How Governments Support Clean Energy Start-ups

Insights from selected approaches around the world

International Energy Agency

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Abstract

This report highlights recent initiatives to inspire policy action at a time when innovation leadership by the public and private sectors is critical to meeting the net zero challenge. Countries around the world strive to become home to the next major company emerging from a start-up with a disruptive clean energy invention, and with good reason. Whilst aiding innovation in support of climate and energy goals, nurturing innovative start-ups to maturity can also create local economic prosperity because clean energy transitions will be a major market opportunity for all countries, all century long. Already, the number of government policy measures to help start-ups get new clean energy technologies to market has risen sharply since the Paris Agreement was signed in 2015. This is extremely encouraging given that energy technology start-ups continue to face challenges attracting patient capital and governments possess some unique resources to speed them through the phases to reach technical maturity while staying in business. Based on 14 detailed case studies and in-depth interviews, this report presents a range of impressive policy measures from a variety of different country contexts, and identifies eight key insights for effective policy to support clean energy start-ups.

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Overview

Money is pouring into companies with big ideas for avoiding energy-related emissions

Unlike most areas of energy investment, and against many expectations, clean energy venture capital investments did not contract during the pandemic. Rather, momentum for annual early-stage investment was maintained at around USD 3 billion in 2020 and rose higher in 2021 as it became more evenly distributed internationally. Increasingly, investors have become convinced that energy transitions are indeed happening and that they will be underpinned in the near term by proactive government recovery policies and robust corporate demand.

The role of governments in facilitating this surge has been little discussed despite the major role of public support for the basic research from which many of the new ideas have sprung and despite the increase in targeted interventions of governments to overcome specific challenges faced by start-ups in the area of clean energy. This is a highly regulated, hardware-intensive sector that faces a fragmented and uncertain policy environment, as well as an investment community often unfamiliar with energy and sometimes poorly aligned with its funding needs. To meet the technology needs of a net zero emissions future, however, a sustained "wave" of investment in a much wider range of potentially disruptive ideas is required, supported by effective public policy.

This report focuses on government support for start-ups – young small and medium-sized enterprises or "SMEs" – striving to bring novel clean energy technologies to market. Although these companies are generally less than seven years old and have not yet commercialised any profitable products or shared dividends with investors, they could provide part of the solution to the significant societal challenges we are facing.

Policy attention to start-ups is rising

Countries around the world strive to become home to the next Tesla, BYD or Vestas, with good reason. Without more innovation, energy and climate goals will be out of reach. Just as importantly, nurturing start-ups to maturity can create local economic prosperity, and clean energy transitions will be a major market opportunity for all countries, all century long.

Policy plays an essential role in clean energy innovation. In the past this has taken place largely through funding R&D projects, providing tax breaks and using market regulation to incentivise improvements to product design and reductions in costs. But, with higher expectations that certain clean energy technologies can be commercialised by entrepreneurs anywhere in the world –especially true for mass-manufactured technologies like batteries, electrolysers, modular reactors, sensors, solar panels and vehicles – governments are moving to support innovative start-ups directly.

The number of government policy measures to help start-ups get new clean energy technologies to the market has risen sharply since the Paris Agreement was signed in 2015. This is extremely encouraging. Many government approaches deviate from the traditional funding models used by public institutions to fund research projects. Instead, they seek to tackle specific barriers unrelated to the quality of the underlying technology. They make use of creative policy designs, sometimes adopted from sectors like digital technology or biosciences, including concessional debt, equity funds, incubation, matchmaking and prizes.

A well-designed support policy for clean energy start-ups will never be sufficient on its own to meet innovation policy goals: the most successful regions address a wide range of innovation system needs. These needs vary widely among countries, and there is rapidly growing interest in clean energy innovation in emerging market and developing economies where resources to address them continue to be scarce compared with advanced economies. Innovation system needs also vary between technology areas. Some key, large-scale, clean energy technologies may not emerge via the start-up route.

Governments possess a range of unique resources for energy technology start-ups

Governments possess a range of strengths beyond their ability to provide grant-based financing to help clean energy innovators grapple with barriers. These strengths include operating world-class laboratories, trusted reputations, extensive networks, and a capacity to target technologies that are widely agreed to be important for the future but which are not yet viewed by investors as having near-term profitability. Governments can also choose to selectively target underrepresented social groups; for instance, several countries have launched programmes in recent years to support female clean energy entrepreneurs. Among the policy initiatives surveyed by the IEA for this report, many include new ways to draw on these strengths.

Prior to this report, few resources existed to make policy makers aware of their options

A daunting challenge for policy makers is to identify which of the many gaps currently hindering early-stage clean energy start-ups they are best-placed to address. According to where the gaps reside, they include:

Governments

1. Limited consideration of the specific needs of different clean energy technologies that can make generic support measures ineffectual.
2. Low awareness of the different pathways new technologies follow from laboratory to market, including the role of start-ups, the barriers they face and their disruptive impacts.

Investors and incubators

3. Continued lack of investor attention to the innovators' need for longer timelines to perfect new technologies as well as for ongoing policy support to address urgent developmental and environmental challenges – despite a recent upsurge of investment in some clean energy technology areas.
4. Scarce knowledge of energy technology, policy and regulation details.

Innovators

5. Perceived excessive risk on the part of high-potential inventors (especially from certain social groups underrepresented among business founders), which makes them hesitant to launch new technology businesses.
6. Insufficient non-dilutive capital to enable start-ups to experiment and learn about their early-stage technologies and business models.
7. Lack of entrepreneur awareness on how to access capital, infrastructure and business services in a timely manner at each stage of the innovation process.
8. Limited awareness of overseas market opportunities, as well as of funds and incubation services available for clean energy technologies in other countries.

Corporations

9. Lack of awareness among energy suppliers and users on the status and potential of new clean energy technologies, and on where to access such information.
10. Insufficient interaction among firms (of all sizes) in unconnected technology areas that could work together to catalyse new approaches.

For each gap, a wealth of choices are possible. For example: Should the government provide support itself or fund a third party to do so? Should start-ups

be able to access support at any time or only in fixed windows, like most research programmes? Should support be available for international companies that have locally relevant technologies or only available for innovators emerging within the jurisdiction? Should support be available for business development or should it be limited to technology projects if there is a risk of distorting competition? And, finally, which level of technical maturity would benefit most from policy attention?

Policy makers seeking to develop new measures or improve those already in place can benefit greatly from a resource that showcases existing international approaches to tackling these gaps. Of course, in most cases it is too early to perceive the full impacts of these policies, but their different approaches and the ways in which their administrators have learned over time are informative.

Countries take a variety of impressive approaches and offer inspiring examples from a range of contexts

Leadership will come not only from advanced economies. Distinctive approaches can be found, for example, in initiatives in Morocco, Singapore and India. Analysis in this report unpacks policy examples according to a framework of four primary support functions and two delivery options.

Types of support governments provide to clean energy technology start-ups

Type of support	How support is provided	
Financing (grants, debt, equity)	Direct (by government-owned entities)	Indirect (via third parties)
Infrastructure (laboratories, office space)		
Services (business services, technical expertise, public recognition)		
Networking (peer-to-peer, investors, suppliers, regulators, international)		

The Women in Cleantech Challenge in Canada complemented its prize design and hands-on support to female entrepreneurs with an unconditional stipend for six finalists that helped them manage critical cash flow concerns during the programme. Green Innoboost 2.0 in Morocco is a programme that allows start-ups to choose between grants or equity investment; if they choose grants, the government funder is entitled to a share of the resulting annual revenue. Innovation Norway, a state-run enterprise to help Norwegian companies allocates advisors to guide each start-up to the most appropriate funding opportunities. The Swedish Energy Agency's grants are designed to guide innovators' technologies to the next level of maturity, including by ensuring that they co-operate with potential customers.

Access to infrastructure such as laboratories can be provided in different ways. The US American-Made Challenges programme is based on competitions in well-defined technology areas identified by policy experts, and successful start-ups receive vouchers for technical support to help them succeed in later stages. The IN^2 programme, also run by the US government, channels private capital to national laboratories so that they can support high potential clean energy start-ups identified through scouting exercises. In India, the Clean Energy International Incubation Centre has built dedicated equipment, and blends public and private money with access to the facilities of a large electricity distribution company. Ecolabs-COI in Singapore takes a similar approach; it has developed links with a range of commercial entities that can host real-world tests of start-ups technologies. This stands in contrast of the United Kingdom's Energy Systems Catapult Living Labs, which provides similar opportunities but in residential households that are equipped for field trials of smart and efficient solutions.

Many policy initiatives also help start-ups with tailored services that they would find difficult to buy themselves. While Chile runs a world-renowned public programme, Start-Up Chile, the European Commission has chosen to fund a private entity to deliver the services available via EIT InnoEnergy. The Indian government also uses an indirect approach for its Technology Business Incubators, but it has designed a distinctive system with the means to channel public financing and infrastructure support to start-ups, as well as business services.

In some situations, it can be highly impactful and cost-effective to focus on enhancing connections between start-ups and potential sources of financing and support. The US Department of Energy used public funds to launch a national network of incubators to strengthen connections that had been identified as too weak; the result, Incubatenergy, is still active and privately funded. In Germany, Start Up Energy Transition is both a prize for early-stage innovators and a means of connecting them with investors, policy makers and the public imagination.

Eight insights for effective policy to support clean energy start-ups

Based on 14 detailed case studies, 24 other policy highlights, and in-depth interviews, we have identified eight insights for effective policy to support clean energy start-ups.

1. **Maximise what you already have**. Look to existing public infrastructure, expertise, networks, reputation and programmes.

2. **Take a global outlook**. Attract applicants from around the world that might be able to solve local challenges. Create the links that will accelerate their paths to overseas markets and finance.
3. **Channel the right money at the right time**. Start-ups are typically in constant danger of running out of capital, and application processes for public funds can exacerbate this. Grants (whether conditional or unconditional), loans, guarantees and equity can benefit both the start-up and the public sector if differentiated by the needs of different technologies and maturities.
4. **Support peer-to-peer networking**. Particularly at the earliest stages of maturity, such networking can be a cost-effective means of encouraging knowledge-sharing among cohorts of innovators facing similar challenges. This should be in addition to supporting other networks if there are gaps in what is available from the private sector.
5. **Publicise innovators and raise awareness**. Leverage the public sector's trusted reputation to reach and attract the interest of informed stakeholders and inspire the public.
6. **Focus support on priority technology areas**. In line with identified national or regional technology needs, target resources alongside broader calls for interest that reveal the strengths of the innovation ecosystem.
7. **Establish milestones and provide regular feedback on progress**. Expert guidance can come at a high cost for young companies, but it can save significant resources if it prevents missteps or delays. It can be especially difficult to access this type of support from private incubators over more than a year or two, which is a poor fit with hardware development timelines.
8. **Offer single access points for multiple support measures**. Help start-ups to navigate the wide and sometimes bewildering range of different types of public support available locally and internationally.

Chapter 1. Introduction

Since 2015, the number of government policy measures to help start-ups get new clean energy technologies to the market has risen sharply as countries around the world (increasingly emerging market and developing economies) seek effective mechanisms to meet their energy, climate and economic goals. New firms have a key role in reorienting economies towards novel industries and renewed economic development.[1] Although governments have employed a variety of approaches to address a range of challenges and objectives, in many cases building on existing institutional practices, no resources exist to make countries aware of all their options or where to seek inspiration.

This report therefore reviews existing government initiatives and draws insights from their experiences to present possible policy options. It is a resource for policymakers seeking to develop new measures or improve those already in place, although in most cases it is too early to perceive the full impacts of these policies, especially since their objectives vary from helping individual companies access financing to improving the clean energy innovation system's long-term productivity. Thus, our aim is not to prove which approaches are most effective but rather to present initiatives that can inspire action all around the world. We hope that analysts and other clean energy stakeholders also find value in the information and framework of this study, as it is part of an International Energy Agency work programme to help countries make better policies to accelerate clean energy innovation.

Strikingly, most of the world's clean energy initiatives have been launched in just the past five years as governments began to recognise that some start-ups, such as Tesla, were accelerating the pace of energy transition, but that this important technology area has otherwise been struggling to translate high-potential R&D into market transformation. Since most programme managers are currently building on experience to date to fine-tune initiatives and extend their impact, this is an opportune moment to highlight their choices for the benefit of governments facing similar decisions today.

[1] "Creative destruction" is the process by which industries undergo rapid and disruptive qualitative changes when new technologies, products or services are introduced. The previous economic structure (business cycle) is destroyed by adoption of the new one, which can cause incumbents to fail. Because radical new ideas often come from outside the dominant firms, established businesses are always either at risk of being upended by innovative start-ups (from which they may shield themselves through acquisition or anti-competition practices) or remain occupied in absorbing the results of their sector's last technological revolution. While individual start-ups have a high chance of failure that cannot be reliably predicted, in aggregate a portfolio of innovators with creative ideas has a high chance of sparking widespread change and redirecting capital to a new way of doing things.

This report focuses on government support for start-ups – young small and medium-sized enterprises (SMEs) – striving to bring novel clean energy technologies to market. Although these companies are generally less than seven years old and have not yet commercialised any profitable products or shared dividends with investors, they could provide part of the solution to the significant societal challenges we are facing.

Our definition of "clean energy technology" in this report is very broad, covering all elements of energy production, distribution and end use (including products and services that can help consumers avoid energy consumption in providing energy services). What start-ups in these technology areas have in common is that they are all developing products that can meet energy needs with a lower environmental impact, based on new approaches to hardware design, new scientific principles and advances in software. In general, technologies of interest are those compatible with energy systems that have net zero greenhouse gas emissions.

Likewise, we use the word "government" broadly. While most case studies are national or supranational, clean energy activities in some countries have a longer history at the state, provincial or municipal level. Among innovation-related policy measures, we generally limit our analysis to those that clearly aim to support clean energy start-ups, although we have also reviewed some initiatives that are broader in technology scope than clean energy, or for which larger companies are also eligible. While most policy measures cited in this study use evaluation or judging processes to offer support to selected groups of individual start-ups at the post-research stage, some mechanisms are available to all eligible start-ups or investors (e.g. tax relief).

Although broader, non-targeted frameworks such as competition policy, bankruptcy legislation and contract enforcement are not covered in this report, they are important factors in determining how successful a start-up will be in developing new technologies. In fact, a well-designed support policy for clean energy start-ups will never be sufficient on its own to meet innovation policy goals: the most successful regions address a wide range of innovation system needs. These needs vary widely between countries, and there is rapidly growing interest in clean energy innovation in emerging market and developing economies where resources to address them continue to be scarce compared with advanced economies.

Governments have a wide range of policy support choices

Using the measures reviewed in this report, policymakers aim to tackle ten gaps currently hindering public and private innovation:

Governments

1. Limited consideration of the specific needs of different clean energy technologies that can make generic support measures ineffectual.
2. Low awareness of the different pathways new technologies follow from laboratory to market, including the role of start-ups, the barriers they face and their disruptive impacts.

Investors and incubators

3. Continued lack of investor attention to the innovators' need for longer timelines to perfect new technologies as well as for ongoing policy support to address urgent developmental and environmental challenges – despite a recent upsurge of investment in some clean energy technology areas.
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5. Perceived excessive risk on the part of high-potential inventors (especially from certain social groups underrepresented among business founders), which makes them hesitant to launch new technology businesses.
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To address these challenges, governments can extend support to start-ups in a variety of ways adapted to their energy, innovation and other policy objectives as

well as regional market deficiencies. When designing specific measures, policy makers should ask:

- Is there a financing gap that can be closed by public funds catalysing private capital?
- Is the market undersupplying a specific type of technology or entrepreneur, such as female founders?
- Is there a lack of connectivity and co-ordination between innovators and investors?
- Is more publicity and awareness-raising needed to raise the confidence of high-potential innovators?
- Who is best placed to channel public resources: a government agency or a third party?
- Which technology readiness levels (TRLs) should be targeted to meet the policy goal and what are the TRL-specific requirements?
- Can any existing public resources such as research scientists and laboratories be mobilised to fill gaps in the innovation system?
- Could the region – and the world – benefit from extending the policy measure to overseas start-ups and, if so, should support be conditional on the location of the start-up's subsequent business activities?
- Can the chosen instrument make a significant difference given the amount of public funding available?

The answers to these questions, combined with the local and institutional context, will determine how governments could provide assistance to start-ups. In general, however, support falls into four categories: financing; infrastructure; services; and networking. Initiatives are often similar in the types of support they provide in each category, but programmatic packages can employ various combinations. Furthermore, policy measures can provide support directly or indirectly. Direct support is provided by a government body to start-ups without intermediaries, whereas indirect support is delivered by funding intermediaries such as private incubators or funds. Governments often have to choose between direct and indirect support, and this report illustrates how the two options can lead to qualitatively different outcomes.

Types of support governments provide to clean energy technology start-ups

Type of support	How support is provided	
	Direct (by government-owned entities)	**Indirect (via third parties)**
Financing	Non-dilutive: • grants to consortiums via calls • grants to solo recipients via calls • grants via prizes • loans and loan guarantees	Non-dilutive: • grants • grants via prizes
	Dilutive: • angel and seed equity investments	Dilutive: • angel and seed equity investments
Infrastructure	• access to public laboratories and research expertise • equipment procurement • access to government-provided office space	• access to real-world testing environments • access to private laboratories and research expertise • access to office space
Services	• business services (including help to assemble a management team, improve pitches to investors, formulate a financial structure and recruit staff; legal advice; and intellectual property and business strategy assistance) • technical expertise • validation and public recognition	
Networking	• peer-to-peer • investors and potential customers • suppliers and other entities in the value chain • policy connections • international connections	

How this report is structured

Following this introduction, Chapter 2 sets out the reasons for government interest in the clean energy start-up policy area and the breadth of choices available. Chapters 3 to 6 present the design decisions made for existing policy measures according to the four areas of support (financing, infrastructure, services and networking). These chapters draw their information from 14 case studies representing diverse policy features, geographies, national contexts and lengths of experience (hyperlinks lead to case study summaries). Finally, Chapter 7 outlines the qualitative insights gained from analysing this non-exhaustive sample.

Case studies were selected based on recommendations and desk research in early 2021 and are chronicled separately in a set of summary documents accompanying this report. We conducted 22 interviews in mid-2021 with responsible government officials, programme operators and start-up support recipients. While interviewees and other contributors of written material have had the opportunity to review the material, any interpretation or presentation errors are the authors' own.

Selected case studies

Country	Programme	Summary
Canada	Women in Cleantech Challenge	A three-year programme of incubation and unconditional funding for six finalists, culminating in a large cash prize to encourage and promote early-stage female clean energy entrepreneurs
Chile	Start-Up Chile	Incubation for Chilean and international high-potential start-ups, with some energy-related calls for applicants.
European Union	EIT InnoEnergy Highway®	Funding for a private entity to provide acceleration support to international clean energy technology developers who could address EU objectives. Highway includes in-house services and access to a global network of stakeholders, and the programme operator co-funds it by taking equity stakes and securing in-kind support from partners.
Germany	Start Up Energy Transition	Cash prize, global publicity and stakeholder dialogues for clean energy start-ups from around the world with at least a prototype
India	Technology Business Incubators	Funding for accredited private incubators to select and support Indian start-ups in their areas of expertise, including via grant and equity financing.
	Clean Energy International Incubation Centre	Incubation for start-ups from around the world responding to identified Indian clean energy challenges
Morocco	Green Innoboost	Incubation for Moroccan clean energy innovators trying to move from the laboratory to having a viable company and tested product on the market
Norway	Innovation Norway	Grants and loans for technology developers to establish businesses, execute technology projects and undertake global market research
Singapore	EcoLabs-COI	Business support and access to real-world testing for clean energy start-ups looking for international markets
Sweden	Swedish Energy Agency grants programmes	Grant funding for projects to guide energy innovators to the next level of maturity

Country	Programme	Summary
United Kingdom	Energy Systems Catapult Living Lab	Facilitating real-world consumer feedback and data to help innovators in smart energy-efficient technologies reach market quicker
United States	American-Made Challenges	Cash grants and public laboratory access for prize winners in defined clean energy technology areas
	Incubatenergy Network	Connects incubators and others to help energy start-ups to progress through the right types of support
	Innovation Incubator (IN^2)	Helps clean energy hardware start-ups to access expertise and precision technology testing and refinement at public laboratories.

Some useful definitions

This report intersects the worlds of energy technology analysis and venture investment, both of which use professional jargon that makes clear communication between them difficult. Our Glossary provides useful definitions.

Chapter 2. Six reasons governments support clean energy start-ups

Government support for start-ups, including sector-specific support, is not new, but targeting clean energy start-ups is a relatively recent phenomenon. A number of factors initiated this trend, including greater ambition by some of the world's largest economies to transition to clean energy, and higher expectations for new market entrants to disrupt markets, redirecting them towards more sustainable products. In addition to policy support, this trend to support clean energy start-ups is also manifest in the larger number of incubators and accelerators that focus on clean energy solutions at universities and in the private sector, as well as in dedicated venture capital funds and stakeholder networks.

1. Without more innovation, energy and climate goals will be out of reach

There is wide agreement that meeting the climate challenge will depend on accelerating clean energy technology innovation, as the energy sector is the source of around three-quarters of global greenhouse gas emissions. However, rising demand for energy services is inseparable from a growing global population with aspirations for a better quality of life.

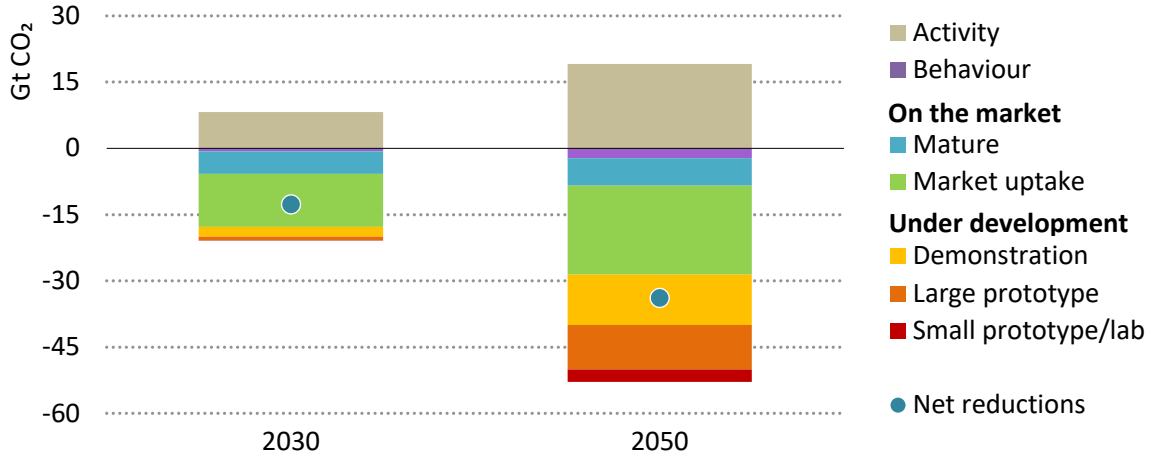
Almost half of the emissions the world needs to avoid to achieve net zero emissions by 2050 cannot be tackled with technologies on the market today. Rather, cutting these emissions will require technologies that are still at the demonstration or prototype stage, mostly in sectors such as heavy industry and long-distance transport. Even in other sectors, however, it is difficult to imagine low-carbon energy penetrating all corners of the global economy without continued performance improvements, cost reductions and adaptation to diverse local contexts.

This concerns the use of renewable energy in new applications, for instance in industry, heating and transport, and for enabling technologies that connect energy supplies to end uses, such as batteries, grids and hydrogen technologies. Despite some encouraging signs in the past three years, patenting activity in low-carbon energy technologies has largely plateaued since 2013 instead of resuming the rapid growth rate of earlier this century.

One oft-overlooked challenge is the development of affordable high-quality technologies appropriate for companies and individuals in emerging market and

developing economies. In the IEA Net Zero Emissions by 2050 Scenario, more than 40% of global energy investment is in these countries, and many clean energy technologies also promise the added benefits of reducing air pollution and enlarging energy access.

Global CO_2 emissions changes by technology maturity category in the Net Zero Emissions Scenario



Source: IEA (2021), Net Zero by 2050.

2. Energy innovation is expanding thanks to start-ups

Much past energy innovation originated from large companies that benefit from considerable market power. These companies, mostly in energy supply sectors but also in industry and transport, operate sizeable research facilities and control extensive infrastructure and markets for deploying new technologies. This innovation model was attractive because it offered the economies of scale and precision engineering necessary to develop and market nuclear energy, fuel processing and combustion technologies; entrepreneurial start-up firms have therefore played a smaller role historically.

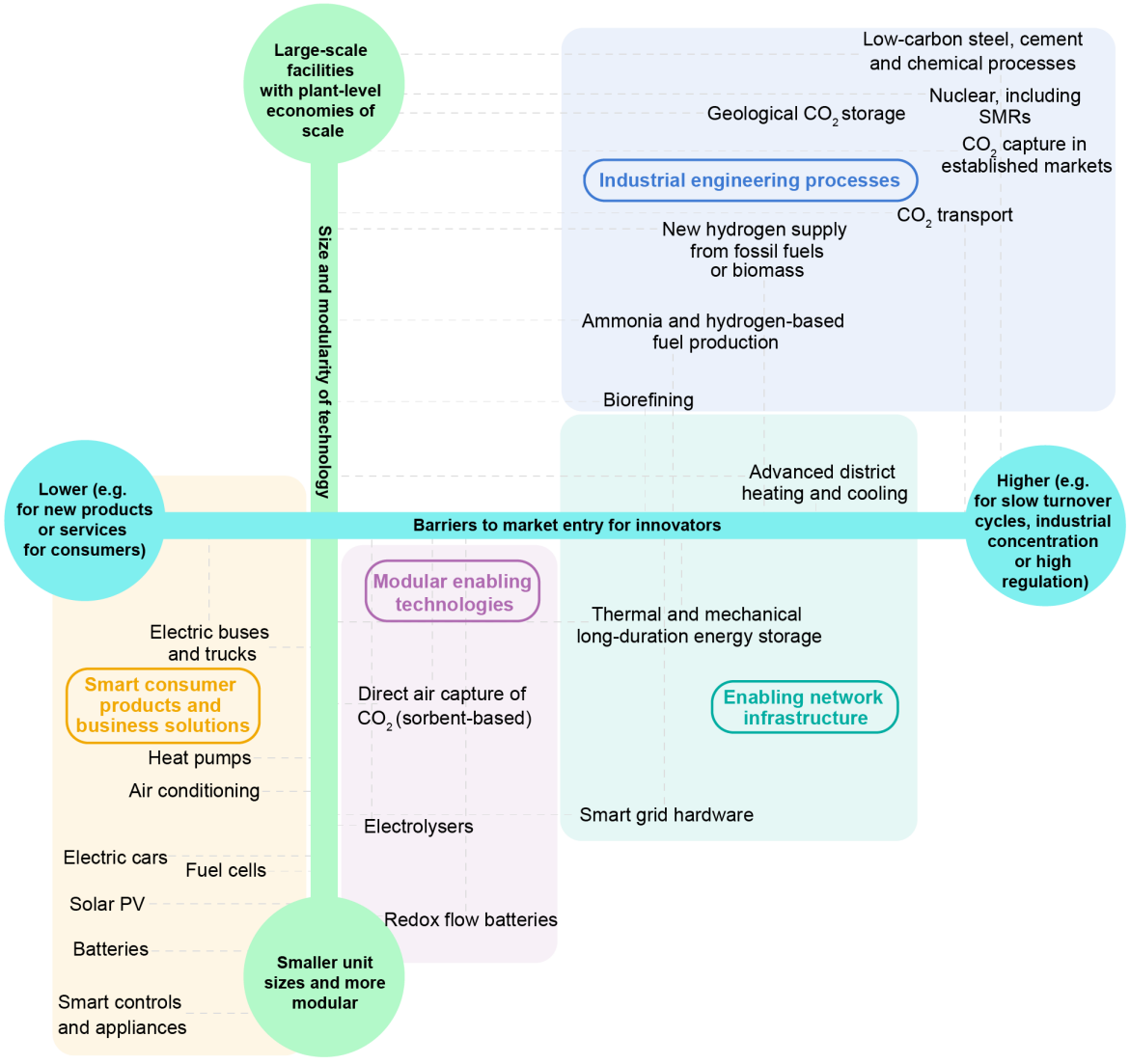
However, with regulations leading to market decentralisation and greater attention being paid to environmental performance, the scope of energy innovation has broadened. A wider range of energy sources, smaller-scale technologies and their associated energy system challenges have now become mainstream.

Technologies that have a small unit size, replacement cycles of less than 20 years and high levels of standardisation, modularity and mass production (e.g. solar photovoltaics and batteries) are increasingly present in numerous areas of the energy system. In terms of packaging for end users, they lend themselves to greater product differentiation (i.e. they can be branded according to their distinct characteristics) and are generally unsuited to vertical value chain

integration and horizontal monopoly ownership. Barriers to market entry for start-ups also tend to be lower for these technologies.

Furthermore, since energy technologies increasingly rely on digital and "deep-tech"[1] advances, fast-growing start-ups are playing more important roles. But regardless of the technology, healthy conditions for start-ups tend to spark new ideas and facilitate the transfer of solutions to new applications and societal challenges.

Low-carbon energy technologies by unit size and modularity vs market entry barriers



Note: SMR = small modular reactor.

Source: IEA (2021), An energy sector roadmap to carbon neutrality in China. Adapted from IEA (2020), Energy Technology Perspectives: Special report on clean energy innovation; Malhotra and Schmidt (2020), Accelerating Low-Carbon Innovation; Schmidt and Huenteler (2016), Anticipating industry localization effects of clean technology deployment policies in developing countries.

[1] Deep tech refers to applying advances in basic science areas to engineering and societal challenges to generate new classes of solutions to improve existing technologies, outside the scope of more incremental R&D. Advanced materials, advanced manufacturing, artificial intelligence, biotechnology, blockchain, robotics, photonics and quantum computing are all typically considered deep tech fields.

The policy imperative to accelerate energy transitions means that governments must take an increased interest in start-ups. Large incumbent firms typically prefer incremental innovation that realigns their existing practices with market trends to the greatest extent possible. This results not so much from a philosophical outlook as from the reality of needing to account for the net present value of existing assets, skills and political alliances.

Conversely, start-ups carry more risk, with investors taking a portfolio approach to bet on possibly high future returns and having greater tolerance for failure than corporate shareholders do. Nevertheless, large corporations continue to be very important in getting new technologies to market, acting as innovators, customers, investors in start-ups and acquirers of start-ups. Corporate venture capital investments in energy technology start-ups have been rising since 2018, amounting to over USD 5 billion in 2020.

3. Energy technology companies are underfunded by private capital

Clean energy technologies are not always well suited to the prevailing venture capital model, which emerged primarily to support information technology start-ups. There is a mismatch between the short time horizons of most venture capital funds (which promise to return capital to investors in around five years) and the longer timelines and large upfront investments needed by developers, particularly of energy hardware. Furthermore, energy technology developers must often overcome many technical, commercial and regulatory hurdles to become sustainable businesses.

One of these obstacles is the lengthy process of creating and implementing the essential government market-creation policies that most of these start-ups will eventually rely on to attract customers. Moreover, since the cleantech bust of around 2011, when investors in early-stage clean energy start-ups lost money because of these mismatches, many venture capital funds have focused on asset-light business models in the energy sector, leaving hardware developers with fewer options for raising capital.

4. Nurturing start-ups to maturity creates local economic prosperity

Economic renewal and growth are usually core policy objectives of government support for energy innovation. Governments (including local ones) therefore aim to help the originators of new technological ideas (who have often benefited from public grants) expand their business to a critical mass of operations in the region. Before attaining this critical mass, a limited number of jobs are typically created for well-educated R&D engineers and business developers. At this stage, there is

a risk of investors moving their start-ups out of the region, for example to be closer to an investor's own ecosystems or to where innovation support is already strong.

Only after the critical mass is reached and sales begin to scale up does the community begin to benefit from employment opportunities in manufacturing, sales and after-sales service. At this stage, start-up owners are more likely to let companies grow where they are, or even make them into strategic divisions of global operations, instead of relocating activities and key people. In addition to offering direct support to individual entrepreneurs, successful regions cultivate a variety of local attributes to create innovation ecosystems that are competitive in their technology areas.

In the clean energy domain, many governments seek inspiration in the success stories of BYD, Northvolt, Plug Power, Tesla and, further back, Vestas. Ten years after its founding in California in 2003, Tesla's Fremont factory in that state was employing 3 000 people. On the other side of the Atlantic, it has been estimated that Denmark's early leadership in wind energy in the 1980s, through innovative technology firms such as Vestas, has created a local ecosystem that supports 9 000 jobs in Denmark for every 1 GW of offshore wind capacity installed in the European Union.

However, the balance between maintaining both domestic innovation support policies and competitive international markets is often delicate. This balance, which is a focus area of the Global Commission on People-Centred Clean Energy Transitions, can be fostered by stronger international co-operation to address social objectives such as equity, inclusion and gender equality.

5. Clean energy transitions will be a major market opportunity for all countries, all century long

Achieving net zero emissions will require an unparalleled increase in clean energy investment. In fact, the IEA Net Zero Emissions Scenario indicates that annual investments in clean energy must more than triple to USD 4 trillion by 2030. Although mobilising such a considerable sum will be challenging, this investment will not only ensure clean energy transitions but also offer unprecedented market opportunities for equipment manufacturers, service providers and developers, as well as engineering, procurement and construction companies along the entire clean energy supply chain.

Indeed, the markets for wind turbines, solar panels, lithium-ion batteries, electrolysers and fuel cells combined represent a cumulative (i.e. up to 2050) market opportunity of USD 27 trillion. In the Net Zero Emissions Scenario, the Asia Pacific region is home to 45% of the estimated market for clean energy technologies up to 2050. This is a momentous opportunity for the best innovators from all over the world to become part of emerging value chains that have

enormous future potential. However, some innovators in emerging market and developing economies will have to overcome or reshape the existing networks of knowledge and capital that have led technology developments in the past.

For start-ups working on clean energy technologies, welcome attention from sustainability-oriented investors and customers will also entail pressure to meet certain criteria. Increasingly, capital allocations to energy companies and projects involve scrutiny for compatibility with environmental, social and governance (ESG) goals. Start-ups may be well positioned to meet this growing demand for ESG-aligned equity, products and services, and opportunities to partner with established firms that need to address their emissions profile will expand further in upcoming years. However, as young companies have only limited resources to measure and document their performance to the required standards, targeted tools or support may be needed to prevent this from becoming an additional barrier to market entry. (Chapter 7 contains more information on estimating the potential emissions impacts of start-ups.)

6. Clean energy entrepreneurship emerged as an economic recovery opportunity during the Covid-19 pandemic

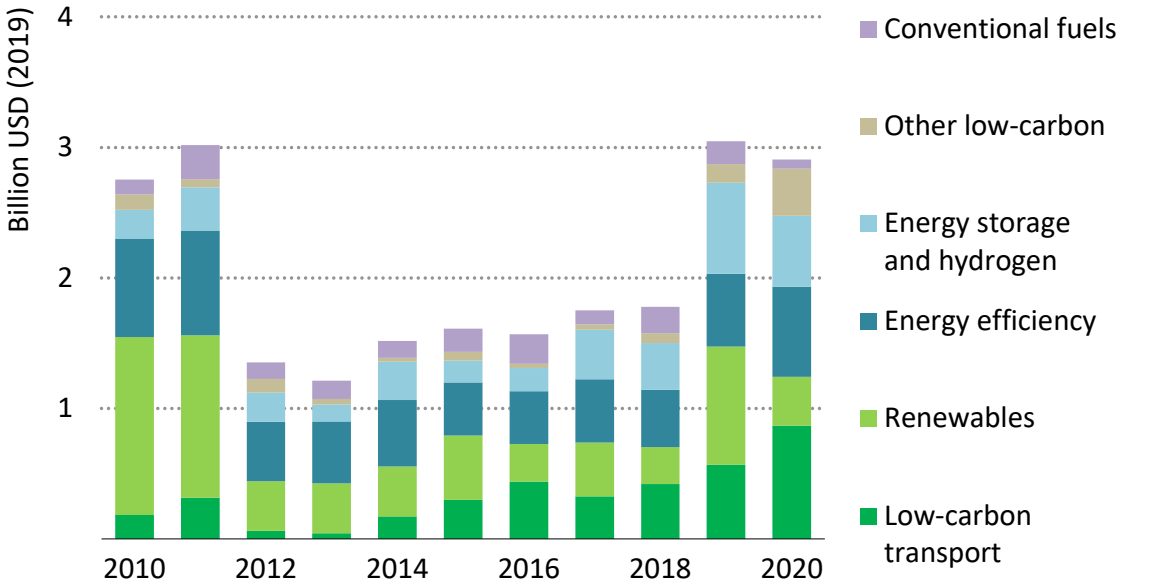
The lockdowns and slowdowns in economic activity accompanying the Covid-19 pandemic have hit SMEs particularly hard. Small firms have insufficient capital buffers, with start-ups often surviving by raising small amounts of financing at frequent intervals. In early 2020, a number of governments extended bridging capital to start-ups in this position to avoid losing high-potential companies and their knowledge. This action also reflects the philosophy that economic recovery can be stimulated by investing in fledgling companies that could seed local economic growth. Since mid-2020, government plans have included investments in clean energy technology areas that aim to redirect and sustain recovery over the longer term.

In parallel, clean energy venture capital investments have not contracted and have become more evenly distributed internationally. Investors are increasingly convinced that energy transitions are happening, and that they will be underpinned in the near term by proactive government recovery policies and robust corporate demand. Compared with traditional sectors, investors are attracted to the higher return potential of technology companies. However, most venture capital and private equity capital targets companies that already have products to demonstrate and sell (TRL 8-9), meaning that only a relatively small portion of the sizeable capital available to invest in sustainable innovation-led recovery is being allocated to early-stage start-ups looking for investment.

While company valuations have risen in the past year and several high-profile recent start-ups have been listed on stock exchanges despite not yet being profitable, the sustainability of this momentum is uncertain. Governments could fortify their role as supporters of pre-commercial technology ideas through R&D funding and could also help any resulting early-stage companies quickly become attractive to venture capital and private equity investors. Governments may also need to look ahead to the possibility that, depending on how the economy evolves, the follow-on funding rounds of some start-ups securing large capital investments today may be smaller, slowing their growth and harming investor perception of the sector.

While virtual working environments have generally helped internationalise the matching of funds with start-ups, this may exacerbate challenges for governments seeking to establish manufacturing and hardware centres in their regions. Governments can work with innovators and investors to identify how to reconcile this conflict, including through R&D funding, support to start-ups and regulatory changes. As venture investment in clean energy spreads around the world, more regions will have the chance to participate and compete with the United States, which has been the primary source and destination of early-stage private capital. This could raise the overall pace of innovative activity, to the benefit of all.

Global early-stage venture capital investments in energy technology start-ups



Notes: Includes seed, Series A and Series B financing deals. Outlier deals of more than USD 150 million that distort the year-on-year trend are excluded from the deal value; they totalled USD 4.1 billion in 2010, USD 2.2 billion in 2016, USD 850 million in 2017, USD 4.7 billion in 2018, USD 990 million in 2019 and USD 340 million in 2020. "Low-carbon transport" includes alternative powertrains and their infrastructure, among other technologies, but not shared mobility, logistics or autonomous vehicle technology unless specifically designed for the electric mobility market. Within "Renewables", bioenergy includes transport biofuels but not biochemicals. "Other low-carbon" pertains to CCUS and smart grids. "Conventional fuels" covers fossil fuel extraction and use, fossil fuel-based power generation, and conventional transport fuel economy.

Source: IEA (2021), World Energy Investment 2021. IEA calculations based on Cleantech Group (2021).

Chapter 3. Financing

Case studies in this chapter	Grants via calls	Unrestricted grants via prizes	Loans and loan guarantees	Angel and seed equity investments
American-Made Challenges		Direct		
Clean Energy International Incubation Centre				Indirect
EcoLabs-COI		Indirect		
EIT InnoEnergy Highway	Indirect			Indirect
Green Innoboost	Direct			Direct
Innovation Norway	Direct		Direct	
Start Up Energy Transition		Direct		
Technology Business Incubators				Indirect
Women in Cleantech Challenge	Direct	Direct		
Non-case study initiatives in this chapter	Breakthrough Energy Solutions Canada; NEOTEC	EIT Climate-KIC Climate Launchpad	European Investment Bank; US Department of Energy's Loans Programme Office	Breakthrough Energy Europe Fund; China's MOST National Guiding Fund for the Conversion of Scientific and Technological Research; ENERGIIQ; European Innovation Council Fund; European Innovation Fund; Italian Start-up Act; Sitra Renewable Energy Venture Capital Fund Spanish Start-up Act

Young technology companies nearly always need more capital. At their launch, they often function on savings or funding from friends and family. At this stage (no more than TRL 3), fast access to government grants could help extend the company's viability from a matter of months to a year or more. Depending on the rules associated with grants, they can allow business founders to build prototypes, recruit staff, access test equipment, undertake market research, attend conferences and buy business services – or simply pay bills.

Most start-up founders prefer not to sell equity (through dilutive funding) if possible, as it can reduce future earning potential. This tendency depends on the region, however, with European start-ups being generally more averse to dilutive financing than those in the United States. While governments typically do not claim ownership shares, it is common for incubators to take equity in exchange for providing capital or services, given the risks involved and the inability of most start-ups to cover incubation costs upfront.

As a company grows, it requires more capital to pay for office space, build prototypes, secure procurement contracts and obtain many other necessities, including eventual production capacity. During a company's later stages of development (TRL 4 to TRL 9), the sources of financing are more varied and government support is more likely to be paired with private capital, with the government either acting as an initial investor to reduce risk perception or co-funding a specific project with a potential customer. In some countries, public grants are available for limited tasks, such as exploring overseas markets or buying equipment. It is rare for governments to provide concessional debt[1] to energy start-ups, but it is not unprecedented.

Government programmes also differ in how recipients apply for funding and how funders evaluate them, with prize-based initiatives sometimes resulting in large grants several years after application and other funds being disbursed within weeks or months, in line with the capital needs of a small and growing firm.

The choices governments make in this area constitute some of the greatest policy differences among our case studies. Variations generally reflect the needs of the targeted companies at the stage of maturity that fits the policy objective. However, in some cases they also reflect legal or budgetary constraints, familiarity with existing R&D funding processes or an attempt to maximise the impact of a limited fund. An example of the latter is Germany's SET Award grants, which are relatively small but generate considerable publicity, recognition and networking. The non-financial benefits of the grant award process are often the primary attractions for many SET Award applicants each year. In some cases, policy differences are related to administrative design, such as whether start-ups are allowed to apply at any time.

The following subsections introduce the various types of government financial support for start-ups, with examples from the case studies and other relevant sources, starting with non-dilutive public grants awarded through calls and prizes, and moving on to dilutive angel and seed equity investments. Each section distinguishes between financing provided directly by governments and indirectly through intermediaries such as incubators and venture capital funds.

[1] Loans with interest below market rates.

Processes by which governments make support available and allocate it

Governments make most financing available using "call windows" to solicit applications during a fixed time frame, and then select from among them through internal and external expert evaluations. While some calls are open only once a year for a couple of months, this arrangement does not suit early-stage technology companies that are often very close to their next funding crisis, moving from one short-term source of capital to another. Some governments have therefore tailored their grant application model to the specific needs of start-ups, using permanently open calls to which applications can be made at any time, and they try to shorten evaluation times.

For instance, Swedish Energy Agency grants follow a pattern of annual formal calls, but start-ups can also approach the Agency outside of the call window if they have an immediate requirement. The main relevant grants are in three areas, each reflecting a different stage of technology readiness and business maturity: "concept development"; "verification of customers"; and "pilot and demonstration project". Grant calls for concept development were previously open all the time, but they now also follow the annual pattern. India's Clean Energy International Incubation Centre also runs annual calls for proposals.

Meanwhile, Innovation Norway's call for interest is permanently open, allowing start-ups to enter the Innovation Norway system at any time. Once a start-up is registered, an account manager evaluates the fit between its needs and the services Innovation Norway can provide, including connections to external incubators, market research, grants and loans. Alongside Innovation Norway, ENOVA, the state enterprise for funding climate change solutions, also uses permanently open calls for its three initiatives to support nascent technology projects (not necessarily involving start-ups, however).

Energy Systems Catapult Living Lab in the United Kingdom and EIT InnoEnergy Highway also welcome approaches from innovators at any time, and Enterprise Singapore has a permanently open call for applications from early-stage companies looking for SGD 250 000-400 000 (USD 190 000-300 000).

The Wells Fargo Innovation Incubator (IN^2) programme, managed by the National Renewable Energy Laboratory (NREL) in the United States since 2014, takes a different approach. IN^2 receives its funds through donation from a private foundation, which allows IN^2 to use a more flexible and nimble contracting approach at NREL. To attract the start-ups that best match IN^2 objectives and resources, NREL canvases referrals from 60 "channel partners" made up of incubators, accelerators and university programmes across selected energy areas, then conducts detailed expert reviews of potential recipients. This approach reduces the cost and time associated with advertising, evaluating calls and sourcing high-quality awardees.

Grants via calls

The most common way governments provide capital to clean energy technology start-ups is through grants. Public grants transfer public capital to a recipient, either directly from a government entity or indirectly through a third party such as an incubator that manages the selection of grantees and disbursement. The expenditures for which recipients can use grant money are usually ringfenced, with the scope of eligible costs normally determined by public spending rules and the recipient's application for funding. Grant awardees are commonly subject to a reporting process in which they must demonstrate compliance with the spending scope and, in many cases, report the outcomes of work undertaken. Furthermore, grants sometimes include clawback clauses that protect taxpayers by allowing public funds to be reclaimed in the case of non-compliance. While grants appear to be a straightforward policy tool, government approaches to their use vary widely.

Direct approaches

Grants transferred directly to start-ups from a government entity can differ in some key features: who can apply; which expenditures are eligible; how start-ups' solvency risks are managed; and how the start-up grant interacts with other public grant programmes.

Who can apply: Consortiums or individual companies?

There is a divide around the world between government grant programmes that solicit applications from individual entities and those that require start-ups to apply as part of a consortium. The main argument in favour of consortium-based funding is that having an established industrial company in the consortium (representing a potential future customer and providing a testing environment) validates the start-up's promise. In addition, consortium partners are generally required to supplement government grants with co-funding to minimise the taxpayer share, something that is usually not possible for start-ups alone with more limited means.

However, consortium-based grants are usually available for technology development or test projects only, so start-ups cannot use the funds for pressing business needs. This can make consortium grants inappropriate for very early-stage companies, especially those that have not yet developed an intellectual property management strategy.

Therefore, in Denmark the twice-yearly calls of the Energy Technology Development and Demonstration Program (EUDP) allow applications from individual companies as well as consortiums to support TRL 4 to TRL 6

technologies. While they do not specifically target start-ups, SMEs (including start-ups and universities) are eligible.

Also in Scandinavia, individual applicants can apply for Swedish Energy Agency grants for concept development as well as piloting and demonstration. Concept development grants are smaller, at up to SEK 300 000 (USD 33 000), while those for pilots and demonstration projects are EUR 7 million (USD 770 000) or more. As is common in Europe, where EU state aid rules apply, start-ups are eligible to receive a higher share of total project costs from the government than larger companies are (45% for SMEs, compared with 25% for large enterprises). In contrast, ”verification of customers” grants, which start-ups can use to develop a technology prototype that meets a specific user’s requirements, are only for consortiums that include a potential customer, with the more established industrial partner investing at least 55% of total eligible costs and the government covering up to SEK 3 million (USD 330 000).

Most other grant programmes for which start-ups are eligible require consortiums and are restricted to precisely defined technology development projects. For example, Innovation Norway Innovation Contracts cover up to 45% of eligible costs of SMEs (as per EU state aid rules), and occasionally up to 50% for a start-up. Green Innoboost, the main IRESEN programme for start-ups in Morocco, also requires a consortium approach. At least one partner must be a Moroccan scientific institute or university, and inclusion of a Moroccan industrial partner is encouraged.

However, some government initiatives will help start-ups find potential consortium partners with whom they can apply for grants, including Green Innoboost in Morocco and the Swedish Energy Agency, which funds Ignite Sweden, provider of a network through which start-ups can identify potential partners.

Which expenditures are eligible: Unrestricted vs narrow focus

Governments usually restrict how, and on what, grant money can be spent. For instance, grants can often be used for technological but not business development. This applies especially to consortium-based grant programmes, which generally target pre-defined technology projects. In some cases, business development expenditures are ineligible for reasons related to state aid regulations, as allowing some companies to use grant funding for business development could give them an unfair advantage that could distort competition and trade in their favour.

State aid is a prominent concern among EU governments and their trading partners. There are state aid exemptions for R&D that would otherwise not be carried out without state support, and EU rules classify R&D according to company size and type of research (e.g. fundamental R&D, industry R&D and precompetitive R&D). Up to 70% of the costs of industrial research, or 45% of

experimental development projects, may be covered for small companies, but in some cases recipients must pay back the funds (especially guarantees and loans) if the project is a success. SMEs are also eligible for post-R&D aid, but only for up to 50% of innovation costs and 20% of investment costs. Consequently, policy measures supporting energy technology start-ups in the European Union often closely follow the modalities of R&D funding programmes previously approved under state aid rules. These programmes generally require consortium-based applications for narrowly defined technology projects.

Some grant-based programmes include a wider range of expenditures in their scope. For instance, in 2018 Canada's Women in Cleantech Challenge awarded annual grants of CAD 115 000 (USD 90 000) to its six finalists in the form of a stipend for three years.[2] Recipients were allowed to spend this stipend however they deemed most valuable, and they used it to cover living expenses, business services, debt, equipment, staff and travel. The goal of the Women in Cleantech Challenge was to help leading female entrepreneurs develop their technologies and businesses, and was one of the Impact Canada Cleantech Initiative's six Cleantech Impact Challenges. In addition to supporting the six finalists over three years, in 2021 the grand prize winner received a grant of CAD 1 million (USD 800 000) for unrestricted use. The six finalists also each received access to business incubation support worth CAD 300 000 (USD 235 000) and to federal government research expertise and facilities worth up to CAD 250 000 (USD 200 000) without co-funding requirements.

In Morocco, grants awarded under the Green Innoboost programme have a more broadly defined scope than most. Start-ups can elect to receive the MAD 1.5 million (USD 160 000) financial support as a grant (rather than as equity) for buying, testing and prototyping equipment, recruiting new team members, travelling internationally and attending conferences or engaging external advisers and business services. The condition for start-ups to receive non-dilutive financing is that they must pay royalties to IRESEN worth 1.5% of any annual revenues gained from the resulting innovation, starting three years from their first recorded revenues and for an indefinite period.

However, start-ups report that limitations on eligible costs under grant programmes can leave companies without funding for business services such as intellectual property advice, market research and legal services. As many clean energy start-ups require more tailored services than those offered by many standard incubator and accelerator packages, Natural Resources Canada launched the Breakthrough Energy Solutions Canada initiative one year after the Women in Cleantech Challenge and included intellectual property support among

[2] Cyclotron Road, a division of Lawrence Berkeley National Laboratory, inspired the stipend model.

its eligible project expenses. Some other policy initiatives, such as Innovation Norway, address this issue by offering some of these support elements separate from grant financing.

Accommodating the financial means and risks of start-ups

Funders view start-ups as inherently risky beneficiaries of capital. Early-stage companies are usually never far from exhausting their funds – a fact that underpins the high-risk, high-return venture capital investment model. However, some governments have public spending rules that prevent the state from transferring grants to companies in financial difficulty. One outcome of this type of regulation is the preference for consortium-based grant programmes in many countries. Another outcome can be a need for applicants to secure bank guarantees before receiving funds, the costs of which can severely reduce the attractiveness of this type of funding.

Two initiatives that use a different method to navigate this tension are Green Innoboost in Morocco and India's Seed Support System. Grant recipients in these programmes gain access to a bank account established by a government agency, into which they deposit the funds. This helps the agency monitor the company's spending and recover unspent funds.

Meanwhile, in the United States the government-operated Advanced Research Projects Agency–Energy (ARPA-E) helps US-based companies realise R&D projects for potentially transformational technologies and offers favourable financing terms for small companies. Although ARPA-E funding is open to all businesses, small companies must cover a lower share of their project costs (10% rather than 20%) and none of their costs in the first year. ARPA-E offers this incentive because it recognises that start-ups are a likely avenue for the emergence of new ideas outside of traditional business patterns and that their financial means are limited.

ARPA-E helps US-based start-ups develop transformational technologies in underserved technology areas

ARPA-E's mandate is to provide funding for high-risk, high-reward research to accelerate technological advances that are too uncertain for industry to undertake on its own and that could lead to new and competitive ways of delivering energy services. The US Congress approved ARPA-E in 2007 and structured it like the Defense Advanced Research Projects Agency (DARPA), which is widely

considered a world leader in promoting radical new technology ideas. ARPA-E was first funded in 2009.

ARPA-E finances projects in technology areas selected for their critical importance to national energy goals and their inability to attract sufficient capital from other sources. It issues five to ten calls each year for new technology areas, producing 10-20 projects each time. In addition, to ensure that no promising areas are left unexplored, open calls every three years and "special project" portfolios can each result in 50-100 projects. Technology areas launched in 2020 and 2021 include: materials to make buildings carbon-negative; low-waste advanced nuclear; methane emissions reduction; synthetic biology for fuels and chemicals; flexible CCUS-equipped power plants; hydrokinetic turbines; and nuclear fusion breakthroughs.

Since 2009, ARPA-E has improved the availability of support for clean energy technology start-ups by introducing a portfolio approach to project funding, and preferential financial treatment for small companies. A favourable evaluation in 2017 found that ARPA-E had provided crucial early-stage funding and one-quarter of projects had received follow-on funding for technologies now poised to enter the commercial market.

ARPA-E applies its portfolio approach at the level of each individual technology area and aims to be inclusive of all high-potential ideas, even if they are at an early TRL. For new technology areas, external experts contribute to a structured scoping exercise, which generally includes a public request for information to gather as much input as possible and results in a recommendation on how to define the call for applicants in a way that will attract a range of solutions at different levels of maturity. Start-ups working in these areas have the opportunity to participate in a portfolio of projects and interact with more experienced developers working on similar problems.

ARPA-E accepts applications from solo applicants or consortiums, providing flexibility that most other funding programmes around the world do not. Solo applicants that are small businesses,[3] or consortiums in which small businesses perform more than 80% of the work, are required to cover only 10% of their total project costs (compared with at least 20% for larger businesses) and do not have to cover any costs in the first 12 months.

ARPA-E support for a project can include exploratory topics or SCALEUP grants, as well as tech-to-market services. For the latter, ARPA-E's Tech-to-Market Team helps companies formulate and carry out a plan to assess and advance the commercial viability of their technology; support also includes networking and

[3] The definition of small business varies by sector but is consistently well above the size normally considered to be an early-stage start-up. For turbine and motor manufacturers the maximum headcount is 1 500, for battery manufacturers it is 1 250 and for heating equipment manufacturers it is 150.

some business services. ARPA-E closely monitors its funding recipients until the end of the project (around three years) and then requests data on progress and impacts via surveys for a further five to ten years.

Co-ordination with other grant programmes

When governments have dedicated policies and programmes to support clean energy technology entrepreneurs, they are rarely the only source of government support available. Countries vary in the extent to which their different support programmes interact and co-ordinate with one another.

In Chile, for instance, the Chilean Economic Development Agency (Corfo) is a government organisation that offers innovation grants to start-ups. Corfo's flagship incubator programme, Start-Up Chile, is one of several initiatives that awards grants, and recipient start-ups can also engage with a variety of Corfo-supported entities, including companies, research centres, business incubators, venture capital funds and other Corfo initiatives. However, start-ups may receive a Corfo grant from only one of these sources.

Meanwhile, Enterprise Singapore is at the centre of an array of grants and other types of support available to technology start-ups. In Singapore, as successful early-stage companies scale up, it is common for them to accumulate multiple different Enterprise Singapore awards.

Enterprise Singapore: A range of grants helps energy start-ups hit global markets

Singapore's journey to become a globally significant technology developer has been relatively short. After boosting the fundamental R&D capacities of research institutes and universities, the government tasked SPRING Singapore (under the Government of Singapore's Ministry of Trade and Industry) with establishing funding programmes, incubators and accelerators to translate the research community's raised innovation potential into market products and economic returns.

Today, Enterprise Singapore is the government agency that champions enterprise development and aims to make Singapore an Asian hub for domestic and international start-ups. Notable successes to date have been mainly in the information and communications technology sector. However, after attracting

several major global information and communications technology companies to invest in R&D centres in Singapore, growth in enterprise-founding and foreign direct investment in the sector has slowed. Sustainability concerns and market opportunities have converged in the ambition to make Singapore a hub for clean energy start-ups, especially in the areas of electricity generation and electrification in Asia.

Enterprise Singapore manages a variety of grants suitable for various company maturity levels. Permanently open calls are used to solicit applications, and the grants reimburse eligible development costs.

- Enterprise Development Grants are available for SME business development projects and can cover up to 70% of costs. Projects can involve three areas: strengthening business foundations (e.g. sales and accounting); innovation and productivity (e.g. new growth areas, greater efficiency, automation and the adoption of other technologies); and market access (i.e. overseas expansion).
- Scale-up SG is a 12- to 18-month programme designed to help selected local companies with high growth potential scale up, including by developing a leadership team and succession strategy. Recipient start-ups can exchange knowledge with their peers and access Enterprise Singapore's expertise and networks, but they are required to fund 30% of their programme costs.
- Market Readiness Assistance Grants are designed to cover up to 70% of a company's costs to explore overseas markets (up to SGD 100 000 [USD 73 000] per company per new market). For example, these grants could cover market promotion and staffing costs to establish a new office.

Plus, in 2019 Enterprise Singapore launched EcoLabs-COI to provide additional assistance in the clean energy sector.

An example of an energy technology start-up that has benefited from multiple Enterprise Singapore grants is Evercomm, which has developed a proprietary artificial intelligence system to identify potential energy efficiency improvements for manufacturing companies. In addition to receiving an Enterprise Development Grant and a Market Readiness Assistance Grant and being accepted into Scale-up SG, Evercomm has also participated in trips organised by Enterprise Singapore to the People's Republic of China (hereafter "China"), Germany and Israel. The company was also accredited by Singapore's Infocomm Media Development Authority, which provided access to certain government tenders and free intellectual property consultancy.

Another Singaporean start-up, V-Flow Tech, a redox-flow battery manufacturer, also received an Enterprise Development Grant. It was complemented by a grant from Temasek Foundation, obtained through a call for sustainable technology projects and managed by Temasek, a state-owned enterprise. The pilot project

funded by the Temasek Foundation grant garnered interest from Japan and Australia, where V-Flow Tech now has operations.

Indirect approaches

Some governments provide funding to independent incubators and other entities, which in turn are responsible for selecting start-ups and issuing grants. In India, the Department for Science and Technology (DST) channels a monthly grant of INR 30 000 (USD 400) through Technology Business Incubator-accredited incubators as a stipend for individuals with a technology business idea. This Entrepreneur-in-Residence initiative targets recent graduates who might otherwise leave their idea undeveloped and take a more highly paid job elsewhere.

In the United States, CALSeed Ventures, managed by New Energy Nexus (a private not-for-profit entity) on behalf of the California Energy Commission, offers seed-stage grants for start-ups. Since the California Clean Energy Fund's launch as a publicly capitalised venture fund in 2004, the public-private partnership has overseen several generations of equity funding and grant programmes. It currently only disburses grants of up to USD 600 000.

Unrestricted grants via prizes

In recent years, prizes have become a more popular way to award grants to energy technology start-ups.[4] Prizes can be attractive for several reasons:

- They confer recognition and give a "stamp of approval" to finalists and winners, which attracts innovation applicants from outside the typical government grant recipient network (i.e. universities, research institutes and corporate R&D divisions).
- Some of the administrative requirements for governments are lower for prizes than for project-based grant calls. For example, detailed evaluations of project plans and audits of subsequent spending in relation to these plans are not necessary.
- Relatively small sums of taxpayer money can mobilise a large number of entries and attract a more diverse set of technology ideas, especially if applicants

[4] While these prizes are often similar to inducement prizes, they do not generally follow the same format. Inducement prizes, including the European Commission's Horizon Prizes and the privately organised XPRIZEs, reward the realisation of a defined and previously unachieved feat, thereby stimulating additional R&D and innovation. Most prizes for start-ups reward their potential to tackle future industrial challenges, as judged by experts in the field.

perceive the bureaucratic requirements to be lower and the publicity co-benefits to be higher than for other grants.

- Prizes generate considerable publicity and prestige for government, sponsors, finalists and winners, raising the profile of clean energy innovation and inspiring future applicants.
- Prize entries can help governments learn quickly and inexpensively about the range and quality of existing (or potential) start-ups in clean energy technology areas.
- Prize awards can often avoid the need for co-funding from the private sector while still conforming with state aide rules, making them attractive to start-ups that have meagre capital.

Direct approaches

Prizes that publicise contest finalists and the innovation ecosystem

For generating publicity, prizes can be far more effective than individual start-up grants – for the same total public budget. If the prize is not large, the value all finalists derive from the publicity can outweigh the cash worth of the prize for the winner, as connections with potential investors and the validation of business ideas can lead to much greater sources of financing. While the disbursement of all public funds must be rigorously evaluated, the expert judgement process can be lighter and speedier when prizes are smaller. Furthermore, well-publicised prizes can showcase the government's work with clean energy start-ups and promote the local clean energy innovation ecosystem in general.

Indeed, this rationale has also spurred numerous private sector organisations to sponsor prizes and awards with modest or no financial rewards for cleantech start-ups in recent years. The additional value of public prizes in this area rests on the credibility and access to key stakeholders they confer.

Germany's Energy Agency (Deutsche Energie-Agentur, known as "dena") has been granting the Start Up Energy Transition (SET) Award annually since 2017. It is a good example of how a relatively modest prize can produce extensive co-benefits in terms of publicity and inspiration, especially as it connects innovators with stakeholders in the venture capital, public and corporate sectors. Target applicants are early-stage energy technology start-ups that have a working prototype but need contacts and financing to become self-sustaining, given the inherent risks and time frames involved in hardware development. Networking opportunities and online publicity are available for the top 100 entrants, and the 15 finalists receive promotional videos and introductions to investors, customers

and policymakers. Winners in each technology category[5] are awarded publicity through the World Energy Council and its media partners, and up to EUR 10 000 (USD 11 000). Eligible entrants can be from anywhere in the world.

Meanwhile, Climate-KIC, an independent entity funded by the European Commission to support innovation to tackle climate change, runs ClimateLaunchpad, a prize with annual national and subsequent regional finals around the world, the winners of which compete in a global final. The global first prize is EUR 10 000 (USD 11 000), the runner-up receives EUR 5 000 (USD 6 000) and third place wins EUR 2 500 (USD 2 800).

Prizes that take winners to the next level of development

Larger prizes funded by public money usually require evaluations as rigorous as for grant calls. However, governments have some flexibility to integrate prize evaluation into the process of supporting a cohort of finalists. Due to the judging time and resources required, evaluations to award such prizes can take much longer than for calls for grants – in some cases several years – and the cost can be greater than the prize purse itself.

For example, in the Women in Cleantech Challenge, Natural Resources Canada partnered with MaRS Discovery District to offer support to female entrepreneurs, an underrepresented group in the science, engineering and clean energy areas. The Women in Cleantech Challenge ran for one prize cycle between 2018 and 2021 and awarded one grant of CAD 1 million (USD 800 000) to the winner at its conclusion. The programme provided significant support to six finalists over three years, during which time their businesses advanced and their progress was evaluated.

As much as being attracted by the final prize, applicants were interested in the annual stipend that would enable finalists to commit 100% of their time to their start-ups, the opportunity to collaborate with leading federal researchers and the incubation programme. In practice, finalists reported that the access to laboratories, development of the cohort of finalists, and the solidarity and business support they received through the incubation programme proved to be of greater value than the final cash prize. For the government, the investment in stipends and services to help women-led businesses and technologies grow made up more of the challenge's cost than the final grand prize.

[5] In 2021, dena selected five categories in line with government energy policy priorities: clean energy generation; demand-side innovation; energy distribution and storage; smart mobility and transportation; quality energy access and UN Sustainable Development Goal (SDG) 7.

In the United States, NREL has been overseeing the American-Made Challenges series of prizes since 2018, each focused on a technology priority identified by the Department of Energy (DOE). The first energy technology challenge was in solar manufacturing, and it built on the success of previous prizes for artificial intelligence. The programme's managers have found that innovators are attracted to their prize format because the entry requirements are lower than for traditional calls for public grants and loans (such as those available through the Small Business Innovation Research [SBIR] programme), which they perceive as being too bureaucratically costly for start-ups.

The size of the prize depends on the specific challenge and stage of the prize process. For example, the American-Made Solar Prize Round 4 had three contests, with unrestricted cash grants of USD 50 000 for 20 winners at the initial "ideation" stage, an additional USD 100 000 for the 10 start-ups that reached the prototyping stage and USD 500 000 for 2 winners at the final stage to perform pilot tests with an industrial partner. Winners at the second and third stages also received vouchers of USD 75 000 to access national laboratories and other qualified facilities for prototype development. Evaluation stringency and timelines grow in line with the prize level.

Indirect approaches

Similar to Germany's SET Award, PowerACE is a Singaporean prize that EcoLabs-COI has contributed to since its launch in 2018. The Sustainable Energy Association of Singapore (a not-for-profit business association) runs the prize, which targets international start-ups with energy technologies at TRL 3 or above. In 2020 there were 60 entrants from 25 countries, all required to have a Singaporean market focus. Twelve finalists receive one month of mentoring from financial and sectoral experts before pitching their start-up at the Asia Clean Energy Summit during Singapore International Energy Week. The winner of the PowerACE EcoLabs-COI Special Award receives a prize worth SGD 100 000 (USD 75 000) that covers one year of EcoLabs-COI support services and access to infrastructure. In 2021, PowerACE also included an SGD 13 000 (USD 10 000) Private Financing Advisory Network (PFAN) prize and an SGD 82 000 (USD 60 000) BloombergNEF prize.

Loans and loan guarantees

For start-ups that need capital to expand their business, loans are an attractive form of capital if the start-up either anticipates near-term revenue or does not want to be pressured by equity investors to "exit" by selling the company. Start-ups that might fall into this category are energy technology businesses with a

software-based product (especially if their product does not need time-consuming regulatory approval) and enterprises that simply wish to retain control over their route to profitability.

If a government wishes to ensure that local innovations develop and take root in a region, it may favour delaying the sale of the founders' ownership of a company to avoid the risk of the business being relocated by investors based elsewhere. A concessional loan from a government entity (at a lower interest rate than would be commercially available to an unproven and poorly capitalised company) might be even more attractive than a grant with associated spending constraints in some cases. However, carrying debt can make a start-up less attractive to future investors, who may need additional capital to pay off outstanding loans as part of the deal. Plus, the failure rates of early-stage start-ups pose a substantial risk for lenders. For these reasons, few governments offer loans to start-ups, but there are some concessional grants and loan guarantees that seek to mitigate these challenges. Trials of recoverable grants and forgivable loans to manage government costs and risks while minimising debt on start-ups balance sheets are a recent development.

Direct approaches

In recognition of the considerable amount of time it sometimes takes to secure grants, Innovation Norway is offering small quick-approval loans to start-ups. Unlike its grants, Innovation Norway's loans can be used to purchase business services, and these loans have long deduction periods adapted to the depreciation of purchased goods.

Meanwhile, the Swedish Energy Agency began using conditional loans as an early policy tool to support start-ups in 2006. The Agency allowed a grace period for repayment, and payback was not required if the project for which the start-up received the loan failed to help get the associated product to market. However, the payback mechanism triggered too early for some recipients, and the loans made their balance sheets less favourable. Sweden has since discontinued the loan programme in favour of grants.

Spain also shifted from providing loans to providing grants under its NEOTEC programme, which counts energy among its focus areas. Between 2002 and 2011, technology-based companies younger than four years old in any sector could apply to the Ministry of Science and Industry for NEOTEC loans of up to EUR 1 million (USD 1.1 million) and the debt would only have to be paid back once recipients generated revenue. However, this condition, combined with the relatively immature status of many recipients was found to be a poor fit with the timelines of start-ups and requirements of public financing. It has been updated

three times: in 2011, the conditionality of the loan repayment was replaced by eight identical annual payback instalments; since 2014, successful applicants have received grants for defined technological projects, which were up to EUR 250 000 (USD 280 000) in 2020; and, since 2017, the minimum company age has been reduced to three years old. In 2022, NEOTEC launched its first dedicated call for projects to establish new technology-based businesses led by women.

Like the Swedish Energy Agency model, the Israel Innovation Authority (IIA) does not require repayment of its loans unless the funded project is successful, and if royalties do happen to flow from the project or equipment funded by the loan, the IIA receives around 50% as loan repayment. This "conditional grant" does not appear as a liability on the books of the SME. Another repayment variation is an agreement that the government agency will convert a certain portion of the borrowed money to equity unless the owners purchase it (at a price of multiples of the company valuation) within a given time frame.

Loan guarantees, which offer insurance against losses and significantly reduce risks for borrowers while allowing them to keep the potential upside, have been used most prominently for SMEs in Chinese Taipei and the United States.[6] In the past decade, the US DOE Loans Programme Office has managed more than USD 30 billion of debt – including loan guarantees and conditional commitments to help project developers secure financing – across a variety of energy sectors.

The DOE office's mission is to facilitate debt financing for the commercial deployment of large-scale energy projects. Funding is project-based and generally appropriate for companies that have already secured later-stage venture capital rounds as well as a major customer, with loans ranging from USD 100 million to USD 5 billion. Meanwhile, European Investment Bank loans for clean energy R&D tend to be smaller, but their bankability and co-financing requirements generally put them out of reach for start-ups.

For start-ups wishing to expand globally, another source of debt finance is export credits, which can take the form of loans, guarantees, insurance products or purchase-order financing. Several countries have tailored solutions for start-ups that are generic rather than dedicated to clean energy, including France, India and the United States among others. However, the programmes in Norway and Sweden have a specific focus on clean energy,

[6] As the provider of the loan guarantee, the government receives a percentage (say 1%) of the loan's value, usually extended by a third party, in return for promising to pay back 50% to 80% of the outstanding value in the case of default.

Indirect approaches

India's Technology Business Incubator (TBI) programme channels funds to start-ups through accredited incubators responsible for applicant calls and their evaluation. These incubators can choose whether to provide the financing as debt or equity.

Angel and seed equity investments

Public capital is part of many venture capital funds around the world and, so far, these investments have had mixed success in their two aims of generating a return on taxpayer money and contributing to start-up advancement.[7] Some private funds

in which governments invest do not respond to government technology priorities, nor do they have a higher risk appetite or longer-term perspective than other venture funds.

Direct approaches

Funds managed directly by civil servants working for public bodies and dedicated to clean energy technologies are scarce, and direct government investment in individual companies is often discouraged due to political concerns about negative publicity in the event of losses as well as legal barriers related to state ownership in some countries. Nevertheless, some governments have pursued this approach in recent years, and other countries, such as Spain, have proposed using public finances, via tax breaks, for investors in clean energy start-ups.

The European Investment Bank participates in one such scheme: the Breakthrough Energy Ventures - Europe Fund (BEV-E). BEV-E, launched in 2019, received half of its EUR 100 million (USD 115 million) capitalisation from the European Commission and the other half from a private investment fund. It is jointly managed by the European Investment Bank and Breakthrough Energy Ventures, and its mission is to invest equity in a manner suited to the capital intensity and long timelines needed to develop energy technologies. In 2021, BEV-

[7]For more information see NBER (2020), *Government incentives for entrepreneurship*; Leleux, B. and B. Surlemont (2003), *Public versus private venture capital: seeding or crowding out? A pan-European analysis*; Cumming, D., S. Johan and J.G. MacIntosh (2017), *A drop in an empty pond: Canadian public policy towards venture capital*; Bertoni, F. and T. Tykvová (2015), *Does governmental venture capital spur invention and innovation? Evidence from young European biotech companies*; Fei Y. (2018), *Can Governments Foster the Development of Venture* Capital?; Owen, R., D. North and C. Mac An Bhaird (2019), *The role of government venture capital funds: Recent lessons from the U.K.* experience; Dahaj, A. S., B. P. Cozzarin, and K. Talebi (2018), *Revisiting the Canadian public policy towards venture capital: Crowding-out or displacement*.

E invested in its first two deals, one of which was EUR 3.4 million (USD 3.9 million) seed funding for the start-up Bloom Biorenewables.

Europe is home to another recent funding project of this type, partially focused on clean energy technology. The European Commission established the European Innovation Council (EIC) Fund in 2020 to make direct equity and quasi-equity investments in TRL 9 "European high-impact and deep-tech start-ups and scale-ups" accepted into the EIC Accelerator. Investments are between EUR 0.5 million (USD 0.6 million) and EUR 15 million (USD 17 million), up to 25% of the voting shares, and with a relatively long time horizon of 7-15 years. Funds come from the Horizon Europe budget and the project represents a new means of using the EU R&D framework programme, alongside its traditional focus on grants.

For TRL 5-8, the EIC Accelerator can also provide grant funding of up to EUR 2.5 million (USD 2.9 million) for development costs and coaching (in general, the equity investment is "blended" with grant funding), mentoring and networking. Start-ups can apply at any time, and the targeted response time is four weeks. In 2021, the EIC prioritised applicants with Green Deal innovations for economic recovery, as well as strategic digital and health technologies. As of November 2021, the EIC Fund had invested over EUR 500 million (USD 580 million) in 111 deals.

In 2011, the Australian Government announced AUD 100 million (USD 100 million) to establish the Renewable Energy Venture Capital Fund (REVC), and appointed a private fund manager who brought in an equal co-investment from Softbank China Venture Capital (SBCVC). The 13-year fund is restricted to investments in companies commercialising renewable energy technologies and overseen by the Australian Renewable Energy Agency (ARENA), which issued public calls for interest until the end of the investment period in 2019, by which time it had invested around AUD 80 million (USD 80 million) in 12 companies. ARENA reinvests any returns in its activities and, by 2020, a return of 4% had been made from sales of equity in two companies. While it had invested only around half of its committed capital by 2020, an evaluation found REVC had broadly met its objectives, especially in attracting private capital into its deals and in creating knowledge and innovation system spillovers. The evaluation notes that REVC portfolio companies struggled to grow into in international markets and that it had needed to manage certain misalignments between the objectives of public and private partners in the fund's management.

In 2021, Morocco's creatively designed Green Innoboost scheme was adjusted for its second call for proposals to let start-ups choose between applying for grant or equity financing of up to MAD 1.5 million (USD 160 000). If recipients select equity, they must yield a stake of up to 20% to IRESEN, which will use possible

future revenues to support clean energy innovation in Morocco. If applicants choose to receive the funding as a grant, they must pay royalties to IRESEN worth 1.5% of any annual revenue from the innovation supported by the grant the third year after collecting the first revenue and for an indefinite period.

In 2017, the Netherlands province of South Holland earmarked EUR 35 million (USD 40 million) for ENERGIIQ, a public clean energy venture capital fund that provides shares and loans. As is the case for other regional and national initiatives, the fund has an economic objective as well as an environmental one: it invests in equity of EUR 200 000 to EUR 4.3 million (USD 230 000 to USD 4.9 million) in start-ups with proven technologies that can demonstrate expected CO_2 reductions in South Holland or which have a head office, R&D or production location in the province. The investment is conditional on private investors joining the funding round with at least as much money, and it aims to complement other types of regional public funding, such as Rotterdam's Energietransitiefonds. There are currently nine companies in its portfolio.

Fiscal incentives for equity investors in start-ups

In December 2021, Spain proposed a draft Start-up Law that contains specific conditions for strategic sectors including energy technology. For example, while the law generally applies to innovative[8] start-ups that are up to five years old, in energy and other strategic sectors they can be seven years old, as clean energy technologies require more time to develop. This law, inspired by the EU Startup Nations Standard of Excellence (signed by 24 EU member states and Iceland in 2021), is expected to be passed in 2022 and includes fiscal incentives for equity investors as well as entrepreneurs.

- For equity investors: The maximum tax-deductible amount for investments in start-ups is being raised (from EUR 60 000 to EUR 100 000 per year), as is the deduction rate (from 30% to 50%).
- For start-ups: The corporate income tax rate is being reduced from 25% to 15% for the first four fiscal years after taxable income is first recorded, and the annual tax exemption on stock options is being raised from EUR 12 000 to EUR 50 000 (for start-ups that distribute shares or share units derived from call options).

Italy's 2012 Start-up Act does not target clean energy specifically but provides equity investors with a variety of tax breaks, a tax credit for hiring highly qualified

[8] As defined in criteria set out by the SME National Innovation Company, ENISA.

personnel, and an exemption from the duty to affix the compliance visa for compensation of VAT credit. These tax incentives are part of a broader policy package for start-ups that includes tailor-made labour laws, exemptions from certain incorporation fees, extension of terms for covering losses, fast-track access to SME funds, fast-fail bankruptcy procedures and a public guarantee system for bank credit.

Although not specifically dedicated to clean energy, Sitra, the Finnish Innovation Fund, is noteworthy for its focus on equity investing (among other tools). This independent foundation, which reports directly to the Finnish parliament and can make policy interventions without a government mandate, has placed the ecological reconstruction of society at the top of its list of five goals for 2021-2024.

Founded in 1967, Sitra became an independent body in 1991, and in 2019 was favourably evaluated as a leading international example of a national innovation agency. In addition to being a think tank and promoter of experiments and operating models, it invests in Finnish start-ups and other SMEs, mainly through venture capital funds. Committed to the ownership and development of portfolio companies for an average period of four to ten years, it is a longer-term investor than most venture capital funds. 12% of its portfolio is currently allocated to venture capital and private equity, with this capital coming from annual returns on capital investments of its initial government endowment. It does not provide grants or concessional financing, but works with VTT (a public research institute), Enterprise Finland and Business Finland (a public R&D funder). Sitra has been organising annual Cleantech Venture Days focused on clean energy start-ups since 2006.

A sharp rise in clean energy venture capital investments in China is fortified by government equity investments in later-stage start-ups

Although there was hardly any venture capital activity in China's energy sector just ten years ago, investments began to skyrocket around 2015, preceding the waves of recovery in other regions after the "cleantech bust" of 2012. In fact, in 2018-2020, China accounted for nearly 35% of global early-stage financing for clean energy start-ups, and in 2019 energy attracted roughly as much venture capital investment as semiconductors or medicine and health.

Between 2015 and mid-2021, transactions involved mainly electric mobility and batteries. Of the cumulative USD 10 billion Chinese start-ups raised in early-stage financing, over 90% went to companies developing electric vehicle technologies, and much resulted from mega-deals of over USD 150 million. Just nine start-ups, all established after 2014, raised around USD 15 billion in funding at all stages from early-stage venture capital to initial public offerings and follow-on funding.[9] A significant share of these deals involved public financial entities.

China supports start-ups with public equity more than other countries do. The government typically provides financial support through the investment branches of large state-owned enterprises (SOEs), national and subnational public banks and investment funds, and university funds. Since 2016, WM Motor has received funding from the central government's State Development and Investment Corporation, the SOEs SAIC Motor Corporation and China Minmetals Corporation, the central government banks Industrial and Commercial Bank of China and China Construction Bank, and subnational government funds in Hubei, Guangzhou and Shanghai. Local governments also fund R&D infrastructure and manufacturing capacity, in addition to offering direct financial support.

Public sector equity investment is most common in larger, later funding rounds, but there are also funds that target earlier-stage companies. Addor Capital, a fund established by the province-owned Jiangsu High-tech Investment Group, is one of China's largest venture capital funds and backs electric vehicle, environmental technology and biotechnology companies.

The government has also set up large "guidance funds" to help commercialise emerging technologies, including from university research. The Ministry of Science and Technology's National Guiding Fund for the Conversion of Scientific and Technological Research had established over 20 venture capital sub-funds by 2019, with some listing clean energy and transport as investment priorities. In 2001, the State Council created Tsinghua Holdings Corp Ltd, a state-owned asset management company within Tsinghua University, with USD 400 million in capital to support R&D and entrepreneurship, provide innovation services, and help bring new technologies to market. Tsinghua Holdings' affiliates include three of China's largest venture capital funds. Among these, Tsing Capital specialises in clean energy and related technologies.

[9] Including Xpeng Motors, WM Motor and Leapmotor.

Indirect approaches

Governments fund equity in start-ups through two main types of intermediaries: incubators and venture capital funds. These two approaches differ considerably in both financial management structure and where the returns accrue. When public funds are invested in equity by a private incubator, it is generally so that the incubator can use any subsequent equity sales to fund future incubation costs. When public funds are invested in a venture capital fund or fund-of-funds, the government usually receives the profits from any future sales. More initiatives invest public funds in clean energy technology start-ups via incubators than through venture capital funds.

Since 2010, the European Institute of Innovation & Technology (EIT), an agency of the European Union, has co-funded a private entity, EIT InnoEnergy, to run a European Knowledge and Innovation Community (KIC) on the topic of sustainable energy. KIC InnoEnergy was one of the first three sectoral KIC proposals to be approved and, as of 2022, eight KICs are funded to "strengthen cooperation among businesses (including SMEs), higher education institutions and research organisations [and] form dynamic pan-European partnerships." The EIT InnoEnergy Highway programme is one of several ways in which EIT InnoEnergy executes its mandate to support start-ups under its EU funding grant. The programme, which is also co-funded from non-public sources, solicits applications from start-ups via a permanently open call and also scouts for energy technology innovators to join the scheme. In return for EIT InnoEnergy taking a minority equity share, recipients receive tailored acceleration services.[10] Returns from these investments are expected to help secure EIT InnoEnergy's future finances and it has sold shares in around 25 companies to date. One feature of Highway is that innovators can join the programme before incorporating a company.

India's Clean Energy International Incubation Centre (CEIIC) – launched by the Government of India and Tata Trusts in 2018 under the auspices of Mission Innovation and operated by Social Alpha – has several financing options for start-ups that win its energy technology challenges. Selected start-ups are eligible for seed equity investments of up to INR 10 million (USD 130 000), which Social Alpha invests using its own resources. CEIIC start-ups are also eligible for product development support and scale-up grants. Social Alpha also connects all start-ups with its network of investor partners.

Among its other support measures, India's Technology Business Incubator (TBI) has issued calls for proposals from independent not-for-profit incubators to fund a large network of incubators to channel government funding as equity to start-ups. The Department for Science and Technology's National Initiative for Developing

[10] As the funds for these grants come from the public sector, they are subject to EU state aid rules and can only be spent on technology development, entrepreneurial skills training and team creation (including recruitment).

and Harnessing Innovations (NIDHI) has managed the system since 2015, and while energy technologies are not the system's primary focus, certain accredited incubators (such as Indigram Labs) have established energy priorities.

An example of how NIDHI uses accredited incubators is the Seed Support System, launched in 2016 to ensure the timely availability of financial support for "proof of concept", prototype development, product trials, market entry and commercialisation. Under this system, start-ups can apply to participating incubators in the TBI programme for debt or equity investments of INR 1 million (USD 13 000) to INR 2.5 million (USD 34 000), or up to INR 10 million (USD 130 000) in exceptional circumstances. Recipients can spend these funds on a wide range of eligible costs, including product development, marketing, mentoring, intellectual property issues and personnel. Whether a TBI incubator provides debt or equity is at its own discretion, although equity is encouraged and must be chosen if funding exceeds INR 2.5 million (USD 34 000). The system's rules require that incubators reinvest any proceeds to secure the long-term viability of the incubator after the initial five years of the TBI funding operational costs have ended.

As a TBI-accredited incubator, Indigram Labs takes 2-5% equity in funded start-ups. Indigram Labs' public funding has so far come from three different government departments: the Department for Biotechnology (DBT), the Department for Science and Technology (DST) and the Ministry for Micro, Small and Medium Enterprises (MSME). It has incubated clean energy start-ups in the areas of bioenergy and solar PV.

Through the European Investment Fund (EIF), the European Investment Bank of the European Union manages a number of equity funds directed to start-ups via third-party fund managers. Although none of them are dedicated specifically to clean energy technologies, the EIF reports a strong presence in cleantech categories. The rationale for public investment in venture capital funds is the disproportionality between the costs of assessing a relatively small company's financing needs and the potential financial return. Because it is often more cost-effective for venture capital funds to concentrate on later-stage and less disruptive firms, there is a market weakness when it comes to channelling private capital to start-ups, especially those that could generate positive externalities such as clean energy technologies. Public funds can "crowd in" more private capital.

Brazil's public programmes support energy start-ups, including with equity investments

Brazil does not have dedicated public programmes for clean energy technology innovators, but it offers support through several recently established non-energy-specific initiatives.

Between 2012 and 2019, Start-up Brazil used Ministry of Science, Technology and Innovation funds to support 13 accelerators across the country with up to BRL 400 000 (USD 70 000) per selected start-up, half of which was used for promotional activities. The programme also provided grants of BRL 200 000 (USD 35 000) to promising Brazilian start-ups for development work. For instance, it supported Desh, a start-up with energy metering technology, and Guell (now SOMA), an electric vehicle company.

Start-up Point is a central source of information about available funding and services, and it aims to be a one-stop shop for applicants to the various programmes. Meanwhile, Start-up Industria provides networking services for industry experts and new entrepreneurs.

Among the several private incubators and accelerators that target energy start-ups specifically, Energy Hub was proposed in 2019 to address the finding that only 0.6% of known Brazilian start-ups were in the energy sector. The electricity regulator, ANEEL, is currently revising regulation 9.991, which governs the minimum level of R&D spending by regulated utilities, and will extend it to include activities such as investing in and supporting start-ups.

Chapter 4. Infrastructure: Providing access to costly facilities

Case studies in this chapter	Access to laboratories and testing	Equipment procurement	Access to office space
American-Made Challenges	Direct		
Clean Energy International Incubation Centre	Indirect		Indirect
EcoLabs-COI	Indirect		Indirect
EIT InnoEnergy Highway	Indirect		Indirect
Energy Systems Catapult Living Lab	Indirect		
Start-Up Chile	Indirect	Direct	Direct
Green Innoboost	Direct and indirect	Direct	
IN²	Direct		
Technology Business Incubators	Indirect		Indirect
Women in Cleantech Challenge	Direct		
Non-case study initiatives in this chapter	Breakthrough Energy Solutions Canada; Lab Partnering Service; Science and Technology Assistance for Cleantech; Shell GameChanger Accelerator; Yanqing New Energy Incubator		PortXL

Access to laboratory equipment and office space are two essential costs that can be difficult for early-stage companies to finance. Laboratory access is critical for developers of hardware products at all stages, from the earliest experimentation to prototyping and, later, product development for demonstration and sale.

Furthermore, in highly regulated sectors such as energy there is often a need for accredited testing to ensure compliance with industry standards, whether for appliance safety, electricity grid integration or fuel supply norms.

Only a relatively small share of the clean energy technologies needed are software or devices with minimal high-tech components. The elaboration of most equipment requires precision development, repeated experimentation and generous assembly space. While universities might provide continued laboratory access to spin-offs (i.e. companies that develop technologies invented through university research), it is rarely free or optimised for industrial product design. Even electronic and digital technologies simple enough to be constructed on a laboratory bench or in the "fab labs" of well-furnished incubators can require access to the type of commercial demonstration and testing facilities only industrial facilities have. Some countries operate state-owned laboratories suitable for these needs or can help start-ups pay for access to third-party facilities.

Office space is another cost start-ups must bear. Governments rarely provide funding for it directly, but some programmes include it as an eligible use of public funds while others help start-ups finance space at incubators.

Access to laboratories and testing

Direct approaches

Not all governments have state-run energy laboratories, but some countries that do have recently been exploring how to make this valuable resource available to start-ups. Three elements make public energy laboratories useful for SME development:

- Public energy laboratories – whether national or subnational – are atypical in having state-of-the-art facilities adapted to the commercial and industrial needs of the regulated energy business, including end-user equipment.
- Successful testing at these facilities is valuable for communicating technical verification to investors and companies.
- Because of their expertise and access to professional networks, research personnel at public energy laboratories can guide start-ups in refining their technology development and business model decisions.

Feedback from programmes that facilitate interaction between clean energy technology entrepreneurs and public laboratories indicates that the benefits outweigh the budgetary cost to the government. For start-ups, it would not be possible to buy equivalent access or expertise in the private sector for the same sum, and for laboratory personnel, these programmes present the chance to learn about potentially disruptive opportunities and technology needs.

In the American-Made Challenges programme, the US Department of Energy gives start-ups vouchers to access equipment and expertise at their 17 national laboratories and other qualified facilities. In this system, a start-up's expenses are allocated to the programme budget, which is spent as the enterprise redeems its vouchers at the laboratory within a specified time frame. Start-ups can use vouchers to get support for testing the technology and to obtain advice from researchers at national laboratories. In some cases, if the laboratory does not have the appropriate testing facility or equipment, it may develop or procure it.

NREL's IN^2 programme and the Shell GameChanger Accelerator also offer public laboratory support from NREL, which assigns a researcher to each start-up to guide it towards opportunities to accelerate commercialisation. These initiatives complement other federal US programmes to engage national laboratories more deeply in innovation and commercialisation.

The US Department of Energy has a range of initiatives to commercialise clean energy technology innovation

In recent years, the US government has been introducing various federal programmes to increase national laboratory involvement in energy innovation and commercialisation.

Thus, the Department of Energy has had a Chief Commercialization Officer since 2018, and it also hosts a Presidential Innovation Fellow with experience in entrepreneurship as part of a government-wide initiative launched in 2012.

The Department of Energy has also overseen a Lab Partnering Service since 2018 to facilitate connections among innovators, investors and public laboratory experts.

Furthermore, the Energy Programme for Innovation Clusters (EPIC) explores how the country's 17 national laboratories can seed clean energy hardware innovation hubs in "innovation districts" outside of traditional coastal and urban clusters. In June 2021, the Department of Energy awarded USD 900 000 for the establishment of a Midwest Regional Innovation Partnership, with the participation of Argonne National Laboratory. It also awarded similar grants to Alaska, the Carolinas, New Mexico, the Pacific Northwest and the Rocky Mountains Great Plains region.

At the subnational level, state governments have contributed considerable funds to incubators and other initiatives to establish innovation clusters, including for energy. For instance, the New York State Energy Research and Development Authority (NYSERDA) is widely recognised as a funder and service provider for energy start-ups that might raise prosperity in the region, including those from outside New York State.

Canada uses a different approach to help start-ups access expertise and testing at its federal energy-related research centres. Since 2017, SMEs applying to its Clean Growth in Natural Resource Sectors Program have been able to choose a model of funding known as Science and Technology Assistance for Cleantech (STAC). Under this schema, the SME and the research centre apply as a consortium led by the SME, and the government funds the work packages of the participating entities separately. This means that research centre costs are met by the government up to a total of CAD 9 million (USD 7 million) over five years across a network of eligible research centres.[1] Natural Resources Canada also offered funding for federal laboratory support to finalists in the Breakthrough Energy Solutions Canada and the Women in Cleantech Challenge competitions, directly targeting clean energy technology start-ups. This model is now being refined for use in a wider set of programmes.

In Morocco, the Green Innoboost scheme facilitates access to two IRESEN facilities for R&D and testing: the Green Energy Park (GEP), inaugurated in 2017, and the Green and Smart Building Park (GSBP), operational since 2019.

Indirect approaches

Governments can provide start-ups access to laboratories indirectly, mainly by funding incubators and accelerators that offer this service to clean energy technology innovators.

In the United Kingdom, Energy Systems Catapult Living Lab is a unique initiative that brings together a network of digitally connected homes to serve as a safe and affordable real-world test environment. It was created in 2017 in recognition of the importance to the UK of energy efficiency and smart energy systems, as well as barriers to testing in real-world environments, especially for start-ups. Innovate UK, a public body, funds the programme through Energy Systems Catapult, an independent not-for-profit entity.

Energy Systems Catapult Living Lab allows innovators to design and test products, services and business models with real people in over 500 digitally connected, inhabited smart homes around the United Kingdom, covering a variety of tenures, property types and installed equipment. It has a permanently open call for proposals, so technology developers can make contact at any time to explore the possibility of using the Living Lab for testing.

In India, the Clean Energy International Incubation Centre (CEIIC) offers laboratory space and rapid prototyping as part of its services. Selected start-ups

[1] Canadian Wood Fibre Center; CanmetMATERIALS; CanmetMINING; CanmetENERGY – Varennes; CanmetENERGY – Ottawa; and CanmetENERGY – Devon.

receive credits redeemable for infrastructure support over the duration of the 12-month programme, and these credits can be worth more than INR 2.5 million (USD 33 000) per start-up. Start-ups can also use infrastructure on a pay-as-you-go basis, paying either with cash or by yielding the equivalent equity value to Social Alpha.

The CEIIC has a rapid prototyping lab with 3D printers and scanners, circuit board printing and testing facilities. Plus, start-ups have access to six research facilities at Tata Power, including battery and meter testing laboratories, switchgear and power transformer workshops, and communications and smart grid laboratories. Hosted in the same building as Tata Power Delhi Distribution Limited's Smart Grid Lab, CEIIC also has access to a testing facility for energy storage and smart grid applications, as well as to a solar PV generator.

Many incubators participating in the Government of India's Technology Business Incubator (TBI) initiative are located at universities or research institutes and can therefore offer laboratory support. TBI-accredited incubators also provide office space to start-ups, and some have generic facilities (sometimes called "fab labs") for rapid small-scale prototyping, as well as limited testing equipment. TBI-accredited incubators can upgrade their facilities by applying for government grants such as those available through the PRAYAS programme.

Governments have also been known to facilitate entrepreneur access to university and industrial laboratories, one example being the Technology Stations Programme of South Africa's Technology Innovation Agency.

Furthermore, some government initiatives specifically incorporate laboratory access into programme design. Morocco's Green Innoboost requires that start-up applicants co-operate with at least one national scientific partner, such as a university. Under this system, IRESEN funds the university to provide the start-up with technology development and testing facilities.

Test beds are also a core part of Singapore's EcoLabs-COI, with the government-funded programme providing access to Nanyang Technical University laboratories and facilities for prototyping and testing. In addition, EcoLabs-COI has partnerships with more than 30 test beds in external organisations that it can fund to test new ideas. Some of these test beds are located outside Singapore and include shopping centres, educational institutions and manufacturing sites. Ownership of intellectual property generated by EcoLabs-COI projects involving new products and services is shared by the start-up and NTUitive, a part of Nanyang Technical University. NTUitive supports the licensing of co-developed intellectual property, including licensing it back to the start-up if it wishes to use it.

Meanwhile, Start-Up Chile ensures access to technical facilities in its incubation programme by signing agreements with sponsoring entities for each recipient start-up. The sponsor (for example a potential industrial customer) provides a venue for testing, is remunerated by Corfo and is required to report certain results. EIT InnoEnergy facilitates access to laboratory and testing facilities for start-ups in the EIT InnoEnergy Highway programme through agreements with partner organisations that commit to providing free or discounted access in return for participating in EIT InnoEnergy events and networks.

In China, the Yanqing New Energy Incubator is an example of how a municipal government can provide funding for a technology test zone, including for smart grids, solar-wind hybrid technology and electric vehicle charging equipment.

Funding for equipment

Direct approaches

The cost of procuring precision equipment is difficult for many technology hardware start-ups to cover. New companies with low credit ratings and an uncertain future are not in a strong position to negotiate, and besides, they often do not have enough laboratory space to house bulky equipment. To address this problem, some government programmes for clean energy technology start-ups offer procurement support. For instance, participants in Morocco's Green Innoboost can make use of IRESEN's procurement team, which will scout for and negotiate contracts on the public entity's terms. If the start-up's project is unsuccessful, the equipment becomes an IRESEN asset. Meanwhile, Start-Up Chile provides licences for essential software to certain early-stage companies developing digital services.

Access to office space

It is common for incubators to provide office space and cover administrative overheads for start-ups in an incubation programme. Among our case studies, EcoLabs-COI, EIT InnoEnergy Highway, Indigram Labs within the Technology Business Incubator initiative, and Start-Up Chile all include this service. In the case of Indigram Labs, the Indian Society of Agribusiness Professionals (ISAP), which hosts the incubator, provides the infrastructure. In the case of EIT InnoEnergy Highway, which is co-funded by the European Commission, office space is available if the start-up is located in proximity to one of EIT InnoEnergy's eight European or one US premises.

In the Netherlands, PortXL is an example of an accelerator backed by a local public body (the Rotterdam City government) that focuses on clean energy and will pay a start-up's residential and overhead expenses while the owner takes part in an intensive three-month programme.

Chapter 5. Services: Access to expertise and professional advice

Case studies in this chapter	Business services	Technical expertise	Validation and public recognition
American-Made Challenges	Indirect	Direct	
Clean Energy International Incubation Centre	Indirect	Indirect	
EcoLabs-COI	Indirect	Indirect	Indirect
EIT InnoEnergy	Indirect		
Energy Systems Catapult Living Lab	Indirect	Indirect	
Green Innoboost		Direct	
IN²		Direct	
Innovation Norway	Direct		
Start-Up Chile	Direct		
Start Up Energy Transition Technology Business Incubators	Indirect		Direct
Women in Cleantech Challenge	Indirect	Direct	Indirect
Non-case study initiatives in this chapter	AGNIi; Breakthrough Energy Solutions Canada; Chile Global Ventures		

External knowledge is a highly prized commodity for new companies, especially if their founders do not have substantial previous business experience. For small firms, gaining this knowledge through a consultant is often very costly, or is impossible without strong expert connections. This section covers some of the key services start-ups need, which government policies and programmes offer in various ways. As many of them are the core competencies of incubators and accelerators, governments generally provide these start-up services through third parties rather than developing the capacity to offer them directly.

The most common form of government support is grant funding for incubators, either to carry out general activities or, in some cases, to execute defined programmes for clean energy technology start-ups. Globally, more incubators and accelerators are funded by subnational governments (provincial, state-level, regional and municipal) than by nation states, but it is becoming more customary for them to receive both local and national funding. A notable recent example is the US Department of Energy's Energy Program for Innovation Clusters (EPIC) awards of USD 50 000 to each of 20 regional energy-related incubators, many of which also have local public support. Some countries also finance incubators by offering them tax breaks.

The most pertinent services start-ups require are business services (management assistance, market research, and legal and intellectual property support); access to technical expertise; and validation and public recognition.

Business services

Management support can encompass a wide range of activities, including help to assemble a management team, improve pitches to investors, formulate a financial structure, recruit staff and devise a business strategy. These often constitute energy technology entrepreneurs' widest knowledge gaps, and they can make innovators hesitant to start a new company to commercialise their idea. Most incubator programmes cover these services in their standard programmes and tailor their offerings according to a company's maturity.

In some countries, however, state aid restrictions limit the extent to which governments can finance this type of support, so policies for clean energy start-ups tend to focus more on technology funding. Therefore, rather than selecting companies and providing them with grants to purchase management services from incubators, it is more common for these governments to fund incubator operations directly, enabling them to evaluate and accept more clean energy technology start-ups. Several of the publicly-funded incubator programmes reviewed in this section respond to the longer development times of clean energy hardware by supporting start-ups for longer periods than are typical for digital or other technology fields.

For Canada's Women in Cleantech Challenge programme, Natural Resources Canada partnered with an independent innovation support organisation, MaRS Discovery District, which designed and delivered the business service elements and was reimbursed for its expenses. MaRS created a support package tailored to the Challenge's six finalists, taking the needs of very early-stage technology developers and any gender-related barriers into account. Services were then further adapted to the participating entrepreneurs' requests once they entered the three-year programme.

The resulting services therefore closely resembled the support MaRS gives to companies in its "growth services" programme, even though the finalists were more like clients who normally receive MaRS's much more limited (and less hands-on) "early-stage services". The Challenge package included:

- A curated curriculum of in-person workshops and training every three months, designed to address any issues that had arisen.
- Remote learning modules taught by external experts (partly enforced by the Covid-19 pandemic).
- Access to a hands-on mentoring team of external business consultants and advisers for each finalist.
- Help with milestone-setting and in-person feedback on progress from the support team every three months.
- Introduction to an investor network, and regular feedback from a team of investors on the business proposition.
- Speaking slots at relevant events in Canada and the United States.
- Assistance with market research, for Canada and globally.

In interviews, participants reported their appreciation of the customised support, especially their freedom to select topics such as negotiation training, which has dimensions specific to female founders. They also placed high value on the personal and in-person training but noted that the uniform travel support budget did not take finalists' distance from Toronto into consideration.

EIT InnoEnergy Highway, which is co-funded by the European Commission, also customises its acceleration programme to each participating start-up. Start-ups sign a "roadmap" that details the services to be provided over the course of the programme, which lasts on average two-and-a-half years, reflecting EIT InnoEnergy's investment case for each start-up and responding to their needs. The services are categorised as: access to finance; access to market; access to talent; citizen engagement; governance; product and intellectual property; regulation; sales; and supply chain management (industrialisation).

Services that cannot be provided in-house are externally sourced, including:

- Team-building, including installing a management team.
- Market research and market dynamics studies.
- Intellectual property advice, including how to find and write patent applications.
- Access to financing sources and advice on how to communicate with funders.
- Legal assistance.

Meanwhile, Start-Up Chile is a government initiative that directly provides extensive acceleration services, up to a value of USD 300 000. Assistance

includes an advisory team that meets with recipients each month, workshops on various business services, pitch training and visa application support for overseas recipients. Start-Up Chile has also negotiated discounted external services, including cloud storage, software purchases and legal advice. Though it offers less extensive direct support, another example is AGNIi, an initiative of India's Office of the Principal Scientific Adviser to the Government of India and housed at Invest India, the national investment promotion agency. AGNIi has in-house expertise to help Indian start-ups refine their business ideas and access online training, expertise and legal support. Clean energy is a focus area of the initiative, which also supports the country's electric vehicles mission.

Some publicly backed incubators have distinctive ways of providing business services. For instance, India's Clean Energy International Incubator Centre offers recipient start-ups some business services, including strategic advice, assistance with business and financial models, expert mentorship, discounted software and procurement support. In addition, Social Alpha vets a range of service providers and can help start-ups buy their services at a discount. Such services include hiring and payroll management, branding and communications administration, legal and compliance oversight, tax calculation and filing, secretarial assistance and intellectual property filing. During the 12-month programme, the Clean Energy International Incubator Centre also assesses start-ups for their product-market fit.

Under India's Technology Business Incubator programme, Indigram Labs assigns each participating start-up an internal mentor to guide it through its business development. EcoLabs-COI in Singapore also has dedicated in-house expertise, assigning both technical and business consultants to start-ups to guide development of a strong business model, help position the product in the market and advise on customer and supplier acquisition.

Also in Singapore, start-ups accredited by Infocomm Media Development Authority are given access to Singapore Intellectual Property Office services free of charge, for example guidance on patenting strategies to help them decide whether and when to patent new ideas. In Europe, Innovation Norway helps start-ups with market research and international networking services. For start-ups at an early stage of concept design this support is free, but later-stage companies are charged a fee.

Chile Global Ventures has a notable model for funding business services for participating start-ups: it operates an "equity mentoring" programme through which start-ups can request additional mentors with specific expertise for two years in exchange for equity. While Chile Global Ventures initially takes 7% equity in all the start-ups it incubates, this stake falls to 6% if a start-up enters the equity mentoring programme, but the start-up must cede another 1% to the mentor, who receives a 2% stake. (Mentors also have the option of joining the board of directors

once the start-up graduates from the incubator programme.) Suncast, a solar PV forecasting and predictive maintenance start-up, received support from Chile Global Ventures and reports significant benefits from the equity mentoring programme, especially the regular tracking of progress.

Most incubation programmes offer some type of intellectual property advice to technology start-ups, and start-ups consider this a very valuable element of the business services. There are many reasons why intellectual property issues are difficult for a new company to navigate, including the level of expertise needed to thoroughly review potentially overlapping patents. Intellectual property rights can be especially complex for university spin-off companies, technologies developed with public funding or new intellectual property generated while at an incubator. Chile Global Ventures therefore offers free one-hour sessions with legal advisers each month, and Breakthrough Energy Solutions Canada has offered intellectual property-related mentorship opportunities to selected companies.

Technical expertise

Technical expertise can sometimes be as important as business advice. It can help start-ups refine their technology as they turn it into a product, or to make choices about materials and manufacturing techniques. In some cases, it can help companies recognise opportunities to import ideas from other technology fields to improve their solution, or to pivot their product to an entirely different application. We have already discussed the value of expertise in public energy laboratories (see the Infrastructure chapter), but the case studies furnish other interesting examples of technology service provision.

In the United States, NREL assigns an expert researcher from a national laboratory to each start-up in the IN^2 programme. In addition to other guidance, these researchers help start-ups undertake commercial-scale feasibility studies for their technology concept. The researchers work alongside the start-ups for the duration of the programme and help them develop any required testing equipment.

In Morocco's Green Innoboost programme, each start-up must apply with at least one Moroccan scientific partner, usually from a university. IRESEN helps start-ups identify potential partners if they do not already have one, and it funds the scientific partner to provide the start-up with technical guidance for the duration of the programme and will seek additional technical advice as necessary.

Meanwhile, EcoLabs-COI in Singapore has developed relationships with relevant academic experts, and for each selected start-up it surveys these experts and other start-ups in its network to learn whether there is extant intellectual property in Singapore that could be shared to improve the product's design.

In the United Kingdom, the Energy Systems Catapult Living Lab supports recipients with technical expertise to conduct their Living Lab trial. This includes access to historic data, data scientists and artificial intelligence algorithms. Business services are also available, including access to energy market research as well as user experience, service design and trial design information.

Validation and public recognition

Being selected for public programmes and prizes validates a start-up's concept and confers public recognition. Several case study initiatives explicitly cultivate this service by providing selected start-ups with a platform to attract investor, policymaker and other expert attention. This is a central element of Start Up Energy Transition, for instance, which culminates in the annual Berlin Energy Transition Dialogue conference. In Singapore, the PowerACE prize, featuring the EcoLabs-COI Special Award, takes a similar approach by giving winners a platform at Singapore International Energy Week.

In Canada, Natural Resources Canada and MaRS helped finalists in the Women in Cleantech Challenge identify opportunities to speak at a variety of events in Canada and the United States, including some panels dedicated to the Women in Cleantech Challenge. The finalists' package also included communications support to generate publicity through news outlets, which served to promote their companies and draw attention to the programme's core objective of aiding women entrepreneurs who are advancing world-class clean energy innovation.

Chapter 6. Networking

Case studies in this chapter	Peer-to-peer	Investors and potential customers	Policy connections	International connections
American-Made Challenges	Direct	Direct		
Clean Energy International Incubation Centre	Indirect			Indirect
EcoLabs-COI				Indirect
EIT InnoEnergy Highway	Indirect	Indirect		Indirect
Green Innoboost		Direct		Direct
IN^2	Direct	Direct		
Incubatenergy	Indirect	Direct		Indirect
Innovation Norway				Direct
Start-Up Chile	Direct	Direct		Direct
Start Up Energy Transition	Direct	Direct	Direct	Direct
Swedish Energy Agency				Direct
Women in Cleantech Challenge	Indirect	Indirect		
Non-case study initiatives in this chapter		Greentech Innovation		EIT Climate-KIC Climate Launchpad; MI CleanTech Exchange; Poland Prize

Although they are intangible, networks of peers and professionals are critical resources for start-ups. While their needs change as they mature and grow into larger SMEs, they remain reliant on open flows of knowledge, access to expertise and connections with investors and customers. Investors and incubators often also have limited funds to buy services and research, which can create a system of reciprocity to help networks flourish.

In addition to easy access to laboratory and other testing facilities, strong knowledge networks are a central pillar of successful innovation ecosystems. Governments have long been important in establishing collaborative platforms that enable interactions among diverse participants, especially for pre-commercial technologies, and ongoing efforts continue to enhance cross-disciplinary expert networking to achieve key societal objectives.

In fact, network funding is a core component of some initiatives, with governments treating networks as quasi- public goods, and in other programmes networking has emerged as a key beneficial outcome. From our case studies, we identified four types of networking services helpful for start-ups:

- peer-to-peer connections
- investor and potential customer connections
- policy connections
- international connections.

Peer-to-peer

The benefits clean energy technology start-ups can gain from interacting with other start-ups are multiple, and can be maximised by good programme design (at a relatively low cost). The advantages of peer-to-peer networking derive from:

- Technical exchanges and collaboration on mutual problems or opportunities to develop complementary products.
- Sharing information about potentially relevant contacts, based on understanding one another's needs.
- Sharing ideas on how to tackle business challenges, based on recent experience with similar situations.
- Solidarity, emotional support and reassurance from others grappling with similar obstacles.

In the Women in Cleantech Challenge, the six finalists followed a joint programme, including in-person training sessions in Toronto, which created a tight bond. The finalists rate this "cohort effect" as one of the core benefits of participating in the programme, an advantage that would not have been delivered by other government funding schemes. The finalists connected very effectively because their cohort size was small, they were at the same level of development (all were early-stage start-ups) and they shared similar experiences as women facing common (and often overlooked) female-entrepreneur challenges. Even though the programme has ended, the finalists expect to continue sharing challenges, experiences and opportunities with one another.

Meanwhile, a novel element in some of the challenges of the American-Made Challenges is the offer of small monetary rewards to network members that voluntarily support a team, usually one that goes on to win one of the prizes. The sums are relatively small – rarely more than USD 10 000 each, once the available pot is divided – but are intended to publicly acknowledge and encourage support within the innovation ecosystem. Network members receiving these rewards are called Connectors, and eligibility is extended not only to start-ups but to academics, corporate experts, investors and other service providers. However, any start-up competing in a given round cannot be a Connector for that round.

While the reward sums may be inferior to both the value of the Connector's time and the benefit to the recipient, we learned from one participant that the formal offer of a financial reward stimulated peer-to-peer exchanges that would not otherwise have happened. NREL has tweaked the structure of these rewards as the programme's design has evolved in different technology areas, integrating them mostly into the prizes for solar technologies.

Like a number of other initiatives, Start-Up Chile facilitates networking among the start-ups it has supported from different countries during its ten years of existence. In 2021, it established the Female Founder Factor programme for women in entrepreneurship and innovation. Furthermore, in response to the absence of a network for energy companies specifically, a group of start-ups in Chile has formed ClimaTech to address gaps in the innovation ecosystem for environmental technology entrepreneurs in Chile today.

Investors and potential customers

Obtaining introductions to networks of investors and of relevant large corporations is widely recognised as being crucial for gaining access to financing and markets. Most incubators therefore offer investor connections for start-ups as part of their standard programmes and tailor their offerings to the companies' maturity. However, the nature of connections can range from induction into online start-up and investor communities, to group pitch sessions and one-on-one meetings.

American-Made Challenges has an online platform through which participating entrepreneurs can interact with registered investors seeking investment opportunities. The platform also facilitates interactions with other experts, including companies and potential mentors. In Germany's Start Up Energy Transition, dena enables each year's top 100 entrants to connect with one another and various partners, including companies and potential investors, through regular telephone calls, emails and a LinkedIn group. In addition, Start Up Energy Transition arranges "matchmaking" events at which start-ups can circulate among stations hosted by prospective investors and industry partners. Participants in EIT InnoEnergy Highway, co-funded by the European Commission, benefit from

access to the many connections managed by EIT InnoEnergy among stakeholders from the education, research, industry and investor communities. The EIT InnoEnergy model is notable for the way in which it embeds reciprocity in its agreements with partners, who commit to in-kind support to start-ups in return for participating in events and accessing knowledge and talent, including students, graduates, start-ups and potential project partners.

Also in Europe, the French government launched Greentech Innovation in 2016 to connect climate-related start-ups with one another and with incubators and investors. To this end, it organises annual Meetup Greentech conferences to provide a networking and promotional focal point for cleantech innovation in France. The initiative gives particular attention to three elements of its networking service: the opportunity to connect with over 30 public institutions involved in environmental technology research; creation of a recognisable label that confers trustworthiness and prestige on its members (215 so far); and the promotion of female entrepreneurs.

In the United States, in 2012 the Department of Energy recognised that insufficient interaction among incubators was restricting start-ups' ability to secure opportunities and investments. In response, the government awarded a grant to NREL and the Electric Power Research Institute (EPRI), a private members' organisation for electric utility and associated companies, to launch and manage a network connecting incubators and accelerators for clean energy technologies. Between 2014 and 2018, the Incubatenergy Network was a source of information about US clean energy incubators, fostering engagement and communication among them and providing rich expert and mentor resources. While public funding expired in 2018, EPRI's members elected to continue operating the network with their own funds and it is still an active resource with around 30 incubators and connections to laboratory facilities.

Notably, EPRI's involvement enables direct contact with potential customers at utility companies, including for pilot and demonstration projects, and the Incubatenergy Network is therefore a channel for these firms to learn about innovative new technologies themselves. This is particularly evident in Incubatenergy Labs, an EPRI initiative operational since 2020 that selects start-ups to work jointly with several EPRI members on demonstration projects to accelerate their introduction into the electricity sector, or to identify unforeseen technical or regulatory challenges. Additionally, as the Incubatenergy Network has evolved it has expanded beyond the US market to now include EIT InnoEnergy as a member and is establishing a European base.

The Incubatenergy Network illustrates two additional dimensions of networking: incubators co-operating to identify and support start-ups; and companies in incubator and start-up networks reaping reciprocal benefits. While many policy

measures portray networking as a means for start-ups to connect with potential customers, networking also presents larger companies with learning opportunities and the chance to help distribute knowledge of emerging technologies and products throughout the value chain, which can benefit the clean energy innovation ecosystem as a whole.

Policy connections

The energy sector's high level of regulation can be an entry barrier for start-ups, especially those whose business plans may disrupt the status quo, as incumbent technologies and business practices are often the basis of regulations that stipulate:

- Which companies are eligible to participate in the marketplace and own certain types of assets.
- The operating parameters for equipment to ensure interoperability and safety.
- The level of remuneration and contractual conditions for delivering certain types of services.
- Who can access the data necessary to test new technology and business ideas, and at what cost.

Some proposed business models for clean energy innovations are therefore uncompetitive under current regulations. This can be the case for technologies that involve the participation of end users in the electricity market (e.g. net metering, demand response, virtual power plants and decentralised trading), but independent owners of electricity storage or electrolysers for hydrogen in certain jurisdictions are also affected. In some cases, the regulatory environment presents a barrier simply because of its complexity, necessitating substantial resources to navigate the various requirements.

Few government programmes build the policy networking dimension into policy design, but Start Up Energy Transition is an exception. The programme's annual networking event at the Berlin Energy Transition Dialogue includes dedicated interaction sessions for policymakers and selected start-ups. Plus, dena and the Federal Ministry for Economic Affairs and Climate Action (BMWi) launched the programme's SET Hub initiative in 2021 to create a forum for the government, start-ups and incumbent stakeholders to identify and address challenges and opportunities related to the regulatory environment and the added complexities of decentralisation and digitalisation.

International connections

Government policies and programmes for clean energy technology start-ups vary as to whether they allow overseas entities to participate and whether they facilitate access to overseas markets. From a global perspective, international co-operation on innovation is critical to accelerate energy transitions. In fact, IEA analysis indicates that the transition to net zero emissions could be delayed by several decades if innovation remains regionally isolated.

While inter-firm competition always drives innovation, sharing knowledge internationally, aligning niche markets and enabling cross-border allocation of risk capital will also stimulate invention rather than stifle it. Increasing the chances of innovation success in emerging market and developing economies is especially important given their enormous importance in the future deployment of clean energy technologies, which will need to be tailored to local contexts and will be favoured if local entrepreneurs stand to benefit.

Among the programmes open to participants from all countries, Start Up Energy Transition stands out for having few restrictions. Others, such as EcoLabs-COI, EIT Innovation Highway (for its publicly-funded services), the Clean Energy International Incubation Centre, Innovation Norway,[1] and Canadian government initiatives, require that international applicants either have a local subsidiary or commit to establish themselves in the funding country if they are successful. In some cases, support is available to assist with establishment of a local business. Start-Up Chile targets also international applicants, supporting their relocation to Chile and securing their visas.

Meanwhile, although not dedicated exclusively to clean energy, the Polish government's Poland prize, launched in 2021, is notable because only non-Polish start-ups can apply for funding and incubation support to establish themselves in Poland. The funding, which is complemented by EU and corporate support, is channelled through a private accelerator.

Locational eligibility requirements have led some start-ups, especially those from countries with less mature energy innovation systems, to leave their home countries permanently to follow funding opportunities. In the best-case scenario, start-ups can benefit from interactions in several countries' innovation ecosystems before settling in the most appropriate market. For instance, Fohat, a Brazilian electricity trading start-up, accessed funding and contacts in Australia and the United Kingdom before opting to grow from its São Paolo headquarters.

[1] Innovation Norway has offices internationally that scout for relevant innovative start-ups.

Several programmes also help start-ups access overseas markets. The Swedish Energy Agency has market entry programmes in six countries,[2] and Innovation Norway helps start-ups registered in Norway undertake global market research through their international offices.

Other government programmes focus on bilateral agreements to share knowledge and market access. Under India's Technology Business Incubator programme, Indigram Labs collaborates with incubators in Uganda, while in Morocco IRESEN (which runs Green Innoboost) helped establish the Green Energy Park in Ivory Coast to develop solar energy technology for tropical climates. IRESEN supports innovation activities, including R&D, through knowledge sharing and joint funding from both Morocco and the Ivory Coast.

In Germany, dena (the backer of Start Up Energy Transition) leads energy dialogues to enhance clean energy innovation in emerging market and developing economies. For example, dena has worked with Kazakhstan to help it establish incubators that can be self-sustaining (e.g. by taking equity in start-ups) once German funding has ceased. Dena co-operates with the German Corporation for International Cooperation (GIZ) and has also worked with Mexico, Morocco and Tunisia.

Meanwhile, EcoLabs-COI in Singapore has developed practices to exchange expertise with other national government agencies and higher-education institutions to give its own start-ups the best chance of overseas success. It offers public-supported start-ups from Canada, India and Korea the opportunity to receive on-the-ground incubation support in Singapore, for example to access Asian markets. To boost international market access, EcoLabs-COI has cultivated relationships with government agencies and companies in Germany, Israel, Korea, Norway, Chinese Taipei and the United States. Collaboration typically involves finding a potential customer in one of these countries to provide a test bed for a project in its commercial and regulatory environment, and in several cases this has led to joint project funding by two or more governments.

Notably, Evercomm and V-Flow Tech, two start-ups supported by EcoLabs-COI, were accepted into the Eureka GlobalStars funding programme in which Singapore has participated since 2020. GlobalStars, a call-based initiative of Eureka, supports projects that involve co-operation between an SME from one of the 14 Eureka Network countries and an SME from the target country of the call. Funding comes from the home governments of the two SMEs, depending on their independent evaluations and resources. For instance, Evercomm applied to the

[2] The Swedish Energy Agency has accelerator programs established in India, Indonesia and Germany based on bilateral agreements with Sweden. In other countries, as in China, the United Kingdom and the United States, the Swedish Energy Agency has established thematic programs.

GlobalStars programme jointly with UK firm IONATE, after having previously won a prize with the Israeli company Natergy, co-sponsored by the governments of Israel and Singapore. V-Flow Tech applied with a Korean SME that it had been introduced to by EcoLabs-COI.

Another programme designed to be globally inclusive is Climate Launchpad, a prize-based initiative operated by EIT Climate KIC (an EU-funded body) since 2014. The decentralised organisation has more than 50 national offices handling entries from each country and supporting regional finals and boot camps. Climate Launchpad targets very early-stage entrepreneurs, ranging from those with an idea but not a company, to those less than one year old that have not raised significant financing. Successful entrants can access financing and coaching over the course of the 12-month competition.

In India, the Minister for Science and Technology announced a new collaborative global initiative in June 2021 called the CleanTech Exchange as part of the second phase of Mission Innovation. Its aim is to share country-need assessments, run joint scouting activities and conduct innovation exchange programmes to help innovations have a “soft landing” in international markets.

Chapter 7. Policy insights

The policy measures presented in this report demonstrate that governments can support clean energy technology start-ups in several valuable ways. At the outset of this study, we adopted an open attitude to the public sector's role in innovation, beyond R&D programmes and generic support. Most countries already have extensive networks of private and university-affiliated incubators and accelerators, and financial resources ranging from angel and venture funds to private equity and corporate financing. However, our case studies show that there has been a burst of policy experimentation targeted specifically at identified market failures for clean energy technology commercialisation in the past five years. While this experimentation has yet to produce a consolidated catalogue of agreed best practices, it has shown the numerous ways taxpayer resources can be used to significantly boost innovation, beyond what conventional public and private sector support can do.

This chapter highlights how our case-study policies and programmes have addressed innovation support gaps. In general, these programmes help start-ups in their earliest stages (i.e. before they have products on the market), addressing the main financing, infrastructure, service and networking gaps identified in Chapters 3 through 6. We have not drawn conclusions on the effectiveness of direct versus indirect support for specific services, as both approaches have their advantages. However, it is vitally important in all cases that governments design programmes to build upon and amplify existing schemes and the work of private stakeholders. The way private foundation money helps US government laboratories provide services to private start-ups is a notable example of this.

Maximise what you have: Infrastructure, networks, reputation and programmes

The value of some services governments provide directly to start-ups far outweighs the financial cost to the taxpayer. This is especially true for granting access to laboratory infrastructure and using the government's brand to unite stakeholders.

Clean energy technology start-ups generally need more time in laboratories with costly precision equipment than other new ventures do. In recent examples from around the world, governments have been finding ways to make their publicly owned energy laboratories and R&D staff available to entrepreneurs. Particularly

noteworthy are the American-Made Challenges and IN^2 models, which offer vouchers for laboratory access, sometimes with the help of external funds from private foundations. Alternative approaches to this concept are Canada's STAC method of embedding laboratory support in R&D grant calls and its inclusion of public laboratory access for all finalists in the Women in Cleantech Challenge.

In addition to equipment, extensive world-leading expertise is often to be found at public energy laboratories. An advantage unique to governments is their ability to call upon in-house experience and knowledge to evaluate proposals (especially for complex technologies) at minimal additional cost. For instance, what distinguishes the US Loans Program Office from commercial lenders is its ability to evaluate proposals for a wide range of technologies that the private sector is unable to process – from electric vehicle fast-charging equipment to small modular nuclear reactors.

In some countries, public universities are another source of high-quality expertise and laboratory equipment: Ecolabs-COI in Singapore and Green Innoboost in Morocco actively connect start-ups with these publicly-funded resources. Universities are also a common location for incubators in India and around the world, a situation that can be especially advantageous for clean energy, which relies on scientific advances that routinely emerge from government-funded university R&D. Governments in Belgium, the Netherlands, the United Kingdom and the United States support university-based incubation and acceleration emphasising clean energy technologies, while other university incubators include energy among other priorities for commercialising their core science. While results from university incubators have sometimes been mixed, good practices are emerging to help the public sector create value above and beyond that of private initiatives, including though scientific specialisation, regional collaboration and not over-extending support to firms with a low chance of success.

Governments can also organise stakeholder interactions relatively inexpensively, through events or online networks that build on the government's reputation and profile. For instance, the European Commission, France, Germany and Norway all have energy-specific initiatives that use different approaches to bring participants together. Alternatively, governments can use public funds to launch more targeted networks for overlooked elements of the innovation system, for example the Incubatenergy Network in the United States, which unites clean energy incubators specifically.

Take a global outlook

While most governments design support programmes with the objective of national (or regional) economic growth, some programmes are more co-operative and pursue long-term global goals as well. Germany's Start Up Energy Transition

and its energy dialogues seek to reward clean energy innovation wherever it is based, and India's Clean Energy International Incubation Centre has a formal link with Mission Innovation that gives its start-ups international exposure and networking opportunities. Mission Innovation's CleanTech Exchange, announced in 2021, also has similar goals. Meanwhile, flagship programmes in Canada, Korea and Singapore co-operate to exchange services for each other's participating start-ups. Start-Up Chile secures visas for the foreign start-ups it supports, requiring them to relocate to Chile for the programme, and EIT InnoEnergy Highway supports start-ups from around the world that can address EU objectives, helping them to establish European subsidiaries where appropriate.

Governments also have opportunities to exchange best practices in clean energy innovation policymaking. For instance, in 2021 the IEA co-hosted a working-level dialogue among emerging and developing economies on commercialising clean energy innovations, and Mission Innovation's Insights Module also provides a platform for such exchanges alongside the IEA Committee on Energy Research and Technology. Global networks of private sector entities can also help disseminate good practices around the world if they are engaged in relevant public-private initiatives.

Additionally, governments can be instrumental in setting common standards if they work together. An area of emerging importance is the evaluation of future climate impacts of early-stage technologies. Although several government programmes around the world have already integrated climate impacts into *ex ante* or *ex post* evaluation criteria, they currently use very different approaches, so the method used by a start-up to quantify metrics for one application often cannot be used for applications to other programmes.

Developing common tools and practices may be particularly important for clean energy start-ups because investors and customers are increasingly using environmental, social and governance (ESG) reporting metrics to underpin their strategic decisions. However, many young companies often do not have adequate resources to measure and document their performance to the required standards. Targeted tools or support to ensure that start-ups meet standards may therefore be needed so that this does not become an additional barrier to market entry.

Climate impact evaluation: Growing demand has not yet yielded a dominant approach

Although governments are keen to evaluate the climate impacts of clean energy technologies, the various techniques for doing so are still at an early stage of development. Different approaches have different strengths, resource requirements and levels of robustness. While techniques generally fall into two categories – *ex ante* evaluation of the potential impacts of technology concepts and *ex post* evaluation of the effectiveness of public support – the most desirable method would undertake both with consistency.

In evaluating applications for public support in recent years, several programmes have introduced estimates of a technology's potential to avoid greenhouse gas emissions. Similarly, in the private sector "impact investors" are keen to judge investment options based on quantifiable environmental credentials. Some initiatives include this element but do not use a specific framework: for instance, EIT InnoEnergy and IN^2 ask applicants to estimate their potential climate impact using a methodology of their own choosing. The GHG Protocol and the CRANE methodology are examples of common third-party tools.

Start Up Energy Transition, which had the same approach, no longer includes this evaluation element, while other schemes have their own dedicated tools: for example, Breakthrough Energy Solutions Canada asks applicants to complete a standardised spreadsheet with information about the expected project inputs, outputs, efficiencies and baselines. Programmes can also employ third-party tools, though it is estimated that the 15 available frameworks produce results that can vary by 100%. Variations arise from the inconsistent treatment of:

- Market success: What market penetration should be assumed, and if it is measured in terms of market share, how should total market size be estimated?
- Dynamic baselines: For example, what reasonable counterfactual scenario can represent a world in which the assessed technology never exists? What would be the default technology in such a situation? What technology, policy and market developments can be anticipated, and how would the assessed technology affect them (e.g. by spurring higher climate change mitigation ambition)?
- Boundaries: For example, should the assessment consider the impact of a device in isolation or address its overall impact on the energy system as an enabler or displacer of other energy technologies? Should emissions be estimated as lifecycle cradle-to-grate or cradle-to-grave impacts, and how can these be standardised across technologies? Should secondary impacts such as rebound effects be included?
- Competition: For example, how should an estimate of a hydrogen vehicle refuelling technology's potential also take into consideration possible parallel

improvements in battery electric vehicle technology and divergent pathways for future energy and material prices?

- Attribution: If multiple technologies are required to bring a new value chain to market, such as for many smart or hydrogen technologies, how should the overall emissions impact be allocated among them?
- Geography: For example, should the input data reflect only the conditions in the country running the programme or include all the contexts in which the technology could be deployed to reach full potential?
- Time frames: For example, should the assessment be based on the current emissions intensity of electricity or that of 2030, when widespread deployment might be foreseen?
- TRLs: For example, how should estimates consistently account for cost and efficiency uncertainties, which are much higher for low-TRL technologies and are routinely underestimated by developers?

India's Clean Energy International Incubation Centre uses a third-party tool, the Avoided Emissions Framework, and outsources assessments. This framework is ambitious in terms of its boundary and baseline, but it is still difficult to translate it into a methodology that can apply comparable and computable data to diverse applicants. Furthermore, most methodologies are limited in their capacity to compare the impacts of end-user or enabling technologies (which integrate renewable electricity in a "marginal" manner) with those that directly replace fossil fuels or prevent their emissions.

Additionally, once a start-up has exited a public support programme, evaluating whether it fulfilled its promise to avoid emissions is another challenge, and needing to directly allocate the emissions impact of the programme itself further exacerbates the problem. To these ends, the Swedish Energy Agency requires its grant recipients to report their greenhouse gas emissions for ten years after completing the project, using their own preferred methodology. Meanwhile, Indigram Labs, one of India's Technology Business Incubators, has developed its own greenhouse gas tracking tool. ARPA-E in the United States requires that funded entities report impacts for up to ten years but has no fixed methodology for monitoring greenhouse gas emissions.

Innovation Norway is an example of a programme manager that connects the *ex ante* and *ex post* evaluations: at the end of the project, recipients must update their estimates of emission avoidance potential made during the application phase. Innovation Norway also sends out a tracking survey for four to ten years after a consortium has received funding to track performance.

Channel the right money at the right time

For early-stage technology start-ups, it is often more important to avoid running out of working capital in the immediate future than to secure a large or prestigious grant in 12 months' time. Obviously, as start-ups pass through the successive stages of scaling up (if they are successful), their financial needs evolve and it is understood that governments need to calibrate their policies carefully to accommodate gaps in growth equity financing as well as the public sector's risk appetite. Nevertheless, some countries (sometimes for legal reasons) have not tailored their R&D project funding processes to these considerations.

There are several ways to adapt R&D funding programmes to the needs of clean energy technology start-ups at different stages of development. While some of these examples imply the allocation of additional public resources, which in some countries is scarcer than in others, we do not recommend reducing research project funding as a result.

- Use permanently open calls and aim to complete evaluations quickly. Examples: European Commission, Norway, Singapore and Sweden.
- Pay grants as stipends that are less constrained in terms of eligible costs. Example: Canada's Women in Cleantech Challenge offered its finalists stipends for three years while they competed for the larger prize.
- Tailor grant programmes and services to successive stages of scale-up. Examples: Morocco has dedicated programmes for different TRLs, and Singapore has a range of grants available for different purposes.
- Avoid dilutive funding for early-stage start-ups to differentiate public from private resources. Few governments seek equity shares in start-ups in hopes of reaping future returns, and this is likely to be more justifiable in the later stages of a company's development. Examples: All case study countries provide grant funding, and Norway additionally offers loans.
- Ensure long-term budget consistency and allow successful applicants to transfer to successive tailored programmes. Denmark, Norway and Sweden have R&D programme variations that accommodate projects and applicants in different innovation phases. These programmes have been quite stable for many years and are not generally threatened by new budgetary cycles. After more than a decade of European Commission co-funding and development work by its operating company, EIT InnoEnergy Highway benefits from an extensive global network of support and knowledge.
- Use concessional grants or loan guarantees to help fast-growing SMEs delay selling ownership and avoid being bought out, giving them a better chance to

take root and remain in the home community of their innovation activity.[1] Examples: Israel and Chinese Taipei.

Support peer-to-peer networking

Helping start-ups help each other has emerged as a particularly impactful service governments can provide. Among the public sector interests in this area is a special mission to raise the overall success of all entrepreneurs who have the potential to help solve clean energy technology problems. Participants in support programmes for clean energy start-ups are all rapidly learning how to overcome a wide variety of technology and business challenges at different speeds and stages, all focused on energy. They do not generally compete directly with one another, so are usually very keen to share their experiences on a reciprocal basis. Furthermore, the increased interaction among them confers other social benefits, as founders feel less isolated and more motivated by each other's success.

Canada's Women in Cleantech Challenge programme was particularly effective in this regard, as its cohort members all experienced similar non-technical gender-based challenges. However, almost all government programmes can incorporate peer-to-peer networking among participants, "alumni" and others in the energy innovation ecosystem at relatively low cost. For instance, NREL's offer of small cash rewards for collaboration in the American-Made Challenges programme is an innovative way to raise overall effectiveness.

More generally, establishing a networking system can be a high-impact use of public funds to support start-ups, especially if it creates new configurations of innovators and other relevant experts to work on a common challenge. Such networks can reveal synergies and generate new intersectoral knowledge spillovers, for example by bringing together start-ups and companies that could become important parts of future value chains for emerging technologies but that have little awareness of the opportunities available. If a valuable bond can be forged among some like-minded peers with the means to maintain it independently, direct government support can end once the network is established. This was the case with the Incubatenergy Network of incubators and, subsequently, energy utilities that can facilitate market access.

Publicise innovators and raise awareness

Participation in a government programme confers a "badge of quality" that is not available from most private sector incubators or investors. As this recognition can

[1] Indeed, it is arguable that governments seeking to profit from local innovation-based economic growth (in addition to the environmental benefits) should avoid supporting start-ups with a business model that targets an early "exit" (i.e. sale) to investors, especially investors based outside the jurisdiction.

be particularly helpful for start-ups seeking follow-on funding or customers, active promotion of participating start-ups is a core part of the services several initiatives offer. The awarding of prizes is particularly easy to communicate to the press and other stakeholders, and even though some prizes are similar in practice to grants, they can be much more attractive to entrepreneurs because of the publicity they generate. Start Up Energy Transition and EcoLabs-COI therefore effectively integrate promotional activities into their prize-based support.

In addition to its advantages for start-ups, awareness-raising can benefit clean energy innovation overall. For example, Canada's Women in Cleantech Challenge dedicated considerable effort to publicising its finalists and promoted examples of successful female energy entrepreneurs in general to inspire others. The Challenge completed just one cycle but evidently stimulated ongoing activity, as MaRS Discovery District is using its model and private sector funding to create further cohorts of female clean energy entrepreneurs.

Focus support on priority technology areas

Clean energy technologies span a wide variety of technology types, development needs and appropriate business models. Based on their R&D strengths, natural resources and other factors, most governments have identified priorities within these technology areas in which progress would be particularly desirable. By discriminating between technology areas based on policy priorities, governments distinguish their impact from that of the private sector.

Policy experience suggests that focusing start-up support on priority technologies can both advance their maturity and help governments to learn about the scope and status of the possible solutions. However, most of the initiatives reviewed in this report do not strongly prioritise the technologies for which start-ups can receive support. In some cases, this reflects a lack of resources to run parallel programmes for different technologies, and in others it is incompatible with winnowing the pool of potential applicants by non-technical criteria (such as location or gender). In general, there is often also a desire not to exclude unknown but high-potential innovations by setting the scope too narrowly.

Some programmes address these objectives by combining technology-specific calls with less restrictive ones. Alongside its general programme that is not energy-specific, Start-Up Chile has issued call for proposals in the areas of solar and energy efficiency management. EIT InnoEnergy Highway ran a call dedicated to batteries in 2018 that was successful in raising the number of start-ups they screened in a priority area for European investors and policy makers. Similarly, IN^2 has sought start-ups in the areas of agriculture and buildings technologies in some years, while keeping a broad scope in general. However, none of these examples are as systematic in their identification of priority technology calls as

ARPA-E, which issues five to ten calls each year for new technology areas and around every three years it also issues open calls and unrestricted "special project" portfolios. Though ARPA-E is not exclusively designed to support start-ups, it has a distinctive approach to selecting technology areas that are underexplored but have potential strategic importance to the future US energy system. Structured scoping exercises are used to learn the state-of-the-art from external experts, usually through a public request for information. Start-ups have the opportunity to provide input and contribute to how the calls are defined to attract a range of solutions at different levels of maturity.

Other programmes always restrict the clean energy technologies that can receive support, but cover a variety of priority areas. For example, American-Made Challenges runs a range of contests in different technology areas simultaneously. In 2021, ten prizes were launched, each one sponsored and co-designed by technology policy experts at the US Department of Energy. These covered areas such as desalination, enhanced conductivity materials geothermal lithium extraction, interoperable commercial lighting systems and technologies for more inclusive energy systems. The approach of the SET Award is somewhat different: it dedicates categories within its prize structure to each one of a set of Germany's priority technology areas each year. These categories are wider in scope than those of American-Made Challenges and currently include clean energy generation, demand-side innovation, energy distribution and storage, smart mobility and transportation, and quality energy access and Sustainable Development Goal (SDG) 7. In contrast, EcoLabs-COI and Green Innoboost set the scope of their support by publishing lists of eligible technology areas but do not evaluate applications in these areas separately. Green Innoboost has nine such areas, including biomass, digitalisation, solar energy and wind energy. Living Labs, which is dedicated to smart, energy-efficient residential technologies, is the most technology focused of our case studies as it responds to a narrower policy priority.

Establish milestones and provide regular feedback on progress

Helping start-ups set milestones and track progress is a routine exercise for many incubators, so it is frequently part of the services provided when governments channel support indirectly through incubators. Feedback from start-ups indicates that it is a highly valued service but can vary in quality. For example, it is most valuable when offered by experts familiar with the peculiarities and challenges of the relevant clean energy sector, and not by generalists or by experts in, say, digital business. It would therefore be helpful to integrate best practices from around the world into both direct and indirect support programmes. Two case

study programmes that emphasise milestone-setting and progress-tracking are Canada's Women in Cleantech Challenge and the EIT InnoEnergy Highway.

Offer single access points for multiple support measures

Nearly all our case studies offer combinations of financial and service-based support together. Some, such as American-Made Challenges, Breakthrough Energy Solutions Canada, EcoLabs-COI, IN^2 and the Women in Cleantech Challenge include all four support areas (financing, infrastructure, services and networking) in their programmes. Green Innoboost and Start-Up Chile also offer broad packages of services.

Meanwhile, Innovation Norway aims to become a one-stop shop for start-ups to access the Norwegian government's various support measures adapted to different TRLs. Innovation Norway already provides start-ups with an adviser to guide them through its programmes.

Case studies

American-Made Challenges

Government: United States

Responsible government entity: National Renewable Energy Laboratory (NREL)

External partner: N/A

Target type of innovator: Differentiated by stage of maturity, from idea to technology readiness level (TRL) 6

Links: https://americanmadechallenges.org/

Key elements:

- Vouchers that can be redeemed at national energy laboratories or other approved facilities in the American-Made Network are part of the prizes.
- Small cash incentives are used to encourage peer-to-peer support.
- The prizes are technology-specific, and each has a sponsoring government department (departments can propose problem statements for new challenges). The model allows for private-sector sponsors to fund NREL-led prizes.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: non-dilutive grants awarded as prizes (without spending constraints)	Direct: vouchers for national energy laboratories and other facilities	Direct: support to help teams prepare for competition Indirect: Recruitment support and business services via six third-party organisations	Direct: an online networking platform and rewards for peer-to-peer collaboration between network members

The US Department of Energy (DOE) and NREL initiated the programme to support innovations that could stimulate more domestic US solar manufacturing. The DOE sponsors it and NREL administers it. The first challenge, called Solar Prize, was launched in June 2018 and focused on solar manufacturing. The model has since been expanded to include prizes in technology areas including buildings, water, geothermal and advanced manufacturing. Each prize is unique, and while most focus on making inventive hardware solutions, some also encourage new

business models or software solutions. Since 2018, NREL has customised several different prize structures to fit the needs of the programme as it has targeted additional technology areas.

How support is made available and allocated

Prizes are designed in co-operation with DOE departments based on identified technology needs. In 2021, ten prizes were launched. The window for applications varies in length and can be between 4 and 12 months. If a prize has multiple steps, these may run sequentially, with total duration between launching the first step and completing the evaluation of the last step being two and a half years or more. HeroX, a private crowdsourcing platform, is used to register applications. An expert panel reads, scores and comments on video and written submissions, and NREL and the DOE sometimes hold interviews with applicants. The level of detail and length of evaluation depend on the nature of the prize topic and can vary for different award levels within a prize. The final prize judge is usually the DOE.

Financing

American-Made Challenges provides non-dilutive cash prizes (i.e. public grants that are direct payments with unrestricted use) and in some cases, vouchers for national energy laboratories and other qualified facilities. Each prize targets different innovation stages and has different prize values, rules and timelines. For example, the American-Made Solar Prize Round 4 had three contests, designed as three escalating challenges:

- "Ready!" – cash grants of USD 50 000 for each of up to 20 winners at "ideation" stage, wanting to propose a path to prototype.
- "Set!" – cash grants of USD 100 000 and national energy laboratory vouchers[1] up to USD 75 000 for each of up to 10 winners to further develop prototypes.
- "Go!" – cash grants of USD 500 000 and national energy laboratory vouchers up to USD 75 000 for each of up to two winners to perform pilot tests with an industrial partner.

Infrastructure

Recipients can use laboratory vouchers to access equipment and expertise at the 17 national energy laboratories and other qualified facilities, and the rules also provide the possibility to spend part of the voucher at a private facility of the winner's choice. NREL helps participants to locate and use the national energy

[1] These can also be used at other qualified facilities.

laboratory and other facilities, including those that can make, test and validate specific pieces of technical equipment.

The monetary value of the laboratory services is agreed by the recipient and laboratory staff and debited from a dedicated American-Made Challenges budget at NREL. NREL, and other national energy laboratories, make available the resources to work with teams in exchange for the vouchers. Typical technical services to the start-up companies include product testing, validation, analysis and fabrication. In the American-Made Solar Prize, the vouchers were valid for one year from the award of the prize.

Services

NREL subcontracts with third-party organisations that help teams prepare their entries in the competition. Six of these organisations, called Power Connectors, were selected for funding as part of the programme in 2020. The services provided vary according to organisation and prize. They include: assistance with recruitment; leading team-building events; implementing so-called Demo Days; linking the teams to technical expertise; and reviewing ideas, submissions and business plans. The Power Connectors are required to help the relationships they enable to have mutual benefit for all parties involved.

Networking

The American-Made Network includes national energy laboratories, incubators, investors, philanthropists, industry, researchers and other experts from around the United States. NREL asks network members to provide technical insight, marketing expertise, product validation and other support to start-ups and help to connect recipients with suppliers and customers. NREL is considering options for expanding the domestic network by adding connections to the Incubatenergy Network and similar opportunities with international networks. The network, which includes stakeholders that are not part of other DOE networks, is used to raise awareness of other DOE programmes and opportunities.

A novel element of American-Made Challenges is the availability in some of the challenges of small monetary rewards to network members that voluntarily support a team, usually one that goes on to win one of the prizes during the competition. The values are relatively small – rarely more than USD 10 000 each, once the available pot is divided – and are intended to serve as a bonus to publicly acknowledge and encourage support within the innovation ecosystem. Connectors are not only start-ups: they can also include academics, corporates, investors or other service providers. Competing start-ups in a given round cannot be a Connector for that round. NREL has tweaked the structure of these rewards

as the prize designs has evolved into different technology areas, and integrated them mostly in the solar prizes.

NREL has developed a matchmaking tool, currently in beta version, and plans for it to become automated, including by using artificial intelligence to help match start-ups' needs with relevant services and expertise in the network.

Evaluating and tracking impacts

NREL collects data related to the teams' experiences during the programme, their ongoing business success and interesting technical achievements. These results are shared with the DOE to enable programme improvements.

At this time, NREL does not currently evaluate applicants on their potential to reduce greenhouse gas emissions nor track their impact after receiving an award. However, it is working with DOE experts to see if these aspects can be included in future. The technology-specific prize design means that the underlying problem is already identified as a bottleneck to significant greenhouse gas reductions.

Experiences and learnings so far

As of the end of 2021, 27 prizes had been launched, of which 10 are completed, 13 are in progress and 4 are open for applications.

Findings, according to staff involved:

- Researchers and entrepreneurs with innovative technology ideas are attracted to the prize format because the barrier to entry is lower than for traditional calls for public grants and loans. Because the prizes reward past efforts to develop new ideas they carry lower risk for the government than grants awarded for future work based on *ex ante* evaluations of applicants' potential.
- American-Made Challenges has proven to be a speedier means of supporting start-ups than other existing US government grant programmes. Recipients that are able to advance through a series of time-based competitions can reach stages of maturity in months that could have taken years to achieve via other public programmes.
- Recipients mention that receiving even small amounts of unrestricted funding can be more impactful than receiving larger amounts of grant funding that are conditional on certain restrictions and reporting requirements. Despite being generally unfounded, some start-ups perceive a risk with government grants that the government could have a claim to resulting intellectual property and this would deter equity investors.
- The prize approach attracts all levels of ideas experience, bringing new innovators that have not traditionally worked with the DOE or national energy laboratories into contact with them. As some of the ideas would not be mature

enough for traditional government funding programmes, American-Made Challenges has proven to be a relatively low-cost means of learning about the potential of a technology, team or business proposition.

- The ability to work directly with NREL researchers to identify available laboratory resources and possible testing programmes is highly appreciated because most innovators are unaware of how to work with national labs and do not know the range of available expertise, facilities and equipment.

Complementary and related programmes

ARPA-E

GCxN

Incubatenergy

IN^2

Lab Partnering Service

Presidential Innovation Fellows

Small Business Innovation Research (SBIR)

Clean Energy International Incubation Centre

Government: India

Responsible government entity: Department of Biotechnology and Biotechnology Industry Research Assistance Council (BIRAC)

External partners: Social Alpha, Tata Trusts and Tata Power Delhi Distribution Limited

Target type of innovator: Early-stage clean energy start-ups (technology readiness level [TRL] 3-9)

Links: https://ceiic.socialalpha.org/

Key elements:

- The public-private partnership model is atypical and significantly expands the support to start-ups, especially by providing access to industrial testing facilities and possible commercial partners.
- As an initiative launched under the auspices of Mission Innovation, the Clean Energy International Incubation Centre (CEIIC) has an international outlook and international contacts. CEIIC encourages overseas applicants that can contribute to solving India's energy challenges.
- Government funding has helped build a state-of-the-art physical space for start-up incubation in a short period of time, including prototyping and computing assets.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Indirect: Seed equity investment using Social Alpha funds	Indirect: CEIIC has in-house laboratory and technical support, and its corporate partners offer access to their laboratories and testing facilities	Indirect: A wide variety of in-house business and technical services, plus discounted access to other professional services	Direct: participating government institutions help connect start-ups with their networks Indirect: Social Alpha and its corporate partners have access to extensive networks of experts

CEIIC was established in 2018 as a joint public-private initiative under the auspices of Mission Innovation, an intergovernmental forum for multilateral energy technology co-operation. It is a joint initiative of the Government of India and Tata Trusts, a philanthropic organisation that is majority shareholder of the Tata group

of companies. It is run by Social Alpha, a not-for-profit innovation-focused organisation, with support from:

- Department of Biotechnology of the Government of India.
- BIRAC, a not-for-profit public body that helps biotechnology enterprises.
- Tata Power Company Limited, India's largest electricity generator and distributor.
- Tata Power Delhi Distribution Limited, an electricity retailer in the north and northwest parts of Delhi, 49% owned by the Government of the National Capital Territory of Delhi.

CEIIC was set up as public-private partnership with a cost-sharing model between the Government of India and Tata Trusts (43:57). Operational costs are shared with Social Alpha and part of the government's ongoing support comes from BIRAC's BioNEST (Bioincubators Nurturing Entrepreneurship for Scaling Technologies) initiative.

CEIIC's mandate is to look for start-ups with innovative solutions to challenges across the entire energy value chain in India, with a strong focus on affordability, accessibility and user experience. Its sectoral scope is broad, covering household energy access, clean cooking, smart appliances, rooftop solar, industrial waste heat recovery, industrial energy efficiency, agricultural irrigation, cold chain, waste-to-energy, electric vehicles and charging, building automation, energy-efficient cooling and heating for buildings, and energy transmission networks.

The range of support measures offered draws upon Social Alpha's existing suite of tools, including seed funding processes, a market access programme and a network of investors, companies and sources of profession support. It is open to applications from overseas start-ups looking for help entering the Indian market.

How support is made available and allocated

CEIIC uses both a permanently open call for all eligible technologies and an annual call with a technology focus to solicit applications for support. In addition, it receives referrals from partners, such as other incubators, and scouts for talent. The annual call is titled Techtonic – Innovations in Clean Energy (previously, Social Alpha Energy Challenge) and it typically attracts over 500 applications for financial and incubation support. Its technology focus is articulated as a set of problem statements for the annual calls, which in 2021 covered clean energy for better livelihoods, smart energy systems, energy storage and thermal comfort. As an example, the problem statements for thermal comfort were:

- High upfront and operating costs of clean energy-powered efficient heating/cooling solutions.
- Adverse health impact due to traditional unclean solutions.

- Unavailability of affordable efficiency control devices that could lead to reducing energy demand for heating, ventilation and cooling, making it more affordable.
- Lack of customised solutions to specific regional, climatic and community needs.

Evaluation is based on impact potential (on climate and society), technological novelty, ability to achieve financial sustainability, and potential to reach large-scale operations.

Depending on how the start-ups enters CEIIC's programmes, different models of support are available:

- Basic: A basic package of business services is available to all start-ups.
- Equity-based: start-ups who receive equity investment benefit from the most extensive support, including access to laboratory tools, office space and a deeper engagement on strategy and product development.
- Credits: start-ups selected as winners of the annual "challenge" calls or are referred from partner programmes but do not pursue the equity-based model, receive an allowance of credits that can be worth more than INR 2.5 million (USD 33 000) and are redeemable against infrastructure and services.
- Pay-as-you-go: Start-ups that are not receiving equity-based incubation support, have not received credits or have already redeemed all their credits can pay for use of any available infrastructure and services using cash or by yielding the equivalent equity value to Social Alpha. This model is often most suitable for overseas start-ups that are not selected via the annual challenge calls.

The typical length of CEIIC incubation programmes is 12 months.

Financing

Not all start-ups supported by CEIIC receive financing. However, selected start-ups are eligible for seed equity investment of up to INR 10 million (Indian rupees) (USD 130 000), which is invested by Social Alpha using its own resources. Social Alpha undertakes the financial assessment and due diligence process for interested start-ups.

In addition, start-ups selected for support at CEIIC are eligible for non-dilutive grants for product development and scale-up. Social Alpha also connects start-ups with its network of investor partners.

Infrastructure

Start-ups receiving incubation have access to infrastructure including laboratory facilities, a co-working space, conference rooms and concierge services. At its headquarters, CEIIC has a rapid prototyping lab with 3D printers and scanners, circuit board printing and testing facilities, laser cutters, computing infrastructure with software suites, and various workshop tools. Planned additions in 2022

include more measurement equipment, sensors, thermal imagers, calibrators and data acquisition systems, plus a battery testing facility and an ability to undertake electromagnetic interference and compatibility testing against industry standards.

In addition, start-ups have access to six research facilities at Tata Power, including battery and meter testing laboratories, switchgear and power transformers workshops, and communications and smart grid laboratories. Hosted in the same building as Tata Power Delhi Distribution Limited's Smart Grid Lab, CEIIC also has access to a testing facility for energy storage, smart grid applications and a solar PV generator.

Start-ups receiving credits can spend them on support that is in line with the needs assessment made for each start-up by CEIIC at the beginning of its incubation programme.

Services

Some support services are free to access for all selected start-ups. This basic package include strategic advice, assistance with business and financial models, expert mentorship, access to coaches, discounted software purchases, workshops, procurement support and assistance with designing impact metrics. CEIIC monitors start-ups for their improvements during its period of support.

Start-ups receiving equity-based incubation or credits also have access to services such as: branding and marketing; intellectual property filing; legal, secretarial and compliance advisory; accounting and book keeping; and more mentorship and advisory support from domain experts. Start-ups receiving equity-based incubation have a higher level of assistance with fundraising.

CEIIC vets a range of service providers and can help start-ups to buy their services at a discount. Such services include hiring and payroll management, branding and communications, legal and compliance, taxation, secretarial assistance, and intellectual property filing.

CEIIC assists start-ups in identifying and accessing suitable funding opportunities from other sources. These include grants and accelerator programmes run by the Department for Biotechnology and BIRAC, plus the different types of support provided by the government's National Initiative for Developing and Harnessing Innovations (NIDHI). CEIIC also works with organisations that can provide funding and market support, such as Sustain Plus, a foundation for energy access and development co-founded by Social Alpha, the Selco Foundation and Collectives for Integrated Livelihood Initiatives (CInI), also supported by Tata Trusts and IKEA Foundation.

Networking

CEIIC's networking support builds on the networks of Social Alpha, Tata Power and Tata Power Delhi Distribution Limited. These networks include some of the main scientific universities and think tanks in India. The government's Department. of Science and Technology, Department of Biotechnology and NITI Aayog institutions commit to supporting start-ups with connections to their networks.

CEIIC's connection to Mission Innovation has enabled its start-ups to receive exposure and networking opportunity internationally.

Evaluating and tracking impacts

CEIIC integrates emissions impact assessment into its evaluations. This is performed in collaboration with RISE in Sweden, which applies its own Avoided Emissions Framework. RISE estimated the combined emissions avoidance potential of 20 start-ups incubated at CEIIC to be over 200 million tonnes of CO_2 equivalent per year by 2030.

Start-ups' impact potentials are also tracked using outcome and impact indicators defined for each start-up and mapped against the UN Sustainable Development Goals. Using these metrics, CEIIC assesses progress at least monthly for each recipient during the 12-month programme.

Experiences and learnings so far

CEIIC incubated start-ups have received have received over 70 awards and recognitions as well as additional funding. The awards include the prestigious Earthshot Prize, won by Takachar and featuring SOLshare as a finalist.

CEIIC administrators identify several learnings from their experience so far that they are using to improve the programme:

- The early-stage start-up ecosystem for clean energy remains fragmented in India, and there is a continuing need for support from government and not-for-profit sources.
- The public-private model has delivered benefits beyond the direct support to selected start-ups. The involvement of the private sector has strengthened the clean energy innovation ecosystem in general and made the participating companies much more engaged in the opportunities and challenges in the area.
- There is more than one "valley of death" for clean energy start-ups, which necessitates a more strategic approach to support, in terms of both financing and other services.
- There is significant value in building technology problems and net zero emissions compatibility into the eligibility criteria at the outset based on a

corresponding investment thesis. This helps to ensure that resources are prioritised in line with social and environmental needs.

- CEIIC's strategic partnerships have been a particularly valuable part of the support provided. Incubators' impact is much larger if they act in concert with the wider innovation ecosystem and strengthen their partnerships.

Planned developments for CEIIC include more international co-operation with institutions in other countries to facilitate scale-up in cross-border markets, more focus on climate impact and enhancements to all existing CEIIC programmes.

Complementary and related programmes

NIDHI, including Technology Business Incubators

Atal Incubation Centre

EcoLabs-COI

Government: Singapore

Responsible government entity: Enterprise Singapore

External partner: Nanyang Technical University (NTU)

Target type of innovator: Recently incorporated companies ready for real-world pilot testing of energy technologies (technology readiness level [TRL] 7+), and also some TRL 4 innovators

Links: https://ecolabs.sg

Key elements:

- The EcoLabs Centre of Innovation for Energy (EcoLabs-COI) focuses on collaborations that can help energy technology developers to explore commercial opportunities, and has established an international network of accessible test beds in companies around the world.
- It includes support for business development and has developed in-house expertise to pair advisers with recipients.
- It has an international approach to finding markets for start-ups and working with overseas government agencies to partner with their equivalent programmes.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
-	Indirect: NTU and its partners are building a network of accessible test beds globally to pilot new technologies	Indirect: Through the EcoLabs-COI Centre, NTU and its partners offer services including fundraising advice, connections to potential clients and access to consortium projects	Indirect: NTU and its partners facilitate international connections to other government programmes and provide exposure for recipients at events

Enterprise Singapore, NTU and the Sustainable Energy Association of Singapore (SEAS) jointly established EcoLabs-COI in 2019. Enterprise Singapore, overseen by the Ministry of Trade and Industry, funds NTU to host and run EcoLabs-COI. EcoLabs-COI aims to help Singapore-based energy start-ups and small and medium-sized enterprises (SMEs) that are applying cutting-edge scientific principles. EcoLabs-COI provides them with access to facilities and connections

that can help technology developers to explore commercial opportunities. This includes access to R&D experts, lab infrastructure, test bed sites and business opportunities to help them successfully commercialise and scale up their technologies. To date it has focused on electrification, energy efficiency and digitalisation. In addition, in line with evolving government priorities and national strengths, EcoLabs-COI's focus has expanded to include urban mobility, renewable integration, smart grids, CCUS and topics related to the so-called circular economy.

How support is made available and allocated

EcoLabs-COI has a permanently open call for applications for support. Start-ups from around the world can apply, as long as they have potential value to Singapore.

Financing

N/A

Infrastructure

The awards are for defined projects and can include access to infrastructure for building and testing a technology or access to services for help with developing the commercial offering. For projects receiving infrastructure support, EcoLabs-COI has different options depending on the maturity and needs of the start-ups.

For early-stage start-ups, EcoLabs-COI can provide the access to NTU laboratories and facilities for prototyping and testing. Renewable Energy Integration Demonstrator – Singapore (REIDS) is its largest hybrid microgrid test bed. It accommodates various end-use technologies and tests flexibility requirements. It can be available to start-ups wanting to validate their energy storage, renewable integration or microgrid solutions.

For other start-ups, EcoLabs-COI has partnerships with more than 30 test beds in external organisations. These include shopping centres, educational institutions and manufacturing sites. The premises of the Carros Centre and car parks of 1923 Pte Ltd can be utilised, as well as the Experimental Power Grid Centre for EVs and electricity system integration and Punggol Social Innovation Park for autonomous robotic vehicles. Mistletoe incubator and JTC government infrastructure are partners for testing technologies within their remit of climate change solutions. Some of these test beds are overseas, including Bangalore International Airport Limited (BIAL) for buildings energy efficiency, electric mobility, smart cities technologies and internet-of-things applications.

Intellectual property (so-called joint foreground IP) generated as a result of EcoLabs-COI projects on new products and services is shared by the start-up and NTUitive. NTUitive supports the licensing of this co-developed IP, including licensing it back to the start-up if it wishes to use it.

Services

For projects receiving business and technical service support, EcoLabs-COI provides various types of in-kind assistance. These include pairing start-ups with a potential corporate customer to co-operate on designing a project that EcoLabs-COI and the corporate entity can jointly support through corporate funds, and EcoLabs-COI's access to infrastructure and services. The value of EcoLabs-COI's in-kind contribution (a combination of infrastructure and services) can be approximately one-third to one-half of project costs.

EcoLabs-COI has dedicated in-house technical and business expertise and assigns recipients to one of seven business consultants. The consultants guide the development of a strong business model, help to position the product in the market, and advise on customer and supplier acquisition, as appropriate. EcoLabs-COI supports market research, assessment of technology novelty and feasibility analysis. If EcoLabs-COI does not have the necessary expertise, it works with SEAS to access it. EcoLabs-COI charges a nominal fee for access to innovation and commercialisation service providers outside its pool of expertise with which it has standing agreements.

EcoLabs-COI organises monthly pitch sessions for recipients with its group of private investors who are looking for high-potential start-ups.

EcoLabs-COI works with recipients to identify existing intellectual property or research at NTU that could benefit the start-up.

EcoLabs-COI also assists recipient start-ups and SMEs in applying for government grant funding opportunities, especially those from EcoLab's sponsoring agency Enterprise Singapore. This service is for start-ups meeting the eligibility requirements for Enterprise Development Grants: being registered and operating in Singapore; having 30% local shareholding or more; and being in a financially viable position to start and complete the funded project.

EcoLabs-COI also supports the PowerACE EcoLabs-COI Special Award. The winners of the EcoLabs-COI Special Award in 2019 to 2021 each received a prize worth SGD 100 000 (Singapore dollars) (USD 75 000). This prize includes the equivalent value one year of EcoLabs-COI support services and access to infrastructure.

EcoLabs-COI also promotes recipients at relevant events and the media. This is a central part of the support provided to finalists of the EcoLabs-COI Special Award.

Networking

EcoLabs-COI in Singapore has developed practices to exchange expertise with overseas government agencies and educational institutions to give its own start-ups the best chance of overseas success. To exchange expertise, it works with Canada (High Commission), India, Korea (Korea Trade-Investment Promotion Agency [KOTRA]) and New Zealand (Ara Ake) to offer public-supported start-ups from those countries to receive on-the-ground incubation support in Singapore and assistance with access to nearby markets (a so-called “soft landing”).

To help with international market access, EcoLabs-COI has relationships with governments and companies in Germany, India, Israel, Korea, Norway, Chinese Taipei, the United Kingdom and the United States. A typical type of collaboration is to find a potential customer in one of these countries that can provide a test bed for a project in its commercial and regulatory environment. In several cases, this has led to joint project funding by two or more governments. It is also currently collaborating with the Korean trade commission to run a structured joint programme from 2022.

Evaluating and tracking impacts

EcoLabs-COI tracks the progress of recipients and the overall programme using key performance indicators, including the number of recipients, the success of subsequent deployment and company valuation.

Experiences and learnings so far

In three years, EcoLabs-COI has supported over 35 start-ups and SMEs in clean energy technology, a sector in which Singapore has not traditionally been a major player. It has over 30 test beds for pilot testing of different technologies and five non-government funding partners.

Findings, according to staff and recipients:

- EcoLabs-COI is playing a valuable role in helping start-ups to secure contracts with international entities by creating connections and bringing the reputational benefit of government backing to the process.
- EcoLabs-COI’s attention to business development has helped start-ups with hiring and service aspects not covered by other Singaporean funds.
- The availability of energy-specific calls was welcomed by start-ups in the field that find themselves at a disadvantage in open economy-wide initiatives

because of the long lead times and large funding requirements associated with energy hardware and the lack of energy market knowledge among evaluators.

- It has been valuable to have priority technology areas (initially, electrification, energy efficiency and digitalisation). However, this limited Singapore's entry into growing global areas such as CCUS and hydrogen, which have now been integrated into EcoLabs-COI's portfolio.
- Start-ups report that EcoLabs-COI has been successful in creating an ecosystem for clean energy technology innovation in Singapore that did not previously exist.

Complementary and related programmes

Enterprise Singapore: Enterprise Development Grants

Scale-up SG

Globalstars Singapore

Clean Energy International Incubator, India (a partner of EcoLabs-COI)

EIT InnoEnergy Highway®

Government: European Commission

Responsible government entity: European Institute of Innovation and Technology (EIT)

External partner: EIT InnoEnergy

Target type of innovator: Early-stage start-ups with a proven concept and high potential to scale up, make a positive impact on the pace of energy transitions globally and bring value to European economies

Links: https://bc.innoenergy.com/for-start-ups

Key elements:

- Provides financial support and services in exchange for an equity stake in ventures.
- Recipients participate in an acceleration programme tailored to each start-up's needs and based on a mutually agreed roadmap.
- Services are delivered by an in-house team based in Europe and the United States as well as trusted EIT InnoEnergy partners around the world that commit to providing in-kind support to the programme in return for access to the network. While the focus is on delivering EU objectives, the scope of the network is global to identify overseas talent that can operate in Europe and help EU talent succeed abroad.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Indirect: EIT InnoEnergy is publicly co-funded to support start-ups (including with cash transfers), which it does in exchange for equity investments	Indirect: access to laboratory equipment via InnoEnergy partners, plus office space is provided in Europe and the United States	Indirect: EIT InnoEnergy is publicly co-funded to provide acceleration services in-house or via third parties	Indirect: InnoEnergy is publicly co-funded to build and manage a network including private and public investors, companies, research centres, universities and public institutions

In 2009, the European Institute of Innovation and Technology (EIT), an agency of the European Union established in 2008, launched the Knowledge and Innovation Community (KIC) InnoEnergy as one of the first three KICs selected for co-funding (from among 20 proposals) to "strengthen cooperation among businesses

(including SMEs), higher education institutions and research organisations [and] form dynamic pan-European partnerships." The KICs cover training and education programmes as well as thematic business acceleration programmes. As of 2022, there are eight KICs.

The consortium that was awarded the grant to run KIC InnoEnergy incorporated itself as "EIT InnoEnergy" to be able to act as a single legal entity with the strategic and financial outlook of a private company. EIT InnoEnergy's mission is to help companies and innovators accelerate energy transitions by making energy more affordable, secure and sustainable, including as the recipient of an EU grant that covers up to 25% of the costs of operating KIC InnoEnergy. Its 26 shareholders represent a range of educational, research and business entities. It is also financed by other public European programmes as well as having its own resources, which it plans to increase through returns on its equity investments.

The EIT InnoEnergy Highway programme is one of the ways in which EIT InnoEnergy executes its commitment to support early-stage start-ups to make their technology-based businesses reach the market "bigger, sooner and safer", for example by reducing the risk they present to customers and investors. This commitment is set out in the grant agreement with EIT (which governs EIT InnoEnergy's EU public funding) and is met through a combination of funds that come directly from that EU grant, plus other sources and in-kind contributions from partner organisations. In addition to Highway, EIT InnoEnergy runs educational programmes for students and other learners, for which it receives some income from course fees. In 2017, the European Commission gave it a mandate to lead the European Battery Alliance, and it also supports other industrial value chains initiatives such as the European Solar Initiative and the Green Hydrogen Acceleration Center. Furthermore, it supports and invests in innovative companies beyond the Highway programme, some of which are more mature than Highway start-ups. For example, EIT InnoEnergy has invested since 2017 in Northvolt, a Swedish company seeking to scale up lithium-ion battery manufacturing in Europe that is now valued at over USD 10 billion.

How support is made available and allocated

Start-ups may apply to Highway at any time, and EIT InnoEnergy also scouts for relevant start-ups, including through referrals from contacts in its network. In 2018, a technology-specific call was used to attract innovators in the area of batteries for electricity storage in response to rising interest from the investment community and strong performance of battery-related start-ups already in the EIT InnoEnergy portfolio.

EIT InnoEnergy evaluates Highway applicants according to criteria including technology quality, novelty, market potential, team competence, potential to scale-

up and potential impact on greenhouse gas emissions and consumer energy costs.

Innovators can apply to Highway before they incorporate a company. In such cases, EIT InnoEnergy can assist with incorporation.

Applicants, who can be located anywhere in the world, are selected for their potential future contribution to EU energy and economic objectives. However, to receive support measures that are funded via the EU public grant to EIT InnoEnergy, non-EU start-ups are assisted to establish EU subsidiaries. For example, Principle Power, initially a US-based developer of floating wind technology, was helped to establish a Portuguese subsidiary.

Financing

Recipients of Highway support receive dilutive equity investment (a minority stake) in exchange for acceleration support. The nature of the support services, including milestones and objectives, is detailed in a "roadmap" that is agreed after the signing of the Highway contract between the start-up and EIT InnoEnergy.

While many services are provided in-house or procured for start-ups, some support is provided to start-ups by transferring funds for the purchase of certain services or equipment identified in the start-up's Highway roadmap. These "sub-grants" are public funds stemming from the EU public grant, and, while EIT InnoEnergy can allocate the funding at its discretion, they are nonetheless bound by public procurement rules. Therefore, the sub-grants may only be used by start-ups for technology development, equipment purchases, entrepreneurial skills training (for example, in sales, finance, pitching or negotiation, depending on needs) and team creation, including recruitment.

Infrastructure

Through its partners, EIT InnoEnergy can facilitate access to research facilities or laboratories for technology development and testing for recipients of Highway support. These partners include universities that commit annually to making laboratories available to Highway start-ups or commit to providing laboratory access at a discount. For example, CorPower Ocean, a developer of wave energy devices, accessed KTH Royal Institute of Technology laboratories in Stockholm.

For start-ups in proximity to one of EIT InnoEnergy's eight premises in the European Union or its one location in the United States (Boston, MA), office space can be provided.

Services

Recipients of Highway support are provided with a tailored set of services that reflect EIT InnoEnergy's investment case for each start-up and responds to the start-up's needs. The services to be provided are in the roadmap. The support lasts two and a half years on average, a period that is longer than typical incubation programmes, in order to respond to the longer development times of clean energy hardware. Nine different types of services are possible:

- access to finance
- access to market
- access to talent
- citizen engagement
- governance
- product and intellectual property
- regulation
- sales
- supply chain management (industrialisation).

Networking

Recipients of Highway support benefit from access to the many connections managed by EIT InnoEnergy among more than 700 stakeholders from the education, research, industry and investor communities in Asia, Europe and the United States. Over more than ten years, a system has been developed for stakeholders to gain access to EIT InnoEnergy events, knowledge and talent (including students, graduates, start-ups and potential project partners) in return for making a contribution to the support provided by EIT InnoEnergy. The 26 EIT InnoEnergy shareholders are among these partners. The support is generally "in-kind support" and can include laboratory access, services (either free of charge to the start-ups or at a discounted price) or participation in advisory committees. The resulting network – a so-called trust-based, open innovation ecosystem managed by a private company – is a first of its kind.

EIT InnoEnergy organises an annual event, The Business Booster, to convene stakeholders. It has attracted over 1 000 attendees in past years and includes pitching competitions and other opportunities for start-ups to introduce themselves to investors and corporate representatives.

Evaluating and tracking impacts

The aggregate impact of the Highway portfolio of start-ups is measured with the EIT InnoEnergy impact framework. This framework estimates economic, environmental and social impacts.

Economic:

- direct and indirect jobs created
- external funds raised by portfolio companies
- revenue generated by portfolio companies.

Environmental:

- carbon dioxide (equivalent) avoided
- energy costs saved
- energy generated from clean energy sources.

Social:

- households with access to energy in developing countries
- number of female entrepreneurs
- different nationalities supported (and nationalities per company).

Experiences and learning so far

In total, EIT InnoEnergy screened over 5 000 start-ups, supported over 480 of them, and invested in over 250 between 2010 and December 2020. Participants in in the Highway programme represent a large share of investees, but not all. The 480 companies have collectively raised EUR 3.4 billion (USD 3.8 billion) in external funds, filed 269 patents, launched over 300 products and averaged 16 months to reach market after EIT InnoEnergy investment. More than nine out of ten of the companies are still active and four of them have launched initial public offerings. While two have been valued at over one billion dollars, the support they received from EIT InnoEnergy was not via Highway.

EIT InnoEnergy judges its experience with running a technology-specific call on the topic of batteries positively. In addition to meeting its objectives of raising the number of energy storage start-ups being screened, it complemented EIT InnoEnergy's involvement in the European Battery Alliance. Technology-specific calls may be used again for Highway for similar aims, but such initiatives increase the administrative effort required and are not needed to ensure a sufficient and manageable flow of interest in Highway.

Since 2009, the situation for clean energy start-ups in Europe has improved dramatically, with much greater public and private attention being given to the topic. This has raised the dynamism of the investment market, which is now more highly capitalised. As a result, start-ups developing certain technologies – such as battery factories or biowaste converters – can navigate the early stages of growth without public support more easily. However, at the same time, the range of technologies that are considered for support has expanded considerably with a firmer European policy focus on the needs for net zero emissions.

EIT InnoEnergy has identified a range of issues that continue to hinder the success of start-ups participating in the Highway programme. It is working to address some of these through its own activities, including:

- Initiatives such as Battle of Green Talent, and its educational courses, through which EIT InnoEnergy seeks to raise the entrepreneurial ambitions of young innovators and address the continuing need to foster female entrepreneurs in the energy sector.
- By engaging with European Commission policy makers, it promotes dialogue about the difficulty for start-ups in certain technology areas to establish EU businesses in the absence of a common regulatory framework among countries, which dis-incentivises non-EU innovators from locating in the European Union.
- Through continual improvement of the Highway programme, EIT InnoEnergy aims to reduce the period for many companies after the earliest stages when they are not considered to be “bankable” by private investors and lenders and cannot scale-up without public support such as investment.

In addition, other issues sit further outside the control of EIT InnoEnergy, but if they were successfully addressed then this would complement Highway and make it more impactful. These include:

- Energy technologies are capital-intensive and are still not well served by the current investment landscape.
- Early-stage energy technology start-ups struggle to participate in long tendering processes for public procurement and secure performance guarantees.
- Compared to the situation in some other major economies, high potential graduates from overseas have fewer opportunities to remain in Europe and become innovators.
- Europe suffers from a lack of local suppliers that can quickly develop supply chains for new technologies.
- Large corporations such as utilities are slow to adopt new technologies from start-ups, which reflects low risk appetite in the energy sector more widely.

Complementary and related programmes

The EIT also funds EIT Climate KIC, which provides grants, incubation, hackathons and prizes. One such initiative is Climate Launchpad, a competition run by an expansive international community.

The European Commission established the European Innovation Council (EIC) Fund in 2020 to allow direct equity and quasi-equity investments in "European high-impact and deep-tech start-ups and scale-ups" to be accepted into the EIC Accelerator. In 2021, the EIC prioritised applicants with Green Deal innovations for economic recovery.

Energy Systems Catapult Living Lab

Government: United Kingdom

Responsible government entity: Innovate UK, a part of UK Research and Innovation

External partner: Energy Systems Catapult

Target type of innovator: Innovators with novel clean energy products or services seeking real-world consumer feedback or data to refine their offering and reach market quicker

Links: https://es.catapult.org.uk/tools-and-labs/living-lab

Key elements:

- It allows innovators to design and test products, services and business models with real people in over 500 digitally connected inhabited smart homes around the United Kingdom with a variety of tenures, property types and installed equipment.
- It provides independent validation by the Energy Systems Catapult, drawing on consumer insight, data analysis and business model experts.
- It helps technology developers to understand the needs of users and market requirements for commercialisation of a clean energy product or service.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
-	Indirect: independent validation of real-world performance in homes	Indirect: access to Energy Systems Catapult technical support, consumer data and analysis, market research, user experience, and service design	Indirect: provides connections to other innovators working on similar challenges

The UK government established Energy Systems Catapult in 2013 as an independent not-for-profit entity that is publicly funded to accelerate the transformation of the United Kingdom's energy system and help UK businesses and consumers to capture the associated economic opportunities. Energy Systems is one of nine Catapults, with others focusing on high-value

manufacturing, offshore renewable energy, medicines discovery and other topics. The first seven of these were launched in 2010. The government intends for the Catapults' innovation activities to be funded one-third from a core grant from the government via Innovate UK, one-third from industry partners, and one-third from collaborative R&D funds bid for by consortiums involving Catapults.

Living Lab was created in 2017 to provide a safe and affordable real-world test environment of digitally connected homes. Energy Systems Catapult designed the facility to enable small and large businesses to rapidly design, market-test and launch their smart energy innovations with real people in their own homes in real time. It also provides a national capability to test and demonstrate new market arrangement, policies and regulations with real consumers. Anticipated outcomes include innovative ways to retrofit homes for net zero emissions objectives, making homes warmer, lowering energy bills and improving health outcomes.

How support is made available and allocated

Living Lab has a permanently open call for proposals. Technology developers can make contact at any time to explore the possibility of using the Living Lab for tests. In addition, recipients of Energy Systems Catapult support under its Energy Launchpad calls for proposals can access the Living Lab if this is determined to be appropriate. One focused call for proposals was run in winter 2019/20 to select three small and medium-sized enterprises (SMEs) with new approaches to building retrofit measures that could be installed quickly in participating households. In that case, Energy Systems Catapult covered around 80% of project costs.

Financing

N/A

Infrastructure

Living Lab is a means through which Energy Systems Catapult provides start-ups with access to a real-world test environment for trialling new products, services and business models. Energy Systems Catapult recruits households on an ongoing basis and uses standardised agreements to facilitate safe working principles, consistent testing conditions and access to data. In return, households are paid by Energy Systems Catapult for their participation in tests, with the amount varying depending on the time commitment for each project. In this way, the costs of initial customer acquisition are dramatically reduced for technology developers. A variety of standard data points are collected from each participating household, including energy consumption, air temperature, relative humidity and local weather. In 2021, electric vehicle charging was integrated into the suite of

equipment and behaviours of some Living Lab households. The cloud-based data platform was upgraded in 2020 to be open and technology-agnostic.

Services

Energy Systems Catapult supports recipients with technical expertise to conduct their Living Lab trial. This includes access to historic data, data scientists and artificial intelligence algorithms. Historical data are available via the USMART platform. Learnings and data from Living Lab homes are shared in webinars and insight papers published by Energy Systems Catapult.

Business services are also available to recipients, including energy market research, user experience, service design and trial design.

In addition, virtual Meet the Experts sessions are open to SMEs regardless of whether they are recipients of Living Lab support. These sessions can be tailored to the interests of the SMEs.

Networking

Energy Systems Catapult helps recipients of Living Lab make connections with potential partners with which they could build consortiums and projects to apply for government funding.

Evaluating and tracking impacts

Energy Systems Catapult evaluates the impact of the Living Lab as part of its relationship with Innovate UK. It also monitors the impact on businesses of Living Lab support to help identify the value of the facility and the opportunities for improvement. For reasons of commercial sensitivity, these evaluations are not publicly available.

Experiences and learnings so far

In 2021, Energy Systems Catapult published a report on lessons from the Living Lab. This mostly focused on a 2017-2018 field trial working with 108 households to learn more about how people actually use heat. It generated insights that will be used to inform future trial design.

In collaboration with the Power Networks Demonstration Centre at the University of Strathclyde, Living Lab is being expanded to explore the impact of household preferences on energy networks. This initiative, called Whole Energy Systems Accelerator, is the world's first example of a facility that can concurrently test the interaction between activity in homes and energy networks – the physics, human

behaviour, technology and market – in real time and across different future energy system and market scenarios.

Energy Systems Catapult highlights AirEx Technologies as an example of success. The technology is a smart ventilation control using an intelligent air brick. Since receiving Living Lab support, the company has received more investment, gotten regulatory acceptance (including approval by UK energy regulator Ofgem for the ECO 3 Scheme) and achieved a fivefold increase in turnover.

Amp X received support from Living Lab to test and refine the design of their autonomous, digital energy assistant ALICE. ALICE has the potential to reduce energy costs and carbon intensity for UK households by automating decisions about energy consumption in response to market signals.

Green Innoboost

Government: Morocco

Responsible government entity: IRESEN (Institut de Recherche en Énergie Solaire et Énergies Nouvelles [Research Institute for Solar Energy and New Energies])

External partner: N/A

Target type of innovator: Moroccan early-stage start-ups and other innovators that are trying to move from the laboratory to having a viable company and tested product on the market (technology readiness level [TRL] 6-8)

Links: www.iresen.org/

Key elements:

- The initiative provides funding that recipients can use for a variety of purposes: to acquire equipment, test and certify the prototype, pay staff, or buy consultancy.
- Applicants can choose to receive the funding either as a non-dilutive grant or an equity investment from IRESEN, in addition to access to a 1.5-year programme of business services and connections to Moroccan experts
- Support for procurement to help start-ups manage costs is included in the programme

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: funding that can be spent on a variety of projects and services (provided as a grant conditional on future royalty payments, or equity)	Direct: access to the Green Energy Park and Green & Smart Building Park platforms Indirect: IRESEN helps recipients to access testing facilities at universities and companies	Direct: procurement support Indirect: Recipients can use their grants to purchase services	Direct: connections to investors are provided, and peer-to-peer networking is being explored

Since Morocco published its National Energy Strategy and established IRESEN to build Morocco's clean energy innovation capabilities, IRESEN has shifted from supporting only R&D and laboratory infrastructure to also helping the potential

products from the R&D projects to reach markets. Objectives of the National Energy Strategy include:

- Develop low-cost, non-complex technologies that can meet the needs of the African market.
- Develop the capacity to be a technology exporter to advanced economies.

These objectives contribute to the overarching desires to contribute to Moroccan economic prosperity by fostering local wealth creation and to quicken Morocco's energy transition (including the target of 52% renewables in the electricity mix by 2030) by building local capabilities and reducing reliance on technology imports.

Green Innoboost is one of two categories of programme run by IRESEN since 2018. The other is Green Inno-project, which targets earlier-stage R&D projects (TRL>3). IRESEN refreshed the format of Green Innoboost in 2021; this case study reflects the new system, called Green Innoboost 2.0.

How support is made available and allocated

There was a first Green Innoboost call in 2018 and a second one in 2021. IRESEN stipulates the technology themes that are eligible for each call, in response to government priorities. The programme requires a consortium approach, with a requirement to have a Moroccan scientific institute or university as a project partner and an encouragement to include a Moroccan industrial partner. International partners are also possible, but only their costs incurred in Morocco are eligible for financing on the terms applicable to Moroccan partners. Applications are evaluated by IRESEN and experts from IRESEN's network, including international experts who can assess overseas market potential.

Financing

A unique design feature of Green Innoboost 2.0 is that it gives the applicants the choice of receiving the financing of up to MAD 1.5 million (Moroccan dirham) (USD 160 000) either as a grant or as equity. If they select to receive it as a grant, they must pay royalties to IRESEN worth 1.5% of any annual revenue from the innovation supported by the grant from the third year after the first revenue and for an indefinite period. If they select to receive it as equity, they yield up to a 20% stake to IRESEN, the possible future sale of which will be used to help IRESEN finance activities in support of the Moroccan clean energy innovation ecosystem.

In both cases, the funding is conditional on it being spent on eligible project costs over 1.5 years. The central element of the project must be technical, with eligible costs for grant expenditures including:

- equipment for testing and prototyping
- recruiting new team members

- international travel and attending conferences
- engaging external advisers and business services.

IRESEN disburses the financing by providing the recipients with a bank account in their name from which they can transfer the funds to pay for eligible expenses. This overcomes concerns about the risk of transferring money to companies that do not have strong balance sheets or credit ratings. In the case of equipment procurement, the equipment becomes an IRESEN asset if the project is not successful.

Infrastructure

IRESEN can facilitate access to well-equipped laboratories in its own platforms or in partner universities, a unique service compared with other start-up support organisations in Morocco. IRESEN platforms include:

- Green Energy Park, a site for solar energy testing, research and training inaugurated in 2017.
- Green & Smart Building Park, an R&D and testing facility for building energy efficiency and smart technologies for renewable energy integration in buildings. The site has been operational since 2019, with only its R&D centre still under construction in 2021.

Services

A range of business services from advisers and consultants are eligible costs for spending the funds, including intellectual property and legal services. IRESEN is exploring how to complement this with more direct provision of services, via training sessions and webinars. The intention would be to allow recipients to customise their programme but keep costs low by providing the services in group settings.

For scientific services, IRESEN manages a scientific board of advisers who review the projects' challenges. The access to the technical expertise of the consortium partners is a central element in evaluating the strength of the project applications.

IRESEN has a procurement team that scouts for and negotiates with potential suppliers. While start-ups can propose a preferred supplier, these are checked for quality assurance and reliability as per public procurement guidelines.

Networking

IRESEN connects start-ups with experts and investors in their network, both in Morocco and overseas.

The Covid-19 pandemic has reduced the amount of peer-to-peer contact within the projects of the first cohort that started in 2019. However, the intention of the programme is to facilitate peer-to-peer networking within and between cohorts in the future.

IRESEN has an international outlook to boosting clean energy innovation in Africa. It co-funded a solar research platform in Côte d'Ivoire to test solar in tropical conditions, equivalent to Morocco's Green Energy Park.

Evaluating and tracking impacts

N/A

Experiences and learnings so far

Green Innoboost is helping to foster an energy innovation ecosystem in Morocco, which did not previously have much activity in this area. When IRESEN was founded, there were no incubators in this area, and there are still only three private actors dedicated to green innovation. As most incubators struggle to provide the type of support needed by hardware start-ups with long lead times, IRESEN is proving the value of public-sector involvement.

As it gains experience, Green Innoboost is encountering barriers to success that require attention from regulators outside this ecosystem. This includes regulatory difficulties in commercialising low-voltage technologies and laws relating to labour and incorporation that make it risky for entrepreneurs in the energy sector.

Complementary and related programmes

Morocco launched Al Moukawala, a nationwide programme to have a platform where start-ups can identify the support organisations most adequate to their needs and development stage.

In 2020, Morocco launched INTILAKA, a funding solution with several commercial banks to make it easier for entrepreneurs to access banking. It can fund up to MAD 1.2 million (USD 130 000) at a 2% interest rate.

In 2021, National Agency for the Promotion of Small and Medium-Sized Enterprises and the association of incubators, Moroccan Start-up Ecosystem Catalysts, signed the Tatwir Startup, an agreement to support start-ups through pre-incubation, incubation and industrialisation. IRESEN is working on a partnership to provide support for prototyping of new technologies.

Fonds Innov Invest (FII) was established with support from the World Bank in 2017 and operated by TAMWILCOM, formerly the Moroccan Central Guarantee Fund.

FII channelled equity, grants and interest-free loans via four venture capital funds and 16 incubators and accelerators with the aim of funding 300 start-ups in three years. The programme did not fully cover incubators' operating costs, which made it challenging to meet the target. It did not specifically target clean energy.

Long-term Europe-Africa Partnership on Renewable Energy (LEAP-RE) is a programme co-funded by the European Union's Horizon 2020 budget. It aims to increase the use of renewable energy by supporting research, demonstration and technology transfer projects in Africa and the European Union. In most of the participating countries, SMEs are eligible to be project partners.

Incubatenergy Network

Government: United States

Responsible government entity: Department of Energy and National Renewable Energy Laboratory (NREL)

External partner: Electric Power Research Institute (EPRI)

Target type of innovator: Energy entrepreneurs at all stages of development, notably those that are complementary to electricity suppliers' businesses

Links: www.energy.gov/eere/technology-to-market/national-incubator-initiative-clean-energy-niice-0; https://techportal.epri.com/incubate-energy

Key elements:

- The initiative addresses a co-ordination gap in the innovation ecosystem, by helping incubators to share knowledge and create pathways for start-ups to progress through the right types of incubator and accelerator support.
- The objective of the government-funded initiative was to build a system that filled a gap in the ecosystem and could then be continued by the private sector without public support. NREL and EPRI achieved this outcome.
- The network, run by EPRI, has now expanded to include Incubatenergy Labs, a partnership for testing and demonstrating with utility companies.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
-	-	Indirect: EPRI was funded to help start-ups to understand and navigate the variety of incubator services in the United States	Indirect: EPRI was funded to strengthen the innovation ecosystem and help networking

In 2012, the US Department of Energy identified that a lack of interaction between incubators in the United States was hindering start-ups from finding opportunities and investment. The government awarded a grant to NREL and EPRI, a private not-for-profit members' organisation for electric utility and associated companies, to launch and run a network of incubators and accelerators for clean energy technologies between 2014 and 2018.

The Incubatenergy Network's objectives were to be a comprehensive source of information about US clean energy incubators, to foster engagement and communication among them, and to provide a rich resource of experts and mentors. The goal was also to learn from the most effective incubators about what makes them successful and share that information with newcomers to increase their chances of success.

While the public funding expired in 2018, EPRI's members elected to continue operating the network with their own funds, and it is still an active resource with around 30 incubators and connections to laboratory facilities.

How support is made available and allocated

N/A

Financing

N/A

Infrastructure

While the government-funded Incubatenergy Network, NREL was supported to provide national energy laboratory expertise to participants in the network. More recently, EPRI's member companies have supported technology demonstration as part of Incubatenergy Labs.

Services

The Incubatenergy Network connects independent incubators and accelerators. It is focused on the United States, which has a well-established ecosystem of energy-related incubators, but also welcomes international participation. The logic for the government intervention is that start-ups across the country now have better access to the appropriate resources they need because incubators exchange information with one another and receive updates from the network co-ordinator. This information could relate to new opportunities at incubators, requests for services to support specific start-ups, proposals for co-investment, government funding opportunities or referrals of start-ups ready to move to a new phase of development.

Today, the network includes incubators, accelerators, industry experts, utility companies, investors, and legal and business consultants.

Networking

While the government initially established the network to foster networking between service providers, it has expanded to provide networking benefits to start-ups as well. It has also broadened internationally, which helps start-ups to access overseas funding and markets. The network first opened its doors to overseas incubators and EIT InnoEnergy joined, and now EPRI plans to open a European office and is exploring opportunities in Asia.

Evaluating and tracking impacts

Experiences and learnings so far

Since its creation, members of the Incubatenergy Network have supported more than 1 000 early-stage start-ups, estimated to have helped create 3 000 jobs. More than USD 1 billion has been invested in start-ups by members of the Incubatenergy Network, and these companies have earned USD 330 million in revenue. The initial government backing played a core role in bringing network members on board and raising interest among incubators in clean energy technologies specifically.

As an organisation that works for corporate members in the electricity sector, EPRI's involvement has taken the network in unanticipated directions. It has raised awareness of new ideas and technologies among utility companies and helped them to see the complementarities for their own businesses. Since 2018, EPRI has extended the Incubatenergy Network to include a new element: Incubatenergy Labs. EPRI has run Incubatenergy Labs since 2020 by selecting start-ups to work jointly with several EPRI members on demonstration projects to accelerate their introduction into the electricity sector, or identify unforeseen technical or regulatory challenges.

Incubatenergy Labs fits well in the context of the electricity sector. The barriers to market entry established by regulations and natural monopolies can be high, yet very few utilities in the United States are in direct competition with one another. Utilities can therefore co-operate on demonstration projects, learn jointly about new technologies and provide them with a path to market by joining forces. In Incubatenergy Labs, EPRI helps its members to create projects for co-funding by groups of several utilities. The rationale is that such demonstration projects provide a template for future projects at other locations, reducing risk and helping to troubleshoot, create standard contracts and raise awareness of the technology.

Incubatenergy Labs runs annually from June to September, which limits the projects to those that can be implemented in a 16-week period. Equipment that can be quickly deployed at a utility's facility is suitable, or simulation-based testing.

In 2021, 15 utilities supported 16 start-ups selected from 253 applicants. Participating start-ups provide biweekly updates and receive midpoint reviews and technology development support from the participating EPRI members.

Complementary and related programmes

Most of the incubators in the Incubatenergy Network programme have some federal, state or municipal funding in the form of grants, tax breaks or real estate. These include LACI in Los Angeles; Greentown Labs in Boston and Houston; ACRE, funded by the New York State Energy Research and Development Authority (NYSERDA); and Cyclotron Road in Berkeley.

Energy Program for Innovation Clusters (EPIC) supports energy innovation ecosystems and stimulates energy hardware development in regions across the United States by awarding grants to regional initiatives. There is a focus on interior states that do not already have leading energy innovation ecosystems.

American-Made Challenges

ARPA-E

GCxN

IN^2

Lab Partnering Service

Presidential Innovation Fellows

Small Business Innovation Research (SBIR)

Innovation Incubator (IN^2)

Government: United States

Responsible government entity: National Renewable Energy Laboratory (NREL)

External partner: Wells Fargo Foundation

Target type of innovator: Start-ups with promising clean energy hardware technologies that have reached the stage of needing precision technology testing and refinement (technology readiness level [TRL] 3-8)

Links: https://in2ecosystem.com/

Key elements:

- The funding is from a private philanthropic source but the programme is administered by a national laboratory, allowing the selection process to be based on expert referrals and the application process to be invitation-only rather than a call for applications. The model, which includes detailed expert evaluation of potential recipients, has been replicated with a different funder.
- Technology validation by a renowned national energy laboratory has significant value for potential investors, and working with innovative start-ups enhances the ability of government researchers to think about radical new technology solutions.
- Each recipient is assigned a technical adviser from NREL or their partner laboratory to guide them through the support available.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: non-dilutive grants by NREL of privately sourced funds	Direct: access to national energy laboratories	Direct: access to technical expertise and industry experts	Direct: access to the Channel Partner network of incubators, accelerators and universities

The Innovation Incubator (IN^2) programme is a partnership between NREL, the Wells Fargo Foundation and the Donald Danforth Plant Science Center. NREL's Innovation and Entrepreneurship Center has operated it since 2014 to boost the commercialisation of clean energy innovations by harnessing the capabilities of the national energy laboratories alongside NREL's network of researchers, innovators, investors and industry partners.

Between 2014 and 2020, Wells Fargo Foundation provided a total of USD 50 million to the programme.

How support is made available and allocated

IN^2 identifies companies with support from a network of 60 "channel partners", including incubators, accelerators and university programmes that refer start-ups to NREL. This approach reduces administrative costs and constraints, but is made possible only by the use of philanthropic non-taxpayer funds.

After a review of identified companies by technical, philanthropic and industry boards, IN^2 selects each cohort of around five start-ups based on their potential to contribute to tackling problems in a specific area. These areas are mostly related to agriculture and buildings technologies, the latter supported by NREL technical facilities. IN^2 welcomes two cohorts each year.

Financing

Selected companies receive a non-dilutive grant of up to USD 50 000 for project support, such as equipment, materials or travel.

Infrastructure

Access to national energy laboratories is at the heart of IN^2. Selected companies receive up to USD 200 000 for technical support at one of the participating national laboratories (NREL and the Donald Danforth Plant Science Center). This is in addition to the USD 50 000 cash grant and it covers the staff time and other costs at the national laboratory to conduct a technical project. NREL has the resources to make unique test and demonstration configurations. Over 12 to 18 months, an assigned laboratory researcher guides the recipients through the process of testing, validating and improving their technology solutions.

Services

IN^2 recipient start-ups receive continuous expert guidance and technical assistance from NREL researchers.

Networking

In addition to technical assistance from national laboratory researchers, the programme management team at NREL's Innovation and Entrepreneurship Center helps to connect companies to its large network of investors and industry partners, as well as incubators, accelerators and universities (the Channel Partners network), which can in turn facilitate access to expertise, services and other contacts.

Evaluating and tracking impacts

During the selection process, prospective recipients have to estimate their potential environmental impact. However, they sometimes overestimate their potential impact when they are at an early stage of development or are unable to predict the potential impact accurately. When necessary as part of the technical project, NREL also estimates potential emissions reductions as it evaluates the technologies to help the companies provide evidence to potential customers. NREL is working with the Massachusetts Institute of Technology (MIT) to evaluate issues and methods of tracking tools and methods across the ecosystem.

NREL asks recipients to complete annual surveys during and after the programme to track the impact of the start-ups.

Experiences and learnings so far

Up to 2021, IN^2 had supported 56 start-ups, all of which are still active.

A virtuous circle has been found to operate between recipient start-ups and the national energy laboratories. Technology validation by a national energy laboratory has significant value for potential investors, and working with innovative start-ups enhances the ability of government researchers to think about radical new technology-based businesses.

To capitalise on the experience of IN^2, NREL and Shell launched the Shell GameChanger Accelerator (GCxN) in 2018. Unlike IN^2, GCxN has calls for proposals in more specific technology areas. GCxN targets earlier-stage technologies and supports the development of these technologies until their prototype demonstration stage.

Complementary and related programmes

American-Made Challenges

ARPA-E

GCxNShell GameChanger Accelerator

Incubatenergy

Lab Partnering Service

Presidential Innovation Fellows

Small Business Innovation Research (SBIR)

Innovation Norway

Government: Norway

Responsible government entity: Innovation Norway

External partner: N/A

Target type of innovator: Norwegian (or Norwegian-based) start-ups and small and medium-sized enterprises (SMEs) looking to validate, demonstrate and hone their technology for market entry.

Links: www.innovasjonnorge.no/en/start-page/our-services/innovation-and-development/

Key elements:

- An account manager is assigned to every start-up that applies to Innovation Norway. These advisers help the start-ups navigate and understand the different programmes offered by Innovation Norway to find the best match.
- Start-ups can apply any time of the year and do not have to wait for specific calls.
- Innovation Norway typically offers grants and loans to start-ups and accepts only companies registered in Norway.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: non-dilutive public grants via calls, plus loans for start-ups close to generating revenue	Indirect: Innovation Norway supports some innovation clusters, including incubators and universities with laboratory facilities	Direct and indirect: Innovation Norway has in-house experts and can buy external services.	Direct: account managers help connect start-ups to incubators and also international opportunities

The Norwegian government established Innovation Norway in 2004 to support Norwegian enterprises, including start-ups, in bringing new products to market, and to promote innovation and value creation in Norway as well as internationally. In 2020, start-ups featured strongly, with 26% of all of Innovation's Norway's primary lines of funding going to companies less than five years old. Innovation Norway supports Norwegian companies within most sectors that have international scope. For start-ups in particular, support focuses on high technology and cutting-edge science and engineering. In recent years, the share of funding

directed to environmental issues has grown, including renewable energy and energy systems more broadly.

How support is made available and allocated

A notable feature of Innovation Norway's approach is that, as of 2021, start-ups apply in a common system, and Innovation Norway subsequently guides them towards appropriate financial support, if appropriate. This process starts with registering online, where applicants present their idea and relevant information on project scope, business model and funding needs. Once registered, Innovation Norway assigns the applicant an account manager from an appropriate regional office to assess the fit between the company's needs and the services that Innovation Norway can provide. This assessment focuses primarily on product-market fit, the strength of the team and the long-term commitment to building a business. If the initial assessment leads to a recommendation that the company may be suitable for funding, the account manager helps them to submit a formal application for evaluation by Innovation Norway. Innovation Norway may also help start-ups to identify potential partners for environmental technology grants or innovation contract projects.

Financing

Innovation Norway has three main ways of supporting start-ups financially:

- start-up grants and loans
- environmental technology grants
- innovation contracts.

Start-ups are eligible for environmental technology grants and innovation contracts, which are both open to larger company applicants.

Start-up grants and loans

These funding tools help start-ups to cover the costs of establishing a new business. Typically, loans are provided for business ideas that are expected to reach market quickly with a relatively low risk of failure. They have a four-year tenor. In contrast, grants are generally provided to start-ups with a longer remaining development phase. In some cases, a grant might precede a loan. Most recipients of start-up grants and loans are less than three years old.

Environmental technology grants

These grants fund projects that make and pilot new environmental technologies, defined in 2021 in line with the categories defined as technology eligible for the EU taxonomy for sustainable activities. In the context of EU state aid regulation,

the projects are exempt because they address R&D (Article 25) or, if they require demonstration in commercial conditions, they concern process and organisational innovation (Article 29) or environmental protection (Section 7).

Innovation Norway makes environmental technology grants available through open calls for consortium projects. In addition, each year one call specific to clean energy and climate change mitigation is included in co-operation with the Research Council of Norway and Enova. This call is part of the Pilot-E programme through which Norway aims to co-ordinate consortium projects towards national "missions". While start-ups are not frequently part of the consortium projects, the open call allows start-ups (and other companies) to enter the Innovation Norway system at any time.

Innovation contracts

Innovation Norway also provides grants for technology development projects structured as contracts between a Norwegian developer (generally an SME, including start-ups, but occasionally large companies if certain criteria are met) and a potential customer, which can be from any country. The potential customer – called the Pilot Customer – must cover at least 20% of total project costs as a signal that they are dedicated to the project and dedicated to the search for a solution to the specific problem being addressed. In addition, this financial commitment from the Pilot Customer provides some confirmation that there is a good product-market fit. In line with EU state aid rules, grants may cover up to 45% of the development costs incurred by an SME developer, and occasionally this can rise to up to 50% for a start-up.

Infrastructure

Innovation Norway funds clusters, such as the Marine Energy Test Centre, which provide expertise and testing facilities in certain areas.

Services

Innovation Norway can help connect start-ups to business services in accordance with applicants' evaluated needs. Innovation Norway also helps start-ups with intellectual property and market research. To a certain extent, Innovation Norway offers in-house business guidance, especially concerning the refinement of business models and market entry strategies.

Innovation Norway also has internal experts in specific technology areas, including clean energy. These experts give feedback on novelty and market potential of proposed projects when relevant. They also maintain contact with industrial actors and stimulate potential project opportunities.

Networking

Regional account managers may help applicants connect with relevant external assistance regardless of whether they receive financing or not. These include other government agencies and incubators, among others.

Innovation Norway's extensive network of international offices seeks to introduce Norwegian start-ups to potential partners and opportunities around the world. It helps start-ups registered in Norway undertake international market research through their international offices.

Evaluating and tracking impacts

Project proposals and project reports estimate the environmental impacts of projects. In terms of climate impact, this does not include potential emissions avoidance downstream from the technology (for example by the users of the products of the Pilot Customers), which leaves much of the potential impact of clean energy start-ups unquantified. Estimates of potential emissions reduction made during the application phase are updated in the final report for comparison.

Innovation Norway tags all project funding according to ten categories of environmental impact that follow the EU taxonomy for sustainable activities, which is broader than climate impact alone. This helps Innovation Norway to track how much funding projects in each area have received. In 2021, 60% of funding had one of these tags by December.

Innovation Norway requests that recipients respond to a survey four years after funding to evaluate the progress and performance of enterprises receiving funding.

Experiences and learnings so far

The innovation contracts model has received positive feedback from developers, including start-ups, and Pilot Customers. Around one-third of funded projects have involved companies less than five years old. The commitment of the Pilot Customer has helped overcome some challenges related to start-ups having limited track records and weak bank balances, which can prevent access to other grant funding programmes. Participants report significant benefits to having the co-financing of the potential customer and their frequent feedback on progress from an early stage.

Innovation Norway is one of several agencies that support entrepreneurship, R&D and demonstration projects in Norway. Different agencies target different technology readiness levels (TRLs) and business readiness levels, and the landscape of public funding may be perceived as complex by start-ups. Innovation

Norway provides start-ups with a local adviser to guide them through Innovation Norway's programmes and, moving forward, aims to become a "one-stop shop" for companies navigating the various support measures available, including EU funding.

Complementary and related programmes

Enova SF is a state-owned agency tasked since 2001 with promoting a shift towards more environmentally friendly energy consumption and production, as well as the development of energy and climate technology. Enova funds projects contributing to energy, climate and low-carbon technology solutions in Norway, including, since 2015, the transport sector. Among its initiatives to speed technology deployment, Innovation Norway, the Research Council of Norway and Enova launched Pilot-E in 2016. This co-operation targets consortiums of companies developing clean energy and climate change technologies with TRL 5-9. The idea is to accelerate the market launch of these technologies.

Start-Up Chile

Government: Chile

Responsible government entity: Corfo (Corporación de Fomento de la Producción [Production Development Corporation])

External partner: N/A

Target type of innovator: Technology-based start-ups from any country that can grow quickly and reach the market within two to three years and wish to be located in Chile

Links: https://startupchile.org/

Key elements:

- This government-run incubator and accelerator provides non-dilutive finance.
- Start-Up Chile has an international outlook and helps overseas applicants with relocating to Chile for the programme.
- It is not energy-specific, but has run dedicated calls for solar and energy efficiency management start-ups.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: Non-dilutive grants via calls	Direct: office space Indirect: infrastructure through a sponsoring entity	Direct: a wide range of accelerator services in-house	Direct: access to industry, investor and mentor networks, and a peer-to-peer cohort

Corfo, Chile's government agency to promote economic growth since 1939, launched Start-Up Chile as its flagship programme for start-ups in 2010 at which time it became the first public business accelerator in the world. The purpose was to attract international entrepreneurs to connect with Chilean start-ups and raise the impact of the innovation ecosystem in Chile. It is a business accelerator and can provide grant financing as well as services. It is widely recognised as a leading government initiative globally, with a strong performance record. While it is not energy-specific, it has run calls for energy-only start-ups and, for example, supported the Chilean start-ups Endurance Electric, a provider of off-grid solar PV via a payment application, and Quempin, which helps industrial customers improve combustion efficiency. In addition, it has supported non-Chilean start-ups Aerial Power (formerly SolarBrush), an Anglo-German developer of a drone

system for solar PV cleaning, and Seeder, which facilitates renewable energy projects in People's Republic of China (hereafter 'China'), among others.

How support is made available and allocated

Start-Up Chile selects applicants for grant funding via two calls per year for start-ups at three different stages of development. Each year the calls are adjusted to prioritise applicants from a specific thematic area or stage of development. For example, in 2020, it prioritised growth-stage start-ups with ready prototypes to try to boost commercialisation times in response to the economic setback due to the Covid-19 pandemic.

Start-ups from any country may apply, but must move to Chile for the duration of the programme if selected.

Financing

There are around 100-200 recipients per year across three stages:

- Pre-acceleration (technology readiness level [TRL] 1-3). Grants at this stage are CLP 10 million (Chilean pesos) (USD 12 000) for new ventures moving from a validated idea to an early-stage prototype (so-called "problem-solution fit"), with the possibility to win an extension of CLP 5 million (USD 6 000). The length of the programme is four months, with the possibility of a three-month extension.
- Acceleration (TRL 4-6). Grants at this stage are CLP 25 million (USD 30 000) for companies moving from a functional product to reach product-market fit, with a possibility to win an extension of CLP 25 million. The start-up must co-finance 20% of the cost of the project (for female-led start-ups, this is reduced to 10%). The length of the programme is four months, with the possibility of a six-month extension.
- Scale (TRL 7-9). Grants at this stage are CLP 75 million (USD 90 000) for companies moving from an expansion stage to no further reliance on public support. The start-up must co-finance 50% of the cost of the project (for female-led start-ups, this is reduced to 40%). The length of the programme is 12 months, with the possibility of a 2-month extension.

At each stage, grants can be used only for eligible technology or business development costs.

Infrastructure

Start-Up Chile provides office space to recipients at all stages of development.

When Corfo awards grants to start-ups, they sign an agreement with a sponsoring entity that is responsible for providing access to basic services and other technical facilities. The sponsoring entity, such as a potential industrial customer, is

remunerated by the grant award and required to report certain results to Corfo and conduct due diligence assessments of the start-up's business.

Services

Start-Up Chile's acceleration services include:

- an advisory team that meets with recipients each month
- workshops on various business services
- pitch training
- regular progress presentations to Corfo, invited experts and investors (so-called "Demo Days")
- a "soft landing" programme for overseas recipients that includes visa application support.

Start-ups can receive up to the equivalent of USD 300 000 in acceleration services from Start-Up Chile. These include an advisory team that meets with recipients each month, workshops on various business services, pitch training and visa application support for overseas recipients. Start-Up Chile has also negotiated discounted external services, including cloud storage, software and legal advice among others.

Networking

Start-Up Chile manages five networks:

- corporate
- mentor
- investor (more than 50 venture funds and more than 50 angel investors from Chile and abroad)
- global (global connections with other accelerators, incubators, governments, embassies around the world)
- alumni (more than 5 000 alumni from over 85 countries).

Start-Up Chile also invites recipients to various conferences, workshops and networking events.

It also supports peer-to-peer networking between recipients in the same entry cohort who meet together each month.

Start-Up Chile has established the Female Founder Factor, a network of women in entrepreneurship and innovation to help close the gender gap.

Evaluating and tracking impacts

N/A

Experiences and learnings so far

Start-Up Chile has supported more than 2 200 new ventures in different sectors, and more than 5 500 entrepreneurs globally. It has provided more than USD 75 million from public resources. Since its launch, Chile has emerged as a start-up hub in Latin America for technologies with high potential for growth.

While Start-Up Chile has dedicated some calls to energy, the clean energy innovation ecosystem remains relatively weak. As mining, extraction of lithium and its upgrading (and other energy minerals) become more important for Chile, a greater focus on innovators in these sectors may be required to align the policy areas. In addition, for start-ups developing larger-scale energy hardware, the available funds and facilities at Start-Up Chile are insufficient to demonstrate technologies. To compete with Europe and North America as a location for growth-stage start-ups in extractive and energy sectors, Corfo has made USD 140 million available to cleantech and mining institutes and start-ups in northern Chile. Hydrogen technologies are a part of this programme.

To address gender balance among applicants, Start-Up Chile now requires 50% of pre-acceleration recipients to be founded by women.

Complementary and related programmes

ATAMOS-TEC, a public-private laboratory for the development of PV systems for high-radiation areas established in 2018 with the support of Corfo.

Corfo's development bank, which provides loan guarantees to start-ups.

Chile Global Ventures, the venture capital area of the public-private organisation Fundación Chile. Chile Global Ventures works with technology-based start-ups to grow and scale them at an international level. It has several programmes that can provide public (from Corfo) or private funding.

Start Up Energy Transition

Government: Germany

Responsible government entity: dena (German Energy Agency [Deutsche Energie-Agentur])

External partner: World Energy Council (WEC) co-organises certain aspects

Target type of innovator: Seed to mid-stage start-ups with at least a prototype that will benefit from a cash prize and global publicity (technology readiness level [TRL] 4-6)

Links: www.startup-energy-transition.com/

Key elements:

- This annual award generates significant publicity and enthusiasm around clean energy technology internationally at relatively low taxpayer cost.
- It engages policy makers, industry experts and start-ups on a common platform to highlight challenges for high-potential disruptive ideas.
- The initiative has an international outlook and is open to participants from around the world.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: non-dilutive public grants via a prize	-	Direct: promotional video and publicity	Direct: regular communications to connect start-ups to one another and to potential investors and industrial partners

Dena, in co-operation with the World Energy Council, launched Start Up Energy Transition (SET) in 2016. The purpose of this platform is to help energy innovators have more impact towards the goal of net zero greenhouse gas emissions. To fulfil this, it raises awareness about emerging clean energy technologies in Germany as well as internationally and enhances networking among policy makers, industries and new entrepreneurs in the clean energy area.

Start Up Energy Transition has three pillars: SET Award, SET Tech Festival and SET Newsroom.

How support is made available and allocated

Companies no older than ten years can enter to win the SET Award between October and January each year in five categories: clean energy generation; demand-side innovation; energy distribution and storage; smart mobility and transportation; and quality energy access and Sustainable Development Goal (SDG) 7. Entrants must already have some financial backing and proof of concept, and they generally have a prototype product or are marketing and selling it. Each year, dena publishes a list of the top 100 entrants and selects 15 finalists (3 per category). These entrants all receive publicity, services or, if they win, financial support.

Financing

Category winners receive a non-dilutive grant of up to EUR 10 000 (USD 11 000) to be spent on technology or business development.

Dena covers finalists' flight and accommodation costs to attend the SET Festival in Berlin.

Infrastructure

N/A

Services

Finalists receive a free promotional video to present their innovation and business in the most the effective way to reach a global audience.

Start Up Energy Transition culminates annually in the SET Tech Festival at the Berlin Energy Transition Dialogue conference and is designed to confer validation and public recognition on the finalists by providing them with a platform in front of investors, policy makers and other experts. In 2019, finalists also participated in the World Energy Congress, a triennial event, which took place in Abu Dhabi. For the longer list of the top 100 entrants, the publication of this list provides valuable validation when they are looking for further support.

Since 2020, dena has run a new initiative called SET Hub, which aims to address a gap in the innovation ecosystem in relation to the regulatory complexity of energy markets. One element of SET Hub is SET Mentoring: experts from dena review the business models of selected start-ups to identify challenges and opportunities related to the regulatory environment and the additional complexities of decentralisation and digitalisation. Applications to SET Mentoring are made via fixed annual call windows.

Networking

SET enables the top 100 entrants each year to connect with one another as well as with various partners, including companies and potential investors. It does this via regular calls, emails and a LinkedIn group. Start Up Energy Transition has arranged "matchmaking" events, at which start-ups can circulate around stands and tables hosted by prospective investors and industry partners.

Start Up Energy Transition includes dedicated interaction sessions between policy makers and selected start-ups at the Berlin Energy Transition Dialogue to discuss regulatory challenges. In 2020, dena launched SET Hub with the Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Klimaschutz [BMWi]) to create a forum for government, start-ups and incumbent players to identify and address regulatory barriers.

Up to 2021, Start Up Energy Transition also had an online platform (SET Connect) on which participating entrepreneurs could interact with investors who register in search of investment opportunities, and other professionals.

Evaluating and tracking impacts

Start Up Energy Transition no longer asks entrants to submit their estimated greenhouse gas emissions impacts because the submissions were difficult to compare, being based on methodologies of the entrants' choosing. An algorithm developed by Early Metrics to assess growth potential and innovativeness performs much of the initial evaluation. It requires computable data inputs.

Experiences and learnings so far

Start Up Energy Transition has raised awareness in an area of the German innovation ecosystem that had few dedicated funds or incubators five years ago. This situation has begun to improve, and Start Up Energy Transition has evolved to become more international. In 2021, there were 2 300 entries from 102 countries, including India, Kenya, Nigeria and Uganda. However, there remains a gap in the availability of capital for start-ups with energy hardware that has long development timelines. The government validation for this sector is considered valuable for helping to reduce risk perception among investors. One particular challenge identified by Start Up Energy Transition is access to data in a highly regulated market such as electricity supply. Another is a lack of clarity around intellectual property ownership for R&D emerging from universities.

The testimonials shared by past winners cited the access to a high-quality network as one of the key benefits of participating.

Complementary and related programmes

Dena leads energy dialogues to enhance the clean energy innovation system in emerging market and developing economies. For example, it has worked together to help Kazakhstan to establish incubators that can be self-sustaining after the end of the German funding (such as by taking equity in start-ups). It co-operates with the German Corporation for International Cooperation (Gesellschaft für Internationale Zusammenarbeit [GIZ]) and has also worked with Mexico, Morocco and Tunisia.

The German Future Fund - EIF Growth Facility is a new equity mandate deployed by the European Investment Fund (EIF) and forms part of the EUR 10 billion (USD 12 billion) German Future Fund launched backed by the German government in 2021 as a successor to the German Growth Co-Investment Facility. It has a ten-year mandate and focuses on providing later-stage venture capital, “in particular on digitalisation, clean-tech, life sciences and other relevant sectors”. It has the ambition of backing EU companies that could have significant penetration in international markets. It prioritises German companies.

Swedish Energy Agency

Government: Sweden

Responsible government entity: Swedish Energy Agency

External partner: N/A

Target type of innovator: Start-ups and small and medium-sized enterprises (SMEs) looking to test or demonstrate their technology with industrial partners

Links: www.energimyndigheten.se/en/

Key elements:

- The agency offers different packages of project funding depending on the stage of technology maturity.
- It connects start-ups with potential customers.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: non-dilutive public grants via calls	-	-	Direct: helps entrepreneurs to find project partners

The Swedish government's support for energy technology entrepreneurs goes back as far as 2004, when it identified gaps in the availability of private capital to scale up R&D outputs. The Swedish Energy Agency sought to address regulatory and market barriers, lack of awareness among investors, and the need for finance compatible with energy hardware development timelines.

The Swedish Energy Agency is currently most active in this area through grant funding. However, this has evolved from the provision of conditional loans from 2006. These loans had a grace period, which meant that payback was not required if the project failed to contribute to market entry for the product. However, this payback trigger was still too early for some of the recipients and the loans contributed to a less favourable balance sheet for the recipients.

How support is made available and allocated

The agency offers yearly calls, with an aim to have two calls per year. Previously, concept development grants had permanently open calls.

Financing

The Swedish Energy Agency differentiates its grants for innovators by the needs of start-ups at successive stages of development:

- Concept development. A grant of up to SEK 300 000 (Swedish kronor) (USD 33 000) for defining and developing a technology concept.
- Verification of customers. A grant of up to 45% of the eligible costs of a project, up to SEK 3 million (USD 330 000) to develop a technology prototype that meets the requirements of a potential customer.
- Pilot and demonstration. A grant of up to 45% of the eligible costs of a project that has capital costs of at least SEK 7 million (USD 770 000). The technology must be at least at technology readiness level (TRL) 5 and through the project aim to reach TRL 6-8.

Infrastructure

N/A

Services

N/A

Networking

The Swedish Energy Agency funds national science parks and incubators. One such actor, Ignite Sweden, provides a network through which start-ups can identify potential partners.

The agency has market entry programmes in six countries, with accelerator programmes established in Germany, India and Indonesia based on bilateral agreements with Sweden. In other countries, as in China, the United Kingdom and the United States, the Swedish Energy Agency has established thematic programmes.

Evaluating and tracking impacts

The Swedish Energy Agency evaluates recipient projects to gather feedback and improve future programmes. It evaluates start-ups' progress using the KTH Innovation Readiness Level tool. Recipients report greenhouse gas emissions for

ten years after the start-up has completed the grant-funded project and are free to use a methodology of their choice.

As part of Mission Innovation, the Swedish Energy Agency supported development of a framework (the Avoided Emissions Framework) for estimating potential avoidance of greenhouse gas emissions by innovations.

Experiences and learnings so far

The Swedish Energy Agency has supported 250 start-ups and provided approximately EUR 90 million (USD 100 million) to a portfolio of companies with an aggregated valuation of approximately EUR 3 billion (USD 3.5 billion) and an estimated impact of 1 billion tonnes of CO_2 avoided. Four out of five supported companies have received follow-on funding and 25 have launched initial public offerings. On average, the follow-on investment has been 15 times higher than the public funding.

The government has identified that its role is most valued during the most capital-intensive phases of product development. In general, clean energy technology start-ups in Sweden rely on capital sources such as university incubators, prizes and own funds before reaching eligibility for Swedish Energy Agency grants.

Complementary and related programmes

The Swedish Innovation Agency supports basic and experimental research for the stationary and mobile energy system via thematic calls.

Almi, a state-owned finance company, offers loans to companies (start-ups or established companies) with growth potential and assists in their business development. Almi Invest provides venture capital for early-stage, emerging companies with high growth potential and a scalable business concept. It also runs seminars for start-ups. The Swedish Energy Agency, Almi Invest and the European Regional Development Fund finance the operations of Almi Invest GreenTech Fund, a public venture capital operation that invests equity in companies with products and services that contribute to greenhouse emissions avoidance.

The Swedish International Development Cooperation Agency (SIDA) provides loan guarantees to help later-stage start-ups access debt for scale-up internationally.

Technology Business Incubator

Government: India

Responsible government entity: Department of Science and Technology (DST)

External partner: Incubators, including Indigram Labs

Target type of innovator: Early-stage technology start-ups needing incubation to develop their business idea

Links: http://nstedb.com/institutional/tbi.htm

Key elements:

- Various not-for-profit incubators are funded by the government for up to five years. The funds are used to cover their operational costs and to take equity stakes or provide debt to the start-ups that they incubate, with any proceeds used to fund more start-ups and a sustainable long-term incubator business.
- The supported incubators cover different technology areas and provide a channel through which several different funding programmes and services are distributed.
- Participating incubators are eligible to receive funding from multiple government departments and programmes, which helps them to create a more diverse portfolio. However, it can also increase administrative complexity.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Indirect: incubators are funded to take dilutive equity stakes or to provide non-dilutive debt funding	Indirect: funded incubators generally have some specialised but limited laboratory facilities	Indirect: incubators are funded to provide incubation	Indirect: incubators can fund networking activities but they are not required to do so

The DST covers the operational costs of selected incubators for five years under the Technology Business Incubator (TBI) programme, largely through the National Initiative for Developing and Harnessing Innovations (NIDHI)[1] The incubators are generally hosted by universities or research institutes. The TBI programme, launched in 2015, provides a platform for accreditation of start-ups through which

[1] The Ministry of Micro, Small and Medium Enterprises (MSME) also supports TBI incubators to establish and fund start-ups.

the DST and other government departments channel financing and support to start-ups. As of 2021, there are around 125 TBI incubators supported by the government.

An example of a funded incubator under this programme is Indigram Labs, which was established in 2015 to support start-ups in the agriculture, food and cleantech areas. Indigram Labs is hosted by the Indian Society of Agribusiness Professionals. In addition to DBT funding, it has received funds from the Department of Biotechnology's (DBT) Biotechnology Industry Research Assistance Council (BIRAC) to run its acceleration programme for start-ups at a technology readiness level (TRL) of 8, starting from 2021. Indigram Labs has incubated several companies, such as New Leaf Dynamic Technologies Pvt Ltd, developer of a bioenergy-based off-grid refrigerator and ripening chamber.

How support is made available and allocated

Selection of start-ups for support is at the discretion of participating incubators.

In the case of Indigram Labs, most applications come via a permanently open call, and the incubator supplements these with region-specific calls and thematic calls (including climate action and clean energy) to address gaps in government priorities. A committee of experts from the Indian Association of Agriculture Professionals reviews the applications for technical potential.

Financing

Start-ups selected for incubation by TBI incubators can get access to a range of funds available from the DST and other government departments. These include:

- Entrepreneur-in-residence. An INR 30 000 (Indian rupees) (USD 400) per month grant paid as a stipend to individuals with a technology business idea, mostly recent graduates who might otherwise leave the idea undeveloped and take a more highly paid job elsewhere.
- Seed Support System. Funding between INR 1 million and INR 2.5 million (USD 13 000 and USD 34 000), and exceptionally up to INR 10 million (USD 130 000), to be spent on a wide range of eligible costs, including product development, marketing, mentoring, intellectual property issues and personnel. Participating incubators are able to choose whether to award the funds as equity, debt or a combination of both. However, equity is encouraged, and must be used for sums above INR 2.5 million (USD 34 000). Seed support provided to participating incubators to disburse to their selected start-ups is conditional upon use of the proceeds from equity investments or repayments as seed support for other start-ups. The government's objective is for the TBI incubators to recoup the disbursed seed funding within seven years, including 30% of any large soft loans within the incubation period.

- NIDHI Accelerator. A fast-track two- to nine-month programme that provides up to INR 15 million (USD 200 000) to a participating TBI to support around 10-15 potentially high-impact start-ups nearing market readiness, through which TBI incubators can provide grant or equity finance.
- Investments by the TBI incubators. The DST (and MSME) earmark part of the funding to TBI incubators for investment as dilutive equity or debt.
- Other public grants channelled by government departments via TBI incubators.

In the case of Indigram Labs, start-ups are considered for different funding options once positively evaluated. In general, Indigram Labs invests 2-5% equity in incubated start-ups and gives priority to start-ups with no prior funding. An investor committee with experts from companies, investors and the DST evaluates equity investment proposals.

Indigram Labs offers Seed Support System grants of INR 2.5 million (USD 34 000) over five years and Entrepreneur-in-Residence grants of INR 450 000 (USD 6 000) over 18 months. It also administers BIRAC's Biotechnology Ignition Grant scheme, a grant of INR 5 million (USD 67 000) to develop and validate a prototype. Under this programme, if recipients successfully reach the market and generate revenue then they are required to pay BIRAC 5% royalty on net sales of the product or technology that was developed though BIRAC support. These payments continue until they cumulatively reach the level of the financing provided by BIRAC.

Infrastructure

Part of the funding allocated by the DST (and MSME) to TBI incubators is earmarked for the incubators to upgrade laboratory and prototyping equipment. In addition, TBI incubators are eligible to apply to the PRAYAS (for "promotion and acceleration of young and aspiring" technology entrepreneurs) programme. Under this programme, up to ten incubators each host ten start-ups per year and are awarded INR 1 million (USD 13 000) per start-up to improve their scientific facilities and help start-ups to reach prototype stage more quickly (the start-up is expected to begin at TRL 2 and finish at TRL 4-5).

In the case of Indigram Labs, it charges incubated start-ups a nominal monthly fee to rent office space and use the facilities. The MSME provided funds to Indigram Labs to establish a laboratory for agriculture and food technologies.

Services

TBI incubators are funded to be able to provide business services to start-ups.

In the case of Indigram Labs, a team of 50 mentors helps and guides start-ups. Indigram Labs offers:

- business mentoring with monthly e-meetings where start-ups can present progress and request support
- pitch presentation training
- market analysis
- intellectual property and legal support
- human resources and recruitment support.

Networking

NIDHI runs several programmes that support the TBI programme to foster stronger networks. The Grand Challenges and Competitions initiative funds TBI incubators to undertake marketing and encourage applications from innovators with new ideas. Successful applicants can receive short training courses and potentially longer-term incubation under other initiatives. NIDHI Centres of Excellence funding helps selected TBI incubators to offer more services, including market research and contacts internationally. NIDHI Startup Corridors is a network of experienced and new institutions collectively promoting start-ups.

One of the TBI programme's objectives is for the participating incubators to establish a network among academic and financial institutions, industries, and other institutions. In the case of Indigram Labs, it has developed collaborations with a range of R&D institutes and the companies in the Indian Association of Agriculture Professionals. It has set up WhatsApp sector-specific subgroups to help start-ups find partners across their value chains. Indigram Labs is involved in the EU-India Bridge programme and with the Uganda based incubator Excel Hearts.

Evaluating and tracking impacts

In the case of Indigram Labs, incubated start-ups complete a greenhouse gas emissions tracking template developed by the incubator. This is used for evaluation during their participation.

Experiences and learnings so far

It is not yet possible to draw conclusions about the efficacy of channelling various support mechanisms through publicly funded incubators. In time, it will be possible to see if the equity-based model allows TBI incubators to become sustainable without government funding for overheads, which is initially only provided for five years. It is, however, already evident that the innovation ecosystem in India has improved with the establishment of so many TBIs at research institutions.

In the case of Indigram Labs, it has supported 118 start-ups so far and they have raised approximately USD 4 million. Indigram Labs has found working with the

DST and DBT to be smooth, and that its management of multiple government programmes gives them longer-term visibility and a full cycle of annual activity. However, in the area of biotech, start-ups still find it difficult to commercialise their products, as the potential customers are relatively conservative. Most applications to Indigram Labs are judged too incremental and not radical enough to generate valuable intellectual property. For long-term success, there is a need to complement the TBI incubators in the bioenergy and agricultural energy areas with training at universities and more appropriate funding for large-scale demonstrations of hardware.

Complementary and related programmes

Clean Energy International Incubation Centre (CEIIC), a joint initiative of Tata Trusts and DBT, BIRAC, Tata Power and Tata Power Delhi Distribution Limited. It is the first international incubator under Mission Innovation offering support specifically to clean energy start-ups in the areas of energy access, energy efficiency and clean technologies.

Biotechnology Industry Research Assistance Council (BIRAC)

Women in Cleantech Challenge

Government: Canada

Responsible government entity: Natural Resources Canada (NRCan)

External partner: MaRS

Target type of innovator: Female cleantech entrepreneurs with high-potential technology ideas who are underrepresented in the area of clean energy technology and need support for the faster development of their technologies and businesses

Links: www.womenincleantech.ca

Key elements:

- All finalists receive an annual stipend to give them financial freedom to commit 100% of their time to the start-up during the duration of the programme.
- It provides access to federal government research facilities to support technology scale-up and testing, with the costs of laboratory time and staff covered.
- Female entrepreneurs get a tailored three-year incubation programme at a private innovation support organisation.
- A cohort of finalists is developed, leading to a stronger network for these women-led businesses.

Summary of the types of support provided or enabled by the policy initiative

Type of support			
Financial	**Infrastructure**	**Services**	**Networking**
Direct: stipend funding for finalists and a large financial prize for the winner	Direct: access to national energy laboratories, and the costs of laboratory time and staff covered	Direct: access to federal energy laboratory research expertise Indirect: MaRS was funded to provide an incubation programme	Indirect: peer-to-peer networking between finalists, and MaRS is funded by the government to provide networking benefits

NRCan launched the Women in Cleantech Challenge in 2018 to promote women-led businesses by supporting entrepreneurs in cleantech areas to scale their technologies and grow their businesses. It is one of six cleantech challenges in the Impact Canada Cleantech Initiative. NRCan designed the challenges to help address pressing environmental problems. Eligible technologies were those that

are able to reach international markets, use fewer inputs, generate less waste and cause less environmental damage than the alternatives. The technologies needed to be between technology readiness level (TRL) 2 and 5 and be potentially "disruptive", i.e. able to redefine the market for a given service and thereby capture significant market share from incumbent technologies.

The three-year challenge to support these women-led business has been completed. It attracted almost 150 entrants, and had 6 finalists and 1 grand prize winner. With the success of the Women in Cleantech Challenge, the delivery partner (MaRS Discovery District) was able to attract private-sector investment to support women entrepreneurs and launched the Women in Cleantech Accelerator with support from the Royal Bank of Canada. This helps support the idea that government programmes can seed organisational capacity building and follow-on private activity to deliver specific policy goals.

How support is made available and allocated

The Women in Cleantech Challenge involved a one-off call for applications that was open for two months. An evaluation committee, assisted by technical advisers, was asked to select a minimum of 25 applicants. Shortlisted applicants went through a more thorough screening process, including an interview with a review committee that selected ten applicants. These ten applicants attended a public pitch event at MaRS Discovery District where a jury of six judges announced six finalists. These six finalists each received a package of support over three years, during which time their progress was tracked by MaRS Discovery District, and the information provided to the jury who selected the single "grand prize" winner.

Financing

NRCan offered all six Women in Cleantech Challenge finalists a non-dilutive unconditional grant of CAD 115 000 (Canadian dollars) (USD 90 000) per year in the form of a stipend during the time that they compete for the prize. The final duration of the stipend was three years and one month. The stipend covered living expenses and the travel costs for programme events, laboratory visits, and meetings with potential investors, customers and partners. The recipients could spend it in whichever way they found most valuable. Finalists also received a small budget for marketing.

The challenge additionally attracted applicants with a "grand prize" in the form of a non-dilutive unconditional grant of CAD 1 million (USD 0.8 million) prize to be awarded to one finalist at the end of the three-year programme. The prize was awarded based on a range of performance metrics, including quarterly reviews, business development, valuation of the company, and on boarded investors.

Infrastructure

The Women in Cleantech Challenge finalists were provided access to federal government research expertise and facility access to support activities such as testing and technology development worth up to CAD 250 000 (USD 200 000) without co-funding requirements.

Services

For the Women in Cleantech Challenge, NRCan partnered with a not-for-profit private innovation support organisation, MaRS, which designed and delivered the business service elements of the challenge. The business incubation support had a value of CAD 300 000 (USD 235 000) for each finalist. MaRS designed a tailored package of support for the six finalists, taking into account the needs of very early-stage technology developers and gender-related barriers. In addition, the services were adapted to the requests of the participating entrepreneurs once they entered the three-year programme. While the finalists were mostly at an early stage of development, the level of services went beyond that available through MaRS' standard incubation and acceleration packages, especially in terms of the amount of hands-on support. The package included:

- a curated curriculum of in-person workshops and training in Toronto every quarter, responding to arising issues and covering dimensions specific to female founders
- remote learning modules taught by external experts (partly enforced by the Covid-19 pandemic)
- a hands-on mentoring team of business and technical advisers for each finalist that met with finalists as frequently as every two weeks depending on needs
- setting milestones for each finalist and in-person feedback on progress from the support team each quarter
- introduction to an investor network, and regular feedback from a team of investors on their progress against milestones
- speaking slots at relevant events in Canada and the United States
- assistance with some market research, for Canada and globally.

Networking

The six finalists followed a joint programme, including in-person training sessions in Toronto, which created a strong cohort and ongoing network among these business leaders.

MaRS introduced the finalists to various investor networks and provided opportunities for them to engage with potential customers and investors at a variety of relevant events, including international events where start-ups were

encouraged to identify the best possible market and investment opportunities globally.

Evaluating and tracking impacts

The Women in Cleantech Challenge tracked results on a quarterly basis using quantitative and qualitative indicators, as well as narrative descriptions of progress. Finalists were required to report on key technical advances, development of prototypes, patents, business growth (employees and revenue), partnerships, investments, funding, awards and media recognition. MaRS assessed finalists on various entrepreneurial competencies and their participation and engagement with business accelerator elements. As part of the grand prize submission, finalists provided summary reports of technical and business progress, final qualitative and quantitative metrics, and plans for their next steps and scale-up. Given that projects are working on early research and prototypes (TRL 3-5), finalists were not required to report on greenhouse gas or other environmental outcomes. While there are no formal reporting requirements after the end of the challenge, NRCan will use interviews, technology and business news scanning and patents to monitor finalists' progress and impact.

Finalists in another NRCan programme, Breakthrough Energy Solutions Canada, were required to estimate that their technologies could potentially reduce emissions by at least 0.5 Gt CO_2 per year. NRCan developed a spreadsheet tool for applicants to complete.

Experiences and learnings so far

During the course of the challenge, the six women-led businesses were able to cumulatively attract CAD 52.5 million (USD 41 million) in investment.

The Women in Cleantech Challenge was a comprehensive package of funding and support that provides insights into the value of both direct and indirect support to clean energy technology start-ups. Six elements were particularly successful in the first cycle, most of which are challenging for the private sector to provide:

- The stipend model of grant funding was highly successful in attracting applicants from the target groups of innovators. In some cases, this provided the security to commit to the company full-time for the first time and spend on the most pressing needs, not just technology development. However, costs were not equal across participants, and differentiated amounts should be considered to reflect the variable costs, such as travel to get to on-site training in Toronto.
- The finalists rate the "cohort" effect (the bond among them) as one of the core benefits of participation in the programme, an advantage that was enabled by the programme design and in-person events and training. One reason this was so effective was the small cohort size, the similarities in stages of development

(all finalists were early-stage start-ups), and the shared experience of all being women facing related and often underappreciated challenges. After the end of the programme, the finalists expect to continue to share challenges, experiences and opportunities with one another.

- Publicity and promotion at national and international events provided faster access to investors, industry partners and customers.
- National research expertise and facility access for testing and validation was highly valued as the cost of this process is normally a barrier to the scale-up of technologies. Continued collaboration support from government researchers and research facilities is critical to consider when investing in this space, particularly to support the scale-up of clean energy technologies.
- The indirect provision of business services and market research provided recipients with greater awareness of international opportunities and less pressure to be limited to domestic markets.
- The customised training and quarterly feedback, while relatively costly, allows start-ups to progress more quickly, especially if they have little prior business experience.

Complementary and related programmes

Breakthrough Energy Solutions Canada, a partnership launched in 2019 by NRCan, private investor Breakthrough Energy Ventures and the Business Development Bank of Canada, a public investor. It is supporting Canadian entrepreneurs in commercialising clean energy technologies in the areas of manufacturing, electricity, transportation and buildings. After an initial call for proposals, ten recipients were selected for non-dilutive finance to develop technologies as well as incubation and acceleration support. Breakthrough Energy Ventures and the Business Development Bank of Canada provide feedback on progress and will consider equity investments in the companies.

Science and Technology Assistance for Cleantech (STAC) was launched under NRCan's Clean Growth Program as a new means of providing small and medium-sized enterprises (SMEs) with in-kind access to technical expertise, equipment and infrastructure at federal laboratories and research centres. It allows contribution agreement funds to be combined with in-kind science and technology services to improve the chances of successful outcomes for cleantech SMEs and Canadian society.

Annex. Glossary

Term	Definition
Accelerator	Accelerators help start-ups scale up quickly, typically by supporting those that already have a product for sale and a detailed business model. Accelerators can have different approaches and specialise in different services, but they generally focus on helping companies become self-sufficient as quickly as possible through mentoring and networking. The distinction between accelerators and incubators, which typically focus on earlier-stage start-ups, is not always sharp, and some initiatives straddle the two models of support. For convenience, this report generally uses the term "incubator".
Clean energy technology	Any device, component of a device or process for its use dedicated to producing, storing or distributing energy with low CO_2 emissions intensity; or a novel device that provides a new or improved energy service or energy commodity that enables users to minimise their contributions to atmospheric CO_2 concentrations in line with net zero CO_2 emissions globally. A list of clean energy technologies – including those related to renewable energy, buildings, hydrogen, nuclear, energy storage, power system flexibility, and carbon capture, utilisation and storage – can be found in the IEA ETP Clean Energy Technology Guide. Clean energy technologies overlap considerably with the range of technologies frequently grouped together as “cleantech” or “climatetech”. However, these other classifications are broader and can include recycling, air monitoring, mobility services and land use in addition to energy applications. The term technology is commonly used to refer to a “technology application” (e.g. renewable power), “technology type” (e.g. solar PV), “technology

	design" (e.g. perovskite cells) or "technology component" (e.g. novel membrane). In this report, it generally refers to a design or component.
Corporate venture capital	Equity investments in start-ups that are developing new technologies or services, by companies whose primary business is not venture capital or other equity investments. In addition to playing the traditional role of a venture capital investor, corporate venture capital investors often support start-ups by giving them access to their customer base, R&D laboratories and other corporate resources. Corporate venture capital is used by companies as part of their energy innovation strategies to enter new technology areas or learn about technologies more quickly than by developing them in-house.
Debt financing	Raising money by borrowing (or selling what are known as "debt instruments") and taking on an obligation to pay back the amount of the loan (the principal) and the interest on the debt at an agreed date in the future. Unlike with equity financing, the company does not have to give up a portion of ownership to receive funds. The most common forms of debt financing are loans, lines of credit and leasing of equipment.
Deep tech	A term used since the late 1990s to refer to organisations and companies tackling major science and engineering challenges to solve environmental and social problems or capture commercial opportunities. The term generally includes the following sectors in its scope: advanced materials; advanced manufacturing; artificial intelligence; biotechnology; blockchain technology; robotics; photonics; electronics; and quantum computing.

Dilutive (or equity) funding and financing	Dilutive funding is any financing that requires a company to give a portion of ownership (i.e. equity) in return. The shareholder is entitled to future profits but has no entitlement to repayment. If the company fails, equity holders are the last in line to receive money. Equity gives shareholders some control over the direction of the company, and some shareholders in start-ups provide managerial or technical expertise. Common examples of dilutive funding include selling shares to angel investors or venture capitalists in a funding round. It could also include equity crowdfunding, in which numerous investors each buy a small share of the company.
Early-stage	In this report, "early-stage" refers to the phase in which a company is continually innovating and refining a technology product through R&D, demonstration, field trials and intensive learning-by-doing. To reflect this period of innovation between lab and market, we consider early-stage funding to include capital acquired up to the equivalent of a Series B funding round.
Equity	Equity is the value of the shares that would be returned to a company's shareholders if all the assets were liquidated and all debts were paid off.
Equity funding and financing	See "dilutive (or equity) funding" above.
Grant	The transfer of funds, usually with an obligation to spend the money on a contractually defined project or set of eligible expenses. Grant payments do not need to be repaid with money or equity as long as the contractual conditions are met. Grants are the most common financial support governments provide to innovators. Some grants (often in the form of a prize) are direct cash payments with unrestricted use.

Growth equity funding and financing	While the boundaries are often blurred, a company that graduates from Series funding (often after a Series B round) raises growth equity. Growth equity rounds can be worth USD 100 million or more, depending on the type of company and its technology or product. Compared with Series rounds, growth equity is more like to have a single large investor, such as a corporation, bank or hedge fund, accompanied by secondary market groups. Companies raising growth equity typically already have a successful business model and promise large returns to investors, either through revenue, acquisition or an initial public offering.
Incubator	Incubators nurture and mentor start-ups in their earliest stages when they are beginning to develop their technology into a product and their idea into a business. Different types of incubators offer different combinations of services, including workspace, funding, mentoring, access to networks or access to other legal, business or procurement services. Various sources can be used to cover incubators' costs, including government or philanthropic grants, fees charged to client start-ups or revenues from the sale of equity stakes acquired in exchange for incubation.
Net zero-aligned technologies	Technologies that contribute to a global energy sector pathway consistent with achieving net zero greenhouse gas emissions by 2050 and limiting the global temperature rise to 1.5ºC without a temperature overshoot (with a 50% probability), with no offsets from outside the energy sector and with low reliance on negative emissions technologies (such as direct air capture or bioenergy with carbon capture and storage), while ensuring continued economic growth and secure energy supplies.
Non-dilutive funding	Funding that is not in exchange for equity or other forms of ownership shares. Non-dilutive funding can

	include grants, debt, licensing and royalties from products, shared-earnings agreements, tradeable tax credits, debt-based crowdfunding, revenue-based financing and asset-based financing. Start-ups often prefer to raise non-dilutive funds to retain more control and a higher share of their company's future value.
Seed capital	Typically, the first money raised by a start-up or enterprise that does not come from savings, friends or family. When seed funds are raised from "angel investors" or venture capital funds, a share of equity is usually expected to be granted to the investor, who is taking on more risk than later-stage investors are. Seed capital can pay for formation of the start-up, development of a business plan, initial operating expenses or R&D. Seed investors generally aim to develop a business idea to the point at which it can attract further funding, for example from venture capitalists or corporations with larger funds.
Start-up	There is no universal definition for the term "start-up". In this report, it refers to a young company founded by one or more entrepreneurs to develop and validate a unique product or service and bring it to market with a scalable business model. While there is no age cut-off for start-ups, some start-up laws, such as the Italian Start-up Act, target companies that have been operational for less than five years and are not listed on a stock market. However, under the Spanish Start-up Act, clean energy technology start-ups maintain their eligibility until they are seven years old if they are independent, have not yet shared profits with owners and have revenues of EUR 5 million (USD 6 million) or less. Germany's Start Up Energy Transition prize is open to companies less than ten years old. Start-ups often have an idea or a meaningful problem worth solving and build a team committed to transforming the idea into a validated, value-generating product and business model. Start-ups

	develop new products or services that do not currently exist in the market, or they enter an existing market with a modified product or service.
Series A and B funding	The stages of capital-raising that typically follow seed funding. Companies that raise "Series" rounds have usually demonstrated a viable business model with strong growth potential but need capital to repay initial investors, continue R&D and expand before entering profitability. Investors in Series rounds include large venture capital funds, corporations, private equity firms and even individuals via crowdfunding. A single lead investor usually invests the largest share, accompanied by small number of co-investors. In exceptional cases, a single round can have more than ten investors. Investors may receive common shares, preferred shares (which are paid before common shares but do not provide their owners with voting rights), deferred shares or debt, or some combination of these. The first round of Series funding is Series A, and successive rounds are named B, C and D (rarely any higher). Each successive round typically involves a larger sum (starting at around USD 1 million up to USD 10 million for most Series A rounds) and focus more on market reach than product development. There is a significant overlap between rounds of Series funding higher than Series B and growth equity.
Technology readiness level	Technology readiness levels (TRLs) provide a comparable snapshot in time of a technology's level of maturity within a defined scale to indicate where the technology is on its journey from initial idea to market. A technology's progress begins from the point at which its basic principles are defined (TRL 1). As the concept and area of application develop, the technology moves into TRL 2, reaching TRL 3 when an experiment has been carried out that proves the concept. The technology then enters the phase in which the concept itself needs to be validated, starting from a prototype developed in a

	laboratory environment (TRL 4) through to testing in the conditions under which it will be deployed (TRL 5-6). It then moves into the demonstration phase of testing in real-world environments (TRL 7), eventually reaching a first-of-a-kind commercial demonstration in a relevant environment (TRL 8) on its way towards readiness for full commercial operation if supportive market conditions exist (TRL 9). While energy technology start-ups differ in their needs for capital and services, a start-up seeking seed funding and incubation typically has a technology at TRL 3-4. By the time a start-up is seeking the support of an accelerator and securing Series funding, its technology is typically at TRL 5-8.
Valley of death	A concept in innovation theory that describes a period in which a new technology or product requires a significant increase in risk capital to demonstrate its effectiveness, costs and marketability. This period often results from a mismatch in available capital from public and private sources: available R&D funding is no longer appropriate and private investors generally do not have the risk appetite to support this increase in both capital requirements and risks. For large-scale technologies, the valley of death usually coincides with the “demonstration phase” around TRL 8, after pilot testing and before near-term market potential has been proven. For smaller-scale technologies, this phase is more likely to require capital for field trials and testing in various commercial environments. In both cases, public support (sometimes more than USD 100 million) and co-operation with industrial partners are usually necessary to bridge the valley of death successfully, regardless of whether the technology is owned by a start-up or a larger entity. For start-ups, especially those developing clean energy hardware, the valley of death concept has

	been applied more broadly. In these cases, it denotes the period after conceptual R&D projects have been realised, when capital is first needed to buy equipment and pay salaries. Until revenue begins to flow, start-ups often have negative cashflow, and support from incubators and the public sector (in the region of USD 10 million) may be needed to top up what is available as debt or from angel and venture capital investors.
Venture capital	Venture capital is a form of private equity financing that venture capital firms or funds provide to start-ups that show high growth potential, in exchange for an equity stake. Venture capitalists usually invest in businesses that most banks and capital markets consider too risky for investment; they therefore expect a considerable return on their investment if the start-up is successful. Typically, the first venture capital investment comes after seed funding, in the Series A funding round. Venture capital funds usually seek to sell their shares in start-ups after around five years and return a share of any proceeds to the funds' investors. However, some funds with longer time frames have emerged to target clean energy technologies in recent years.

Acknowledgements

This report was prepared by the IEA's Directorate of Sustainability, Technology and Outlooks (STO). Simon Bennett (Energy Supply and Investment Outlook division) was the lead author, alongside Amalia Pizarro (Energy Technology Policy division). We are grateful to Nikita Patil, who carried out analytical research and provided significant contributions and to Jean-Baptiste Le Marois (Energy Technology Policy division) for his analytical support.

The report would not have been possible without the support from Tim Gould, Chief Energy Economist, and Timur Gül, Head of Division for Energy Technology Policy. The report is indebted to the high calibre of inputs, comments and feedback from colleagues within the IEA, including Nick Johnstone (Chief Statistician), Blandine Barreau, Lizé Clémence, Araceli Fernández Pales, Paolo Frankl, Vanessa Koh, Christophe McGlade, Luiz Gustavo Silva de Oliveira, Leonardo Paoli, Rebecca Schulz, Siddharth Singh, Michael Waldron and Per Anders Widell.

Many international experts provided input and reviewed preliminary drafts of the report. The information they provided as well as their comments and suggestions were of great value. They include (in alphabetical order):

Manisha Acharya	Indigram Labs
Magnus Agerström	Cleantech Scandinavia
Dag Agnvall	Swedish Energy Agency
Evelyn Allen	Evercloak
Markus Berglund	Innoenergy
Pim de Bokx	Dutch Incubators & Accelerators
Elena Bou	EIT Innoenergy
Debbie Brodt-Giles	National Renewable Energy Laboratory (NREL)
Lindsay Brown	Natural Resources Canada
Chiu-Hao Ted Chen	Evercomm
Trish Cozart	National Renewable Energy Laboratory (NREL)
Sarah Diouri	IRESEN
Pia Dorfinger	German Energy Agency
Anita Fossdal	Enova
Rodrigo Frías	Start-Up Chile
Anne Haas	Electric Power Research Institute (EPRI)
Amanda Hall	Summit Nanotech
Tyler Hamilton	MaRS Discovery District
Cynthia Handler	Natural Resources Canada
Asvini Keerawella	MaRS Discovery District
Alexandra Khripko	German Energy Agency

Marianne Tonning Kinnari	Innovation Norway
Avishek Kumar	V-Flow Tech
Mahesh Kumar	Nanyang Technological University
Andreas Lehner	Trine
Constanza Levicán	Suncast
Jordi López	EIT Innoenergy
Tricia Martinez	US Department of Energy
Claus Meineche	Danish Energy Agency
Canelle Mengual	German Energy Agency
Andrea Mohr	Corfo
Neil Nevgi	BatteryPool
Bill Nussey	Solar Inventions
Smita Rakesh	Social Alpha
Alicia Requena	Cleantech Scandinavia
Hariram Someswaran	Nanyang Technological University
Erik Steeb	Electric Power Research Institute (EPRI)
Andrew Stokes	Energy Systems Catapult
Andreas Stubelius	Swedish Energy Agency
Amanda Wilson	Natural Resources Canada
Ting Yan	Evercomm

Thanks also to the IEA Communications and Digital Office for their help in producing the report, particularly to Astrid Dumond, Jon Custer, Jethro Mullen, Isabelle Nonain-Semelin, Taline Shahinian, Therese Walsh and Wonjik Yang. Kristine Douaud edited the manuscript.

Comments and questions are welcome and should be addressed to:
Simon Bennett (simon.bennett@iea.org) and Amalia Pizarro (amalia.pizarro@iea.org).

This publication has been produced in part with the financial assistance of the European Union as part of the Clean Energy Transitions in Emerging Economies programme. This publication reflects the views of the International Energy Agency (IEA) Secretariat but does not necessarily reflect those of individual IEA member countries or the European Union (EU). Neither the IEA nor the EU make any representation or warranty, express or implied, in respect to the publication's contents (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the publication. Unless otherwise indicated, all material presented in figures and tables is derived from IEA data and analysis.

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Typeset in France by IEA – March 2022

Cover design: IEA

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