clean Energy Industries, in support of cement and aluminium. Further efforts include the National Reconstruction Fund, with AUD 15 billion in funding to support large-scale projects across the economy, including in clean energy.
Austria	Transformation of Industry (TDI)	The TDI initiative, led by the Ministry of Climate, Energy, Mobility, Technology and Innovation (BMK), aims to foster innovation for industrial decarbonisation. EUR 320 million over 2023-2026 will support projects (including but not limited to demonstration), with the aim of reducing national industrial CO_2 emissions by 0.5 Mt CO_2 equivalent (CO_2-eq) by 2030. This initiative also covers bilateral co-operation, such as the Australia-Austria Joint Call 2024, providing envelopes up to EUR 7 million for individual prototype and demonstration projects.
Austria	New Energy for Industry (NEFI)	The NEFI initiative, funded by the Austrian Climate and Energy Fund, gathers a consortium of over 100 companies and 15 research and institutional partners across sectors including cement, steel, plastics and machinery. So far, EUR 98 million has been provided to 24 innovation projects.

Country	Policy	Description
Canada	Net Zero Accelerator Initiative (NZA)	Set up in 2020, the NZA is equipped with up to CAD 8 billion Canadian dollars (USD 5.8 billion) in funding for large-scale investments in key sectors across the country, including in industry (steel, aluminium, cement, mining and mineral processing and chemicals), automotive, power, CCUS and batteries. The NZA sits under the Strategic Innovation Fund, which, at time of writing, had supported 129 projects across all sectors of the economy (not limited to energy), for a total funding of CAD 9.5 billion and total project costs of CAD 78.2 billion. These funds contribute to delivering on the broader policy goals laid out in 2020 in A Healthy Environment and a Healthy Economy (HEHE).
Canada	Energy Innovation Programme (EIP)	Under the leadership of Natural Resources Canada (NRCan), the EIP advances clean energy technologies by funding R&D and demonstration projects. At time of writing, the EIP had opened project applications in areas including renewables, battery storage, methane, smart grids, road transport, CCUS and low-emissions fuels.
Canada	Sustainable Development Technology Canada (SDTC)	The SDTC, which was reinforced by the HEHE policy with an additional CAD 750 million, supports companies (including start-ups) in demonstrating and bringing to market pre-commercial clean technologies. SDTC ranks among the country's largest investor in sustainable small and medium-sized companies.
China	National Key R&D Projects	The 14th Five-Year Plan (2021-25) strengthened support for energy innovation, with budgets for R&D and demonstration projects with the potential to rise above the current level of USD 3 billion per year and including more energy-related projects. We estimate that China exceeded the 7% per year planned increase in energy R&D spending over the period. Official documents report new projects in various fields including hydrogen, energy storage and smart grids, manufacturing, but availability of detailed data for demonstration projects remains limited.
European Union	EIB- Breakthrough Energy Catalyst partnership	The European Investment Bank (EIB) and Breakthrough Energy Catalyst are mobilising EUR 820 million over 2022-2026 to fund demonstration projects in areas relating to hydrogen, sustainable aviation fuels, Direct Air Capture, and energy storage. The goal is to reach a public-private leverage ratio of 1 to 3.

Country	Policy	Description
European Union	EU Innovation Fund	The EU Innovation Fund will provide around EUR 40 billion over 2020-2030 for the commercial demonstration of innovative low-emissions technologies. Emissions allowances will be sold to fund the projects (at EUR 75/t CO_2 and depending on the carbon price), effectively earmarking CO_2 money for decarbonisation. Grant financing is offered through calls for proposals for projects of any size (small: EUR 2.5-20 million, medium: EUR 20-100 million; and large: >EUR 100 million). Projects that fail to receive a grant can get project development assistance from the EIB to improve future application.
European Union	Important Project of Common European Interest (IPCEI)	The IPCEIs – launched annually since 2018 and running over varying periods of time – aim to foster collaborative innovation in the European Union by funding projects co-led by several countries. There are six IPCEIs directly relevant to clean energy, including two on batteries (with EUR 6.1 billion in state aid) and four on hydrogen (EUR 18.9 billion). For each euro of public money, IPCEIs are expected to attract 1.5 euros of private investment, on average.
European Union	InnovFin Energy Demonstration Projects	Until 2022, this mechanism provided loans, guarantees and quasi-equity (see next section on financing instruments) for up to EUR 75 million for first-of-a-kind demonstration projects, particularly in renewables, smart systems, energy storage and CCUS.
European Union	Connecting Europe Facility – Energy	The Connecting Europe Facility invests in EU infrastructure, and its energy branch has made investments in areas such as CO_2 networks (transport and storage), hydrogen and ammonia production facilities, and smart grids. While not all these projects are demonstrations, some rank among the first large-scale facilities of their kind on the continent.
France	France 2030 – Strategy for Accelerating Innovation	Under the broader France 2030 industrial plan, the government seeks to support innovation across the economy, including in clean energy (e.g. hydrogen, low-emissions fuels, renewables, power grids, nuclear, transport, industry). The strategy for accelerating innovation allocates budgets for each stage of innovation, totalling EUR 12.5 billion (including large shares for clean energy, but not limited to the sector): EUR 3 billion for early-stage R&D, EUR 1.5 billion for technology maturation, EUR 2.5 billion for demonstration and first-of-a-kind commercial, EUR 3 billion for early deployment, and EUR 2.5 billion to accelerate growth.

Country	Policy	Description
Germany	National Hydrogen Strategy	As of 2021 (the latest available progress report at time of writing), the federal government and states had selected 62 large-scale hydrogen projects – including demonstrations under the EU IPCEI – for a total of EUR 8 billion in support. These projects primarily spanned industrial (e.g. steelmaking, chemicals) and transport sectors (e.g. synthetic kerosene, advanced biofuels).
Germany	8th Energy Research Programme	In 2023, Germany published a new roadmap for clean energy innovation, aiming for climate neutrality by 2045. Support for technology demonstration is explicitly mentioned in industrial heat; hydrogen production, infrastructure and use; and electricity storage.
India	National Missions	The government typically supports technology development from early-stage innovation to deployment through focused missions or campaigns, which run over several years. Not all schemes include tailored support for innovation, but some do. For example, the National Green Hydrogen Mission (2023) aims to launch pilots and demonstrations, with INR 455 crore Indian rupees (USD 55 million) for steel, INR 496 crore (USD 60 million) for mobility, and INR 115 crore (USD 14 million) for shipping. Other examples include the National Mission on Electric Vehicles, the National Mission for Accelerating Growth of New India's Innovations, the Jawaharlal Nehru National Solar Mission, and the National Mission on Transformative Mobility and Battery Storage. While they all seek to provide support for innovation, their scope remains broader than demonstration.
Japan	Green Innovation Fund	The New Energy and Industrial Technology Development Organization (NEDO) manages a public fund of nearly JPY 3 trillion Japanese yen (almost USD 20 billion) over 2020-2030 to support innovators from R&D to demonstration. Projects cover the power sector (nuclear, offshore wind, advanced solar), hydrogen (from production to industrial use), CCUS (from capture to industrial use), and transport (batteries, aviation, ships).
Japan	Integrated Innovation Strategy 2024	Each year, Japan issues an integrated innovation strategy to deliver on the 6th Science, Technology and Innovation Basic Plan (2021), the Green Growth Strategy through Achieving Carbon Neutrality in 2050 (2020), and the Environment Innovation Strategy (2020). The 2024 edition explicitly mentions clean energy demonstration in fields such as nuclear fusion, renewables, net zero buildings, bioplastics and sustainable aviation fuels.

Country	Policy	Description
Norway	Green Industrial Initiative	The high-level strategy mentions several schemes relevant to clean energy demonstration. Innovation Norway, for example, provides low-risk innovation loans, with one scheme tailored to low-emissions ships, and manages the Environmental Technology scheme, which explicitly targets pilot and demonstration projects. The Research Council of Norway oversees the Demonstration Projects for the Industrial Sector scheme, which supports companies finalising pre-commercial technologies, and the Centres for Environment-friendly Energy Research, which support projects across CCUS, electricity and renewables, hydrogen and transport.
Thailand	National Higher Education, Science, Research and Innovation Policy Council	New measures to support innovation were put in place in 2023 to support Thailand's carbon neutrality objectives. These include increasing funding for R&D and demonstration, not only from local but also foreign investors, sandboxes in targeted regions, and international collaboration such as through the United Nations-backed Climate Technology Centre and Network.
United Kingdom	Industrial decarbonisation strategy	In 2021, the government set out an industry-specific roadmap which explicitly mentions clean energy demonstration. The policy sets demonstration budgets up to 2030 through various instruments to support projects across all industrial segments. Key mechanisms include the Industrial Energy Transformation Fund (GBP 315 million), the Industrial Decarbonisation Challenge (GBP 170 million), the Energy Innovation Programme (GBP 505 million), the Net Zero Innovation Programme (GBP 1 billion) and Transforming Foundation Industries (GBP 66 million). In addition, budgets are allocated to the Net Zero Hydrogen Fund (GBP 240 million), the Clean Steel Fund (GBP 250 million) and the CCUS Infrastructure Fund (GBP 1 billion), among other funds, but these are not exclusively for demonstrations.
United Kingdom	Net Zero Strategy: Build Back Greener	In 2021, the government issued a strategy setting out policies and proposals for decarbonising all sectors of the economy to meet the net zero target by 2050. The strategy document explicitly mentions demonstration projects, with target budgets in many cases, such as for maritime transport, energy storage, nuclear, hydrogen, advanced biofuels, cement production, heat, and CCUS including DAC.

Country	Policy	Description
United Kingdom	Net Zero Research and Innovation Framework (2022-2025)	The government expects to provide R&D and demonstration funding of GBP 4.2 billion (USD 5.5 billion) over the period. Key areas identified for long-term investment are in transport (40% of planned funding), such as aviation and shipping; in power (25%), such as system integration and flexibility, including energy storage, emerging renewables, and nuclear including small modular reactors; industry and hydrogen (15%); buildings (5%), including heating and cooling; and CCUS (2%). In several cases, explicit envelopes are allocated to technology demonstration.
United States	Office of Clean Energy Demonstration (OCED)	The OCED, set up in 2021, oversees USD 25 billion in federal investment to support clean energy demonstrations. At the time of writing, OCED had selected projects for awards across hydrogen hubs (USD 8 billion), CO_2 management (USD 7 billion), industry (USD 6.3 billion), nuclear power (USD 3.3 billion), energy storage (USD 500 million) and distributed energy systems (USD 50 million), among others. The OCED is unique in focusing solely on projects at the demonstration stage. It is supported by the Bipartisan Infrastructure Law (BIL) of 2021 and the Inflation Reduction Act (IRA) of 2022.
United States	National Clean Hydrogen Strategy and Roadmap	The 2023 roadmap, which is also supported by the BIL with up to USD 9.5 billion in funding, and by the IRA with additional incentives and tax credits, introduces pathways for decarbonisation through "clean" hydrogen. It includes OCED's funding of USD 8 billion for hydrogen hubs, as well as IRA grants for industrial demonstrations. Sections dedicated to transportation also include demonstration projects in heavy road transport, aviation and shipping.

Note: This selection is not exhaustive.

Sources: In addition to the hyperlinks in the text, this table draws from the results of the global survey on clean energy innovation policy carried out by the Organisation for Economic Co-Operation and Development (OECD), the IEA and MI, with the support of EU funding, the results of which are reported under the OECD net zero portal.

Mission Innovation supports co-operation towards the commercialisation of clean energy technologies

In recent years, Mission Innovation (MI) has increased its focus on clean energy demonstrations, such as through MI Missions and the organisation of knowledge-sharing events under the MI Think Tank (e.g. MI Financing Masterclass).

At the 7th MI Ministerial in Pittsburgh in 2022, 23 governments and the European Union committed to accelerate the commercialisation of clean energy technologies, particularly in hard-to-abate sectors. During the meeting, MI Mission Action Plans were launched, outlining commitments to deliver 221 demonstration projects globally by 2030,* with a focus on industrial decarbonisation (e.g. steel, cement and chemicals) and renewables integration.

Achieving these commitments hinges on effective international collaboration to rapidly identify, fund and scale projects in different regions of the world. The seven MI Missions – or innovation alliances – provide a co-ordinated framework for these efforts, enabling governments and the private sector to work collaboratively and pull resources together. Several MI Missions have put forward their own goals relating to *demonstration* projects. For example:

- The **Green Powered Future Mission** aims to launch 5 demonstration projects across 5 continents to tackle some of the 50 priorities it identified, such as integrating renewable power to cover up to 80% of needs.
- The **Carbon Dioxide Removal Mission** has launched 30 pilot and demonstration projects, each removing over 1 kt CO_2/year, focusing on scaling up carbon removal technologies and establishing robust measurement, reporting, and verification frameworks to support cross-border carbon markets.
- The **Net-Zero Industries Mission** aims to co-ordinate investment programmes for demonstrations over 2025-2030, and identified 19 projects with potential for co-operation action across participating countries and several industrial segments.
- The **Integrated Biorefineries Mission** created a Community Networking Platform to foster international co-operation on bio-refining among researchers and project developers. The Mission also supports projects developing bio-based sustainable aviation fuel.
- The **Zero-Emission Shipping Mission** is examining alternative fuels and mapping global financial support for zero-emission ships to accelerate innovation in ship design and fuel use.
- The **Clean Hydrogen Mission** co-ordinates the "Hydrogen Valleys" programme, which seeks to develop eight hydrogen value chains – from production to end-use – across different regions. The valleys are expected to feature demonstration projects across heavy industry, transport, and power.

*Not all of these projects necessarily fall within the IEA's definition of demonstration projects.

Financing instruments

Clean energy demonstration projects are typically large, both in scale and in capital requirements. We estimate that of the selected projects over 2022-2035, average funding per project was in the range of USD 400-500 million.[4] Raising such amounts can be prohibitively challenging and costly given the risks and uncertainty. Many companies do not have such liquidity available in cash, and many investors shy away from high-risk projects.

Financing demonstration projects requires dedicated instruments that may be less common among innovators but are often already known in the financial community. Clean energy demonstrations have only come to the forefront of global policy discussions recently, but many project developers and financial institutions around the world are already well-versed in large-scale projects, often with high levels of risk. Examples include infrastructure projects – in and outside the energy sector – in EMDEs with low credit ratings and high interest rates, and the historic demonstrations of technology and equipment for space exploration. Demonstrations are likely to require a mix of instruments that evolve with the project itself, and concerted efforts from government, industry and financial institutions. The table in the following pages provides examples of financing tools. Recognition of the specific challenges of scaling up large, complex technology for markets that are not yet mature has already spurred the development of new instruments and partnerships. These range from dedicated public debt facilities for such projects to complementary finance packages from governments and certain private sector partners, including future customers of the technologies who are willing to give grants to kick-start new industries.

The nature of the stakeholders involved in demonstrations is changing, calling for broader policy coverage. Start-ups, for example, are playing an increasingly important role in sectors with large-scale, complex infrastructure, such as heavy industry, aviation, or nuclear power. Start-ups can be left in a cash crunch by venture capital investors, who typically look for smaller capital investments and a return in 3-5 years, and are more well-versed in equity project finance. In many cases, start-ups are also unable to benefit from conventional support schemes such as R&D tax incentives (as many run a deficit for years) or public calls (given the required administrative resources). Some of these challenges are already being addressed by policy measures, such as in Japan's Integrated Innovation Strategy 2024.

[4] This estimate only includes projects for which some funding information was gathered and assumes that projects for which only public funding data was available find private co-funding at a nearly 50-50 rate, as per the findings detailed in the previous sections of this report. This estimate also considers suspended or discontinued projects, and those for which status information was lacking, to increase sample size.

Choosing the right financing instruments is important for all stakeholders. Project developers need patient and flexible capital to focus on technology; funders need to turn a profit across their portfolio; and governments need to optimise public spending. In practical terms, effective financing instruments spread risks over more actors to decrease overall project costs, foster collaboration, and can be set up quickly and updated dynamically as the project makes progress. Finance instruments that bring public and private partners together to mitigate risk, crowd in additional capital, spur the replication of other similar projects and develop markets are essential. The mix of institutional investors, who bring most of the funding, and of public bodies, who can accept greater risks or lower returns than market rate, helps deploy capital for otherwise hard-to-fund projects.

Selection of financial instruments that can be used to support demonstration projects

Instrument	Type	Description	Examples
Concessional loans from government	Debt	Governments – directly through ministerial budgets or national public banks – can offer loans at more favourable terms than commercial loans and, in some cases, can be the first lender to suffer losses in case a project underperforms. Typical features of concessional loans include a delayed start to the servicing of the debt, and interest rates lower than the market rate. Concessional loans reduce total costs for project developers and can also help them to attract capital from private sources alongside the public lender.	• TerraPower (advanced nuclear), United States, USD 2 billion from the US Department of Energy (DoE). • XE-100 (small modular nuclear reactors), United States, USD 1.2 billion from the US DoE. • Eavor-Loop (geothermal), Germany, EUR 45 million from the EIB and a loan guarantee from InvestEU, for first-of-a-kind commercial demonstration.
Concessional loans from Development Finance Institutions (DFI)	Debt	Loans from DFIs can come with favourable conditions, specifically lower interest rates. The goal of DFIs is to support the socio-economic development of a specific region, rather than focus only on profits. This opens room for more affordable lending conditions. Loans from DFIs are sometimes paired with equity money from the same DFI or from funders, sometimes called blended concessional finance.	• Westgass & IPS (ammonia), Uganda, USD 400 million from Norfund, first-of-a-kind in the country although not a new demonstration. • Verkor (batteries), France, EUR 1.3 billion loan from 19 banks including the EIB, BPI France, and commercial banks, for gigafactory-scale production. • Northvolt (batteries), Sweden, EUR 52.5 million loan from the EIB in 2018 for demonstration. • ArcelorMittal (steelmaking), Belgium, EUR 75 million from the EIB.
Loan guarantees	Debt (risk reduction)	Loan guarantees are used to decrease the risk associated with lending, specifically by committing an institution – such as the World Bank, the United Nations Development Programme or a publicly backed national bank – to service the debt in case of default. This instrument helps lower interest rates and raise more money by appealing to more lenders. A key advantage of loan guarantees is that they do not require any initial capital from the guarantor, although the ability to service the debt in case of default needs to be demonstrated. Guarantees can also be targeted to equipment suppliers to enable young companies to enter contracts without needing to put aside finance to cover the risk of technology underperformance, a requirement that is often imposed by clients and can be a high cost if funded from equity and other sources of early-stage capital.	• Net-Zero 1 (aviation), United States, USD 1.5 billion from the US DoE. • Golfe du Lion (floating offshore wind), France, USD 82 million from the European Fund for Strategic Investments (EFSI). • Qair Eolmed (floating offshore wind), France, EUR 85 million from the EIB with a guarantee from the EFSI. • Stegra (formerly H2 Green Steel) (steel), Sweden, EUR 314 million from the EIB, of which EUR 200 million backed by InvestEU, EUR 114 million through commercial banks, and EUR 57 million from the Nordic Investment Bank, of which EUR 9 million is backed by InvestEU.

Instrument	Type	Description	Examples
Grants from government	Grant	Grants are cash awards to fund a project. They come with no debt for the project developer but can include certain conditions (e.g. job requirements, publication of intellectual property). Many public institutions around the world have set up dedicated funds providing grants for clean technology projects. Grants typically fund only part of a given project (i.e. they are capped) and need to be matched with private co-financing or loans.	• Airbus ZEROe Development Centre (aviation), United Kingdom, will benefit from some of the GBP 685 million in funding from the government to develop new aircraft technology. • Heidelberg Materials Brevik (CO_2 capture), Norway, USD 14.1 million from the government to make up for increasing cost estimates (the project received more funding from government as part of the Longship Project). • Northpoint Biofuels (aviation), United Kingdom, GBP 16.8 million from the government for commercial scale by 2027. • Sublime Systems (cement), United States, up to USD 87 million from the OCED (in negotiation). • Mitchell Plant (cement), United States, up to USD 500 million from the OCED (awarded). • GO4ECOPLANET (cement), Poland, EUR 228 million from the EU Innovation Fund. • Ecoplanta (chemicals), Spain, USD 114 million from EU Innovation Fund and USD 620 million from the private sector • H_2U Eyre Gladstone (hydrogen), Australia, USD 92 million from the Western Australian Government and H_2U. • Yarwun (aluminium), Australia, AUD 111 million Australian dollars including AUD 32 million from ARENA and the rest from Rio Tinto.
Loans from a bank or fund	Debt	Standard commercial loan from conventional lenders such as banks or funds, with interest rates and length set by the market. While these can provide considerable capital, interest rates can be high, repayment start dates early, and default penalties large. They can represent a more challenging option for demonstration projects given the inherent risk, but can complement other sources of finance.	• Harmony Energy (energy storage), United Kingdom, GBP 10 million loan from Triodos Bank.

Instrument	Type	Description	Examples
Equity investment in companies	Equity	Direct investment from any actor in which the investor injects cash in exchange for a stake in a company developing a demonstration project. A range of actors can be relevant: public and private banks and funds, family offices, venture capital investors, and companies. Some governments have publicly-operated venture capital funds, while others contribute to third-party funds.	• Boston Metal (steelmaking), United States, raised USD 262 million in 2023 for commercial-scale demonstration. • ZeroAvia (aviation), United Kingdom, raised several rounds of equity from banks, airlines, oil and gas companies, and venture funds, such as USD 150 million in 2024. • Summit Nanotech (lithium extraction), Canada, USD 50 million to support the demonstration at scale of direct lithium extraction in Chile. • Elysis (aluminium), Canada, USD 286 million funded by Government of Quebec and Rio Tinto.
Project equity investment	Equity	Special purpose vehicles can be established to develop projects, and investors can own shares of these dedicated companies. This funding is a type of project finance, which can also include debt finance. It can be attractive to developers because the investors do not have recourse to the non-project assets of the development company in case the project does not perform as expected. In the case of demonstration projects, large incumbent companies in the sector have an important competitive interest in taking a stake (e.g. front-runner advantage in a new market). It is not common for public entities to take equity stakes in first-of-a-kind projects but, in cases where they do so, they have an opportunity to ensure the positive outcomes of the project are distributed in the public interest.	• Project Roadrunner (hydrogen-based synthetic fuel), United States, USD 75 million funded by Infinium and Breakthrough Energy Catalyst.
Convertible debt to equity	Debt Equity	Convertible debt starts as debt (i.e. a loan with an interest rate) and can be converted to a stake in the company (i.e. equity) later when certain conditions are met – such as successful project development. Banks and funds typically use convertible debt as part of loan agreements to increase their payoff in case of success, while keeping an easy way out. Project developers may find more favourable terms than conventional loans; and funders have greater incentives to support day-to-day operations by leveraging their experience and networks than regular lenders would.	• Baseload Capital (low-temperature geothermal), Sweden, USD 24 million in convertible loan from Breakthrough Energy Ventures.

Instrument	Type	Description	Examples
Quasi-equity, venture debt	Debt	Quasi-equity, also known as venture debt, combines elements of equity and debt. It is a relatively new instrument, developed and used by financial institutions such as the EIB to fund projects. Compared to other debt, quasi-equity may feature flexible repayment terms, low repayment priority, and can be unsecured, which means that physical assets (e.g. infrastructure, equipment) may not be seized by lenders in case of default. In that sense, quasi-equity (or venture debt) stands between equity and debt.	From the EIB: • LeydenJar (batteries), Netherlands, EUR 30 million. • Heliatek (advanced solar), Germany, EUR 20 million. • Energy Dome – Catalyst (CO_2 battery), Italy, EUR 25 million.
Operational financial support	Subsidy	Operational financial support can be central in improving a project's economic viability and securing investment. These could take the form of tax credits linked per unit of energy produced or tonne of CO_2 abated or sequestrated, or contracts-for-difference to bridge the cost gap between production and market prices. Operational support can be fixed or variable revenue, or a mixture of the two. It can also be extended over different timeframes, depending on the needs of the technology, and can build in expectations of future cost evolution if it is allocated for periods of more than a decade.	• In Denmark, part of the CCUS fund was allocated through a tender to the first large-scale capture units on biomass-fired power plants, and will be paid over the project's lifetime per tonne of CO_2 captured and sequestered. • In the United States, the 45Q tax credit provides subsidies per tonne of CO_2 used and stored, thereby improving the economic viability of CCUS projects. Many of them are first-of-a-kind facilities in their respective sector. • In the Netherlands, the SDE++ scheme provides subsidies for qualifying clean energy technologies. For CCUS projects, the subsidy is awarded over a 15-year period and bridges the cost gap between production with and without CCUS, linked to the carbon price in the EU emissions trading system.

Notes: The examples in this table should not be considered as authoritative illustrations for a given financing instrument. Companies typically benefit from a mix of financing instruments over their lifetime and contractual agreements are often confidential, so it can be challenging to identify which specific instrument is being used at which step of an industry-led project, and some interpretation is required when analysing publicly available documents. Most examples in this table could fit in several categories but are distributed across them for the purpose of illustration.

Acknowledgements

This study was prepared by the Energy Technology Policy (ETP) Division of the Directorate of Sustainability, Technology and Outlooks (STO) of the International Energy Agency (IEA), under the leadership of Timur Gül, IEA Chief Energy Technology Officer, and with guidance from Araceli Fernandez, Head of the Technology Innovation Unit.

The analysis was co-ordinated by Jean-Baptiste Le Marois, who is also the lead author of the report. Other key authors, contributors and reviewers within the IEA included, in alphabetical order: Simon Bennett (innovation), Laurence Cret (shipping), Mathilde Fajardy (CO_2 management), Suzy Leprince (R&D), Teo Lombardo (batteries), Shane McDonagh (transport), Leonardo Paoli (innovation), Amalia Pizarro (hydrogen), Richard Simon (industry), and Biqing Yang (China). Loann Marquant (demonstration projects) and Omenah Okogu (finance) supported research underpinning the analysis. The Mission Innovation Secretariat also contributed, including Patrick McCauley and Ingrida Murauskaite.

The report was edited by Lizzie Sayer and its publication was co-ordinated by Astrid Dumond and Clara Vallois from the Communications and Digital Office (CDO).

This report builds on the IEA Clean Energy Demonstration Projects Database and the ETP Clean Energy Technology Guide, which have benefited from contributions across other IEA teams. Jon Custer (CDO) co-ordinated data management on the IEA website.

This publication has been produced with the financial assistance of the European Union as part of its funding of the Clean Energy Transitions in Emerging Economies programme (CETEE-2) within the Clean Energy Transitions Programme, the IEA's flagship initiative to transform the world's energy system to achieve a secure and sustainable future for all.

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Typeset in France by IEA - December 2024
Cover design: IEA
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