4. Energy technology

There is higher share of start-ups in all businesses in Denmark's energy technology stronghold than the all-economy average and the advanced production and food and bio resources strongholds. The average revenue of energy technology start-ups is more than four times' higher than the economy-wide average. Energy technology also has a relatively high share of scale-ups. The revenue share of scale-ups is higher in energy technology than any other stronghold or emerging industry. There is a basic infrastructure in place to support for start-ups and scale-ups in the sector. However, stakeholders in Denmark identified a number of gaps in policy support. This chapter presents key policy recommendations to support start-ups and scale-ups in Denmark's energy technology sector. It includes an assessment of the opportunities and barriers currently faced by start-ups and scale-ups in the sector, as well as an examination of inspiring practice policy initiatives for start-ups and scale-ups in energy technology from Norway, the United States and the United Kingdom.

Policy recommendations for Denmark's energy technology sector

1. **Work with the private sector to develop a stronger sector-specific finance ecosystem**, including both early-stage finance and longer-term patient finance (aimed at the deep tech segment of the sector), potentially including R&D tax incentives adapted to start-ups and scale-ups.
2. **Establish an energy accelerator programme** that specialises in supporting start-ups and scale-ups in the sector, including access to experienced technology managers, market development and regulation experts. The accelerator should work with large firms and investors and include support for access to international markets as well as support with regulations.
3. **Focus on bringing more start-ups and scale-ups into the sector**, and especially into the supply chain, including start-ups and scale-ups based on use of energy data.
4. **Support large firms to work more closely with start-ups and scale-ups** as first customers.
5. **Review the public procurement process and especially the early pre-tender stages to address current barriers** to the participation of start-ups and scale-ups. This should include simplifying the tendering process, facilitating participation in bidding consortia, raising awareness of opportunities, and increasing granularity of contracting.
6. **Develop physical infrastructure, including piloting and testing facilities and relevant science parks** to bring Denmark in line with competitor countries.
7. **Promote a closer and more systematic co-operation between the national cluster organisation and regional entrepreneurial ecosystem actors**, including clusters, science parks, incubators and accelerators.
8. **Provide Energy Cluster Denmark with longer-term and freer funding** to enable it to take more strategic actions, provided as a result of competitive bidding and backed up by regular impact evaluations to steer funding.
9. **Address talent shortages** in key sectors such as the offshore wind sector and incentivise skilled people in the digital sector to move into the energy sector, and promote opportunities in the sector to entrepreneurs of diverse backgrounds, including women, by including diversity objectives in public programmes.
10. **Involve start-ups and scale-ups in the design of regulations** to develop a net-zero energy market.

Introduction

The energy technology sector encompasses technologies related to energy production and energy efficiency. Denmark's net zero commitments and advances with renewables, in particular wind technology, make it a leader in this sector internationally (International Energy Agency, 2022[1]), and there will be numerous new opportunities for start-ups and scale-ups as Denmark's green transition efforts progress. For instance, Innovation Fund Denmark has announced that it will invest DKK 700 million in four mission-driven innovation partnerships,[1] two of which will be focused on Carbon capture and storage and Power-to-X.

In addition to the national cluster organisation (Energy Cluster Denmark), there are a number of other networks that operate in the energy technology sector. These include Wind Denmark, which is a network

with 275 companies and 2 400 members in the wind sector, and Danish Federation of Energy Industries (DI Energy), with more than 800 members. The 2022 agreement "*Danmark kan mere 1*" also sets aside funding for eight local business lighthouses, tasked with future-proofing Danish strengths. Three of these business lighthouses will have a focus on energy technologies.

DI Energy finds that there is the potential for start-ups arising from changes in the areas of digitisation, data driven systems and smart energy systems. Although few of DI Energy's members are start-ups, there is interest in encouraging new start-ups within the broad field of fast energy technologies. Another relevant initiative is Center Denmark, which is an independent non-profit company with a digital platform providing access to data and tools to promote data driven innovation in the energy technology sector, in partnership with a commercial firm and the four technical universities. Center Denmark is intending to set up an accelerator to support early start-ups. It provides data infrastructure to support the green transition, sharing data between its members rather than delivering solutions. It is targeting 100% renewable energy by digitalisation of the system and sector coupling, linking systems for electricity, water and waste water.

The next section describes the following key barriers that start-ups and scale-ups face in the energy technology sector in Denmark:

1. Difficulty bringing radical innovations to market
2. Industry structure
3. Incubators and accelerators
4. The role of large firms in the cluster
5. Access to finance
6. Talent shortages
7. The role of universities
8. Procurement, testing and regulation.

Relevant policy approaches that have been adopted in Norway, the United States and the United Kingdom are then presented, with an analysis of the lessons and takeaways for Denmark.

Barriers for start-ups and scale-ups

Difficulty bringing radical innovations to market

Areas of innovation where start-ups and scale-ups could contribute to dynamism in the supply chain include the development or deployment of new or different materials, reducing the costs of products, and building sustainability into the design of new products. However, there is a shortage of start-ups that develop completely novel solutions to producing energy. Such endeavours require 10-15 years of development and significant amounts of capital, and there are not many investors who are open to this type of commitment. The challenge is greatest when large physical hardware is involved, such as turbines. While it is easier for firms providing services to enter the supply chain, there is still a need to demonstrate and validate their services before deployment.

Industry structure

Wind Denmark reports that the main sources of start-ups are either from within the existing supply chain or spin-offs from universities, building on the very strong research at Danish universities. However, there is a strong tendency in the sector for new firms to merge quickly into existing companies in order for them to access resources and safeguard their future. Moreover, track record, especially in the offshore sector, is vital for large investments, and start-ups can struggle to attain this without undergoing mergers and

acquisitions. The industry is therefore characterised by a steep pyramid with very few companies at the top. This pattern can restrict innovation, but on the other hand, it does align with customer requirements for stability.

Incubators and accelerators

There are relevant incubator and accelerator programmes for the energy technology sector in Denmark. For example, GreenUp is an accelerator programme at DTU which has accelerated 150 climate tech start-ups. In the GreenUp accelerator, a climate tech business goes through a start-up programme, a gear-up programme, and a scale-up programme over the course of 20 months. After this, the business will be ready to enter international markets and launch a Series A financing round. In addition, Next Step Challenge has supported more than 120 companies in its energy technology accelerator programme. Furthermore, as part of the Beyond Beta start-up incubation programme, Energy Cluster Denmark together with Next Step Challenge is running an Energy Incubator for start-ups with innovative solutions for the energy sector.[2]

The role of large firms in the cluster

Large firms in the energy technology sector, such as Danfoss and Siemens, can offer opportunities for start-ups and scale-ups to provide innovation that can support their own product and process development. Public initiatives could encourage more active involvement of large firms with start-ups and scale-ups for this purpose, including matchmaking services and offering financial support and advice to start-ups and scale-ups working with large firms. In particular, there is an opportunity for large firms to act as first customers for new innovations by start-ups and scale-ups. In this respect, large firms could adopt the role of problem owners, with problem solving being delegated to a number of separate but collaborating SMEs and/or knowledge institutions. While the large companies can undertake their own innovation projects, they acknowledge that complex innovation requires collaboration between multiple companies. Sometimes, the larger companies in the sector initiate innovation projects and then customise the results for their own technological advances. Start-ups and scale-ups can bring specialised know-how to these collaborations, for example in the green transition and associated technologies.

The wind industry is also pushing for greater innovation and needs larger firms to be innovative and involve start-ups and scale-ups in innovation processes. Vestas Wind Systems is a major energy company, which designs, manufactures, installs, and services wind turbines. It has approximately 3 000 engineers, half based in Denmark, who work on technology for small flat turbines and the energy system as a whole. Scale-ups are supported through Vestas Ventures, Vestas Wind Systems' venture capital arm. Rather than supporting start-ups, Vestas Ventures focuses on firms at a later development stage, and wants to see proof of concept or proof of sales before investing. It defines a framework of support and takes minority investment in the SMEs, as part of syndicates with other investors. It has screened over 70 companies worldwide but has so far only invested in three Swedish companies. Vestas Ventures reports that it finds fewer start-ups in the energy technology sector in Denmark than in other countries.

One of the barriers to innovation in the supply chain identified by Center Denmark is that some of the larger energy firms have a conservative culture and are facing challenges in adopting digital technologies. These large companies therefore have a need for an ecosystem where start-ups and scale-ups can play an active role in providing new solutions for them. To assist with this, Center Denmark recommends that the government incentivises energy companies to make their data freely available for start-ups and scale-ups to mine, in order for them to develop new business models that can meet the innovation challenges. Current economic incentives are not strong enough in this area. Center Denmark offers a subscription service to its data platform, which receives daily energy consumption and production data from tens of thousands of Danish households.

Germany's EUREF Campus was highlighted by DI Energy as an example of an initiative that could be a model for Denmark's energy technology sector. The private sector organisation has generated a scale up environment for firms focusing on renewable energy in the heart of Berlin. It operates as an innovative community of businesses and researchers, with a climate-neutral energy supply, an intelligent energy grid, energy-efficient buildings and a testing platform for future mobility, as well as numerous research projects.

Access to finance

A barrier to more start-ups and scale ups in the energy technology sector is the lack of a sector-specific finance ecosystem. While there are new opportunities emerging in the energy sector (Butcher, 2021[2]), the consensus in the stakeholder interviews was that there needs to be a more integrated investment environment involving public and private bodies and more funding for innovation projects. This includes collaborative projects with knowledge institutions. It is expensive to be a start-up in the energy technology sector, especially in deep tech fields such as new power sources where there is a scarcity of investors. This points to a need for specialised support that recognises the importance of different types of funding at different stages. This includes more risk capital at early stages where market opportunities are less certain and more patient capital at mature stages in growth when businesses are scaling up, to support activities such as building the management base, piloting and testing. A major barrier identified in the stakeholder interviews is a lack of funding at the late stage of commercialisation, particularly for scale-ups when they reach a medium size. Funding designed for later stages, both for projects and knowledge institutions, would help drive more innovative start-ups and scale-ups. Existing public grant schemes provide insufficient financing volumes and tend to focus on the early stage development of firms. They need to be complemented with further financial instruments including equity and loans at later stages. There also needs to be more clarity on which public funding schemes for the green transition are appropriate for which kinds of firms.

Denmark's Green Investment Fund, which co-finances projects that promote the green transition in the areas of renewable energy, energy savings and resource efficiency is sufficiently well resourced that it has the potential for appropriate projects to significantly close the financing gap in the energy technology sector. The Danish Growth Fund has attempted to invest in the energy technology sector but the market was insufficiently mature and so investments in early stage technologies were lost. There is also some evidence that US funds are coming to Denmark in the deep tech segment of the sector, but for that part of the supply chain, stronger environments and more programmes like GreenUp are needed to encourage further inward investment.

Talent shortages

Several stakeholders suggested that there is a lack of skilled workers for start-ups and scale-ups in the energy technology sector. For instance, there is a need for engineers in the offshore wind sector in Esbjerg. More broadly, there is a need for people from the digital sector to move into the energy technology sector. Sometimes, talent can be recruited from abroad to overcome national shortages. Evidence from the stakeholder interviews also indicates that the energy technology sector is unappealing to women, especially at higher levels. This is evidenced by the low participation of women in the sector. For instance, DI Energy has only two women on a board of 30.

The role of universities

Several stakeholders stated that insufficient sharing of knowledge from research between universities, firms and projects is a barrier to innovation in the energy technology sector. There are a variety of potential factors contributing to this, including the intellectual property regime, researcher incentives and the structure of public funding schemes. An example of an initiative to address this is a new development by the National Center for Energy Storage, which will work with all Danish universities to support spin-outs.

Another model of collaboration is the Danish Centre for Environment and Energy (DCE), which is Aarhus University's central unit for knowledge exchange within the areas of nature, environment, climate and energy. DCE delivers science-based advice and solutions that contribute to the greening of the economy and promote sustainable growth at local, national and international levels. Its customers include the Danish Ministry of the Environment and Food, the Danish Ministry of Energy, Utilities and Climate, Greenland's Government, the Danish municipalities, private businesses and the European Commission.

Public procurement, testing and regulation

A consensus among stakeholders is that the public procurement system needs to be revised to encourage the participation of start-ups and scale-ups. This would include adapting the tenders to the capacity of start-ups and scale-ups in terms of smaller and manageable tenders and removal of restrictions on the involvement of early stage firms. In addition, it is necessary to provide support and brokerage for start-ups and scale-ups to form consortia with other bidders. More positively, it was reported Denmark is ahead of other countries in the areas of testing and regulations for prototypes.

International policy experiences

Norway – Three energy clusters and two catapult centres

Overview

Norway has been a large energy producer for more than 100 years. In the beginning of the 1900s, hydroelectric power was a major source of energy. This was funded by foreign capital, although there were requirements to use Norwegian inputs, such as labour or components, as part of the conditions to be granted concessions to exploit the waterfalls. The same principles were applied to the exploration and exploitation of offshore oil and gas at the end of the 1960s. With the decline of oil and gas production, there is an increased focus on renewable energy sources such as wind power and hydrogen. The lengthy Norwegian coastline offers excellent conditions for offshore wind power installations. Moreover, the construction of platforms for the windmills can exploit the existing value chain for the production of drilling platforms and other equipment used by the oil and gas industry. Norway's abundance of natural gas (primarily methane) will be the basis for blue hydrogen as an energy source for land, sea and air transport. In combination with carbon capture and storage (CCS) technology, which is also a focus area in Norway, the production of blue hydrogen provides a low emission energy source. The Norwegian government has launched a strategy and a roadmap for the safe use and production of hydrogen.

Norway has an internationally-recognised cluster programme, Norwegian Innovation Clusters. The programme is organised by Innovation Norway jointly with SIVA (The Industrial Development Corporation of Norway) and the Research Council of Norway. Norwegian Innovation Clusters groups the clusters it supports into three levels:

- Arena clusters, which are new or immature clusters in emerging industries and sectors. They are funded for 3-5 years.
- Arena Pro clusters, which promote a continued development of the strategic importance of the cluster beyond being an arena for interaction and collaboration. Arena Pro clusters receive funding for 5 years.
- Global Centres of Expertise, which are world-leading clusters with the potential for growth in international markets. These clusters receive funding for a ten-year period.

In general, for all the cluster levels there are four main focus areas: Increased innovation, internationalisation, strengthened attractiveness, access to relevant competence.

The Norwegian Catapult Programme is a government scheme designed to assist the establishment and development of catapult centres, which seek to accelerate the process of moving from a product's concept phase to market launch. The purpose of the programme is to support the innovative capabilities of SMEs in specific industry areas in Norway. The programme is administered by the Industrial Development Corporation of Norway (SIVA) on behalf of the Norwegian Ministry of Trade, Industry and Fisheries, in partnership with Innovation Norway and the Research Council of Norway.

This international case looks at the following three clusters and two catapult centres, which each have a focus on offshore wind or hydrogen energy sources. As the focus of these clusters is on new emerging technologies, the three clusters are classed as Arena clusters.

- The Norwegian Offshore Wind Cluster (Offshore Wind) aims to have the world's strongest supply chain for the floating offshore wind sector. Norway has a very strong petro-maritime supply chain, meaning that Offshore Wind is well placed to attain and retain this position. Companies like Equinor, Aker Solutions and Kværner are already at the forefront, along with a number of other Norway-based companies. Membership of the cluster is open to all companies and organisations either from Norway or the rest of the world. The cluster has a focus on start-ups with a special, low membership fee of NOK 5 000.
- The Ocean Hyway Cluster is a Norwegian hydrogen cluster aiming to realise the maritime use of hydrogen-based fuels. It is Norway's leading network for hydrogen-based fuels in maritime applications. The members of the cluster are active throughout the hydrogen value chain, including in energy and hydrogen production, processing and distribution, storage and bunkering, ship design, as well as R&D. The membership of the cluster ranges from international companies to start-ups.
- The Norwegian Hydrogen Cluster (H2 Cluster) is working to promote the Norwegian hydrogen industry internationally. The cluster was established as a result of the Norwegian Innovation Clusters programme, which mapped the various activities taking place within the hydrogen industry in Norway in order to identify whether there was a basis for a co-ordinated efforts to promote hydrogen internationally with the clusters as a point of departure. As many as 13 clusters, along with a number of CEOs from leading companies within the hydrogen industry, are actively participating in the international promotion of hydrogen. This has resulted in a positioning project, which aims to develop a branding strategy for presenting Norwegian hydrogen technology and competence to an international market, and to create a competitive advantage and increased value creation for Norwegian companies in the field. Since many of the 13 clusters are Arena clusters, SMEs, start-ups and scale-ups are well represented in the H2 Cluster. Many of Norway's clusters work to a varying degree and in different ways with hydrogen. This trend is increasing and clusters that today do not work with hydrogen have plans to do so in the future.
- The Ocean Innovation Norwegian Catapult (OINC) is a national centre for the effective design, prototype development and verification of new solutions for blue growth and green transition of the ocean space. The centre provides equipment, competence and premises for companies to test, simulate and visualise technologies, components, products, solutions, services and processes. OINC is also a hub for interactions between industry and R&D institutions and can provide opportunities for new relations and the basis for continued co-operation. The catapult centre is especially focused on SMEs, start-ups and scale-ups. However, large companies, R&D institutions and educational institutions can also use the centre.
- The Sustainable Energy Norwegian Catapult Centre was established in 2018. Its focus is on green transition and in particular the transition to more renewable energy sources. The catapult centre assists companies in developing and testing sustainable solutions for the production, storage, distribution and control of energy, covering the development and testing of prototypes in a laboratory as well as the testing of finished products in operative facilities on land, ships or in the ocean space. The centre provides the competence and testing facilities that companies need to

transition from idea to market. It can also assist companies applying for project support from relevant grant and subsidy schemes.

Issue 1: The role of catapult centres for innovative start-ups and scale-ups

The catapult centres assist companies in developing prototypes and offer expertise and equipment for testing, visualisation and simulation in order to turn innovative ideas into new products and services in an effective manner and at a lower risk. The centres also provide expertise, contacts and facilities in various technological areas, and can assist companies in accessing new markets and capturing interest from other potential business partners. Such assistance is of key importance to start-ups and scale-ups as they have limited access to such expertise and facilities due to scarce financial resources.

Issue 2: Financial support for start-ups and scale-ups

Start-ups and scale-ups can apply for general support from Innovation Norway and the Research Council of Norway. Innovation Norway is the most important agency for supporting new ventures and innovation at an early-stage (Ali, 2021). The Norwegian system provides a range of direct financial support measures for start-ups within the clusters. These include:

- Establishment grants (phase 1 up to NOK 100 000 and phase 2 up to NOK 750 000). This constitutes a 50-70% subsidy of the actual costs. These grants are specifically aimed at supporting technology-related ideas that are scalable.
- Development grants (industrial R&D grants and public sector R&D grants in the range of NOK 1 to 25 million).
- Innovation Norway offers risk loan and grants for companies that want to develop and commercialise technologies within renewable technology sectors.
- Precubator/technology transfer office funding of up to NOK 100 000 for feasibility studies through regional incubators, which receive public funding.

Issue 3: Tax incentives for R&D investments that are accessible to start-ups and scale-ups

The most important support instrument for start-ups and scale-ups from Research Council Norway is SkatteFUNN, the tax reimbursement scheme for R&D investments. Firms can receive a tax deduction of up to 20% (18% for large companies) of the cost of R&D projects. The maximum deduction is NOK 8 million. SkatteFUNN is a tax scheme that is designed for smaller companies rather than for larger companies. For start-ups and scale-ups with a deficit, SkatteFUNN provides cash reimbursement, making this incentive particularly interesting for start-ups and scale-ups that have not yet generated a surplus. Among firms applying for SkatteFUNN, there are three times as many with a deficit than with a surplus.

Lessons for Denmark

- Long-term funding for the clusters of up to 20 years (but with 10 years as the normal length), accompanied by regular evaluations, provides the resources necessary for strategic actions.
- Providing different entry levels for clusters may be especially important for new or emerging firms in new sectors.
- The programmes include a focus on more specific technologies than the broader energy technology sector identified in Denmark. The more specific focus is particularly important for emerging new technologies such as hydrogen by helping to concentrate resources to secure a faster development.

- The catapult centres play an important role in accelerating the process of moving from concept to market and in providing testing, simulation and visualisation facilities for design, prototype development and verification. They have a particular focus on SMEs, start-ups and scale-ups.

Recommendations for Denmark based on the Norwegian case

- Secure national co-ordination, beginning with the mapping of existing and planned activities for the development of new technologies, as is done in Norway with the hydrogen industry. Energy Cluster Denmark could take on this task.
- Expand the national acceleration infrastructure to support entrepreneurs in taking ideas from inception to scale-up by offering specialist support in areas such as prototyping, expertise and equipment. What is provided by the two GTS institutes, FORCE Technology and the Teknologisk Institut, is currently insufficient. In co-operation with regional ecosystems, Energy Cluster Denmark could provide additional access to testing and piloting, as well as information on technology, markets and networking opportunities.
- Provide specialised indirect financial support, such as tax reimbursement schemes for R&D investments. For start-ups and scale-ups with a deficit, cash reimbursement can be applied.
- Provide clusters with long-term funding, which makes them capable of taking on strategic actions.

United States – Small Business Innovation Research (SBIR) Programme in Energy

Overview

The US' Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programmes encourage domestic small businesses to engage in research with the potential for commercialisation. Through a competitive, awards-based approach, SBIR and STTR enable small businesses to explore technological potential and provide the start-up funding to profit from the commercialisation of the developed technology. The SBIR programme is strongly focused on small businesses, which take a lead in the research process. In the STTR programme, the small business is required to partner with a federally-funded research institution such as a national laboratory or a federally-funded university. However, as with the case of the SBIR programme, the small business leads the process.

In total, ten Federal Agencies have either an SBIR or an STTR programme. One of these is the Department of Energy. Within the Department of Energy, the Office of Energy Efficiency and Renewable Energy (EERE) provides grants to small businesses through the SBIR/STTR programmes. EERE's mission is to support transformative science and emerging energy efficiency, renewable power and sustainable transportation. Knowledge generated by its R&D activities facilitates the development and deployment of innovative energy technologies by businesses and entrepreneurs. It is estimated that about half of start-ups involved in the SBIR programme originate in universities but there is little detailed data on the source of start-ups. A majority of start-ups have a university background, but they are not necessarily affiliated with the university at this point.

EERE provides funding to competitively selected energy efficient and renewable energy technology small businesses on an annual cycle. New financial awards are known as Phase 1 awards. Follow-on awards made to previous Phase 1 awardees are known as Phase 2 awards. All of the EERE's SBIR/STTR awards follow the "Release 2" schedule. The small businesses selected are those with innovative ideas that can align with the Department of Energy's mission. Phase 1 lasts for 6-12 months and Phase 2 lasts for two years. Since 2011, Phase 2 can be repeated if the firm continues to work on the project and it remains promising. This extension is very helpful for energy projects because, at least in the advanced manufacturing area, much research is not ready to be commercialised within three years. In 2018, a third

iteration of Phase 2 was made possible for the same reasons, namely that in the energy sector, lead times are considerable and research is capital intensive for a longer period. In the SBIR programme, Phase 1 grants amount around USD 250 000. Phase 2 grants are typically around USD 1 million, as are subsequent grants. The phases may correspond to differing capital needs within the project, such as a demonstration phase with demonstration funding which is only just being put in place. It covers the "valley of death" that occurs between coming out of R&D and commercialisation. The Department of Energy is starting to address this difficult part of many SMEs' journey.

Some 20% receive funding the first time around. Of those that survive, 35% go through to Phase 2. Approximately 25% of Phase 1 awardees do not apply for Phase 2. However, there is reason to believe that this may be due to the receipt of funding from venture capitalists in many cases.

Issue 1: Concerns over intellectual property rights (IPR) and regulation

The small business owns the intellectual property (IP) it generates in the project unless it is a national lab intellectual property, in which case the national lab retains ownership of the IP. Obtaining IP from universities is a significant problem, since universities have cracked down on ownership. In response to this challenge, the Technology Transfer Opportunity programme has been introduced. Rather than the EERE proposing a topic where the small business solves a problem, small businesses instead work on a topic where there is some existing IP from the National Lab, which the small business then commercialises. The TTO programme provides funding to the small business to commercialise the technology from the university or lab test. The holder of the IP has to give the small business a licensing option. This means that the EERE has some leverage over the universities and national labs because the IP is paid for by the Department of Energy.

The EERE programme does not deal with the regulatory process. There have been programmes where it tries to collect information on and publicise regulatory barriers, but this particular programme is focused on R&D.

Issue 2: Entrepreneurial skills

One of the gaps identified by the SBIR is that of ensuring that small businesses have the entrepreneurial knowledge needed to successfully commercialise technologies. The National Science Foundation's Innovation Corps programme is designed to address this gap. It is specifically designed to provide the necessary skills to small businesses surrounding entrepreneurship and commercialisation, helping to bridge the gap between R&D and commercialisation.

Issue 3: Areas covered

While the types of clean energy projects that are funded vary, the percentage of funding dedicated to this technology area has increased over the years, as has the amount of funding per project. Increasingly, the Department of Energy adopts a strategic approach by compiling a disseminated list of priorities, which then affects the bids received. In 2021, decarbonisation was a priority area that was carried forward and agriculture became a new priority. Waste in the food and agricultural sector also emerged as a major concern.

In 2021, the EERE programme within SBIR encouraged proposals in the areas of:

- New energy sources and resources, power generation, energy storage, and electronic systems for energy sources used in mobile technologies and off-grid type applications.
- Oil and gas and related processes.
- The intersection of energy technologies and data across all areas where integration to energy technology applications is the primary thrust, including computational technologies.

- Nature-inspired processes for sustainable energy solutions and carbon storage, reducing the carbon and resource intensity of hydrocarbon extraction, energy conversion, and its uses.
- Energy storage from the scale of wearable devices to power plant, and energy conversion.

Issue 4: Evaluation

The programme is evaluated every four years by the National Academy of Sciences as a requirement of the SBIR. An evaluation of data from 40 000 projects (Howell, 2017[19]) reported that many clean energy start-ups face a challenging funding environment because their development cycles are long, risky, and capital-intensive. The study found that early-stage grants make a significant difference to young clean-energy firms and increase clean innovation. It concluded that the SBIR grant is most useful in sectors that generate large positive spillovers, such as hydropower, carbon capture and storage, and building efficiency and automotive technologies. However, there was no measurable effect for conventional energy technologies, such as natural gas and coal, suggesting that these sectors are not as financially constrained.

The analysis also found that early-stage grants have large, positive effects on subsequent venture capital investment, firm revenue, survival, and successful exit (IPO or acquisition). However, a larger, later stage grant did not have similar measurable effects. The overall conclusion of the evaluation was that providing more one-off grants to small, young firms could be more effective in driving innovation than a smaller number of larger grants that are allocated to firms through several stages of technology development.

Issue 5: Success factors

The programme's main success factors lie in the evaluation of the potential of applicants and the leverage that having an award gives the award holders. The programme is rigorous and merit based and has a standardised review process. Each project requires a commitment from the applicants to meet particular targets. As part of the technical merit analysis, applicants are judged on whether or not they will meet these requirements.

Another key success factor is having hands-on technology managers who are government employees. Prior to the COVID-19 pandemic, these managers were funded to conduct site visits to advise on progress. Some technology managers have introduced firms to their research networks. Testimonials from award recipients refer to how the expertise, knowledge and networks of the technology managers significantly helped their respective start-ups.

The geographic distribution of projects funded is interesting, since there are advantages for start-ups and scale-ups to be located in centres of expertise, especially top universities. The geographic distribution of research funding is similar for the SBIR and STTR programmes and similar to that of National Science Foundation funding. The bulk of funding goes to places with elite research universities such as California, Massachusetts and Connecticut. These are locations that small businesses gravitate towards because, even without a direct link to a university, they represent a good place to hire suitably skilled and motivated staff. There were efforts in the previous SBIR initiatives to work with regional authorities to build innovation ecosystems, but these were very short lived.

Issue 6: Contribution of the policy to inclusive entrepreneurship objectives

One of the goals of the SBIR programme is to increase the involvement of women, minorities and underrepresented groups in scientific and technical innovation. Evaluations by the National Academy of Sciences are helping to highlight needs in this area. One of the lessons learned is that it is important to include this aim at the foundation of the programme, rather than attempting to achieve the diversity at a later stage. This implies having those diverse stakeholders involved in the development of the programme, allowing diversity to be embedded.

Lessons for Denmark

The first lesson is that it is very difficult to enable some areas of technology to be commercialised, especially in the later stages of projects where it is important to ensure that commercialisation happens. Demonstration is a piece of the puzzle, so it is important to include additional government funding for demonstration projects. In addition to the SBIR programme, there is a loan programmes office in the US, which helps to fund viable energy projects. The loans may be large in scale, typically around USD 100 million in value. Without demonstration of the success of the technology, commercial players are not comfortable with investing due to the higher associated risks.

It is important that potential later-stage funders, and funders more generally, are included in the programme strategy development to ensure their buy-in. This is essential in guarding against the "cliff of funding" that projects can encounter as government support is withdrawn.

It is necessary to have a clear understanding of the goals of a programme. If the goal is to spur the small business energy ecosystem, then the programme has to take a different shape to one that is aimed at commercialisation. Too many programmes in other countries are the former. In programmes that focus on commercialisation, the entire ecosystem needs to provide input, not only those elements involved in R&D. It is also vital that the full pathway from start-up through to commercialisation is covered by programmes.

In the US, SBIR funding is strongly focused on areas where commercialisation makes sense. These correspond to areas in which there is some other available funding, a very strong potential customer base and an existing robust supply chain that provides a place for the technology. Finally, there needs to be a clear market for the product defined early in the process, before too much R&D has been undertaken.

Recommendations for Denmark based on the US case

- Appoint experienced technology managers, with experience in technology commercialisation, when designing programmes of this kind. SBIR testimonials show that their expertise, knowledge and networks are crucial resources for start-ups and scale-ups.
- Carry out regular evaluations of programme performance to identify value added from early stage funding. SBIR evaluation found that early stage grants make a significant difference to young clean-energy firms by increasing clean innovation and raising the chance of getting venture capital or other private funding by 50%.
- Provide additional funding for demonstration projects, which are essential to the commercialisation process.
- Be clear about the goals of a programme. If the programme is centred on commercialisation, then the whole ecosystem rather than just the elements directly involved in R&D need to be included. This ensures that there is a place for the new technology in the supply chain.
- Build diversity into the programmes, with specific programme goals in this area. Include and align programme metrics, evaluation and award selection criteria with diversity, equity and inclusion. Ensure programme leaders are experienced in ensuring diversity.

United Kingdom – Energy Systems Catapult

Overview

The Energy Systems Catapult (ESC) was set up to accelerate the transformation of the UK's energy system. The catapult offers technical expertise and insights from a whole-system perspective, with specialists in consumer insights, digitalisation, modelling, markets, policy and regulation, bioenergy, carbon capture and storage, hydrogen, energy storage, energy networks, nuclear and renewables. With

its Living Lab of real-world smart interconnected homes for the trialling of commercial and technical innovations, ESC has established a deep expertise in market-orientated demonstration environments.

ESC works to bridge the gaps between industry, government, academia and research. It takes a whole-systems view of the energy sector to identify and address innovation priorities and market barriers, in order to decarbonise the energy system at the lowest possible cost. It has approximately 235 staff based in Birmingham with a variety of technical, commercial and policy backgrounds. It collaborates on R&D and bid funding opportunities, connects with industry partners, investors or test facilities, and convenes with domestic and international stakeholders including governments and regulators. A third of the funding comes from the government, a third comes from awards of public money that have been bid for and a third comes from commercial income e.g. from assets, royalties and licensing income.

One of ESC's missions is to understand the future of the energy system and to support innovation by working with start-ups and larger innovators where applicable. Changes in the energy system are often broken down into four key trends, referred to collectively as the "four Ds" of energy system transformation (Soutar, 2021[3]). These are decarbonisation, decentralisation, digitalisation and democratisation. Energy Systems Catapult sees digitalisation and democratisation as currently stimulating the largest changes, with digitalisation in this context referring to the move towards smart energy systems.

ESC's other core mission is to support innovators in commercialising energy products and services through performance validation, real-world consumer insights, business model analysis and system integration. It works with start-ups and scale-ups, especially innovators with disruptive ideas who are seeking to ground their ideas in viable business models, grow their position, acquire investment or refine their approach. The catapult has knowledge of the energy sector and the core skills needed to support innovators. This skill set includes social scientists with an understanding of consumers and engagement and the ways in which service propositions might change.

Energy Launchpad is ESC's innovator support platform. Energy Launchpad works with selected start-ups with high-growth potential, providing support at various stages from innovation assessment to commercial validation. Currently, Energy Launchpad works more with early-stage businesses than with scale-ups. This is a reflection of the evolving yet immature markets and new market spaces, which means that there is a high volume of new firms coming through. The platform also serves as a collaborative meeting place for innovators in the energy sector.

Energy Launchpad has a specific focus on the green transition, with the philosophy that innovation is crucial to transforming the energy system to achieve net zero carbon emissions. In order to stimulate innovation in specific areas of the energy system, Energy Launchpad runs numerous Challenge Calls. These challenges provide innovators with access to ESC's expertise and specialist business support. To date, Challenge Calls have been launched in a variety of areas including digital energy, smart heating and cooling, digital platform and data services, smart buildings and estates, low carbon interoperable energy solutions, and smart energy innovations for international markets.

Issue 1: How the Energy Launchpad works with start-ups and scale-ups

Energy Launchpad is designed to help overcome systemic barriers that prevent products, services and business models from getting to market at scale. It is free to join, with all members provided with a range of support measures including the provision of insights about the UK's energy system and ESC as well as help in finding partners and accessing events and workshops. Partner organisations provide the delivery support network of existing experts and other accelerating incubators that provide more conventional business support.

Via the Challenge Calls, Energy Launchpad provides two additional tiers of support to SMEs:

- **Incubation:** The incubator programme is designed for innovative start-ups that are looking to advance the Commercial or Technology Readiness Levels of new products and processes and

secure early-stage seed funding. The incubator provides tailored support to selected SMEs, utilising the ESC's capabilities and tools, as well as those of its delivery partners. This includes business model development, energy system integration assessments, consumer insights guidance, digital fitness, market testing and validation, investor readiness, specialist advice, and identification for acceleration support. Experienced incubation managers work closely with SMEs throughout the process. An area that is being explored is bringing start-ups together to develop end-to-end integrated solutions.

- **Acceleration:** Energy Launchpad's accelerator programme is designed for more established SMEs looking to scale up and trial solutions in demonstration environments, such as the ESC's Living Lab, export to new markets or secure later stage investment. It provides scale-up support for selected SMEs with high impact potential. The support provided includes help to access demonstration environments, such as the ESC's Living Lab, engagement with potential corporate clients and investors, and links to international opportunities. The alumni group is a means of keeping in touch with and providing continued support to firms that have completed the programme over the longer term.

Typically, each challenge has 30-50 applicants, of which six are selected based on a range of criteria including the potential for innovation, the carbon impact, the characteristics of the team and the additionality or impact that ESC can likely deliver. A new criteria is for businesses to have both software and hardware developments, for example sensors and equipment that enables monitoring and management of assets because this can be associated with greater scale up potential. 56 SMEs were helped through the first six innovator challenge calls, while a further 190 have been assisted through the wider support offerings.

Energy Launchpad's impact from the first six calls was reviewed in January 2021 (Energy Systems Catapult, 2021[4]). The review showed high levels of satisfaction from participating SMEs, with over 81% reporting the achievement of at least one beneficial outcome. Of these, 96% felt that the support had led to enhanced outcomes or accelerated the rate at which they had been achieved. The benefits delivered to SMEs that have participated in the programme include support in obtaining financing, signposting of valuable contacts and access to networks, supplying pitch enhancement to help secure funding, as well as the injection of momentum and confidence. Many start-ups and scale-ups also report that there are reputational benefits from working with Energy Launchpad.

Together, the universal, incubator and accelerator support packages draw on the range of capabilities, tools and testing labs from ESC and its partners in order to accelerate deployment and turn innovators into entrepreneurs. The lack of specialist facilities and capabilities for energy firms was a motivation behind the establishment of the incubator and accelerator.

Issue 2: Infrastructure, pilots and testing

The Living Lab is a unique asset. It is where the Energy Launchpad is fully interconnected with real homes, enabling innovators to pay to trial both technical and commercial solutions. The consumer insights team helps SMEs to trial and interface with the end users, with support in areas such as service proposition or interacting with certain pieces of technology.

Issue 3: Ownership of IP

Even in collaborative projects, the SMEs own the IP rather than Energy Launchpad. The objective is to help the firms develop their IP. The exception to this is if the IP belongs to ESC.

Issue 4: Involving start-ups and scale-ups in regulation design

ESC's regulation team works with the government, regulators, SMEs, innovators, and academia to develop practical, solution-focused market design, policy and regulatory options. A key focus is on designing

policies and regulations to create a net-zero energy market. In the markets, policy and regulation teams, there are policy experts who consider how the market might change and what the corresponding regulation or policy changes may be. ESC also publishes a large amount of thought-leadership work, such as their recent 'Rethinking Electricity Market Design' report.

Issue 5: Diversity

Addressing the lack of diversity in entrepreneurs and workforces in the UK's energy system is a core part of ESC's mission. ESC has consciously decided not to develop specific targets or initiatives, instead focusing on its approach to recruitment. ESC has also published data on the composition of its workforce, broken down by gender and ethnicity.

Fuel poverty is a topic that receives a lot of consideration at Energy Launchpad. There is a risk with the energy transition that more disadvantaged households are left behind. Work is therefore being conducted on how the energy sector might develop in a more equitable way.

Lessons for Denmark

The key lessons for Denmark are that start-ups and scale-ups are strategically important as innovators in the energy sector, especially in green transition approaches. Energy Launchpad provides three levels of support for SMEs, including incubation and acceleration services. The latter involve working with large firms and investors as well as providing access to international markets. Energy Launchpad also involves SMEs in regulatory policy design, building on their innovation capacity. It has a clear commitment to internal diversity but has not addressed diversity in the organisations with which it works.

Recommendations for Denmark based on the United Kingdom case

- Sector support organisations need to adopt a philosophy of working with high-potential start-ups to take them from innovation assessment to commercial validation. Innovation is crucial to transforming the energy system to achieve net zero carbon emissions.
- Sector organisations which have different remits should offer different levels of support to their start-up and scale-up members, based on their stage of development. Of central importance are the availability of capabilities, tools and testing labs.
- Energy Cluster Denmark and public authorities need to involve start-ups and scale-ups in regulation design to develop a net zero energy market.
- All sector support organisations should have a clear policy on equality, diversity and inclusion.

References

Butcher, M. (2021), *6 Copenhagen investors share their outlook on investing in 2021*, Tech Crunch. [2]

Energy Systems Catapult (2021), *Insights and Impact from the first 3 years of the Energy Launchpad*. [4]

International Energy Agency (2022), *Denmark Country Profile*. [1]

Soutar, I. (2021), *Dancing with complexity: Making sense of decarbonisation, decentralisation, digitalisation and democratisation*, https://doi.org/10.1016/j.erss.2021.102230. [3]

Notes

[1] https://innovationsfonden.dk/en/programmes/green-missions/roadmaps-mission-driven-green-research-and-innovation-partnerships

[2] See Energy Incubator - Beyond Beta.