UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Global Cleantech Innovation Programme (GCIP)

CLEANTECH INNOVATION CLUSTER DEVELOPMENT FRAMEWORK

Contents

Acknowledgments

Lead authors

Gabriella Rufo, Cleantech Group
gabriella.rufo@cleantech.com

Noah Ross, Cleantech Group
Noah.ross@cleantech.com

Nino Lazariia, Cleantech Group
nino.lazariia@cleantech.com

Lucy Chatburn, Cleantech Group
lucy.chatburn@cleantech.com

Reviewers

Todd Allmendinger, Director of Research and Consulting, Cleantech Group
Gerswynn McKuur, Global Coordinator, GCIP UNIDO
Olga Rataj, Global Programme Lead, GCIP UNIDO
Sunyoung Suh, Cleantech Expert, GCIP UNIDO
Eric Jensen, Cleantech Expert, GCIP UNIDO
Laura Glasberg, Cleantech Expert, GCIP UNIDO
Daria Shumilova, Communications Expert, GCIP UNIDO

Expert Contributors

The authors would also like to thank all the organizations and agencies interviewed for taking the time to provide input and/or peer review for this report. Specifically, country focal points Samir Idrissi Kassimy, Morocco, Nicolae Soloviov, Moldova, Cansu Durukan, Turkey, Lucy Moteka, South Africa, Richard Victor, Nigeria, Saule Bishimbaeva, Kazakhstan, Vathinh Chong, Cambodia, Silvia Lamela, Uruguay, and company representatives Bernhard Puttinger, Green Tech Valley; Bianca Dorina Dragomir, Avaesen; Cassandra Goh, Enterprise Singapore; David Hayes, Decarbonization Partners Houston; Erki Ani, Cleantech Estonia; Essa Al-Saleh, Volta Trucks; Henrietta Moon, Carbo Culture; José LaSalle, florrent; Juan Vicén, Zeleros; Julia Travaglini, Greentown Labs; Nisha Mukund, CIIC; Sasha Baillie, Luxinnovation; Siddharth Hande, Kabadiwallah Connect; Stefano Coss, Arteria Technologies GmbH; Tyler Hamilton, MaRS.

Introduction

Purpose of this document

The Global Cleantech Innovation Programme (GCIP) is designed to respond to the increasing global demand for environmental sustainability, climate action and to unleash the potential of cleantech innovation and entrepreneurship to help transform priority sectors and systems. Under GCIP's Theory of Change, the desired impact of the overall program is to enable innovative cleantech start-ups and small- and medium-sized enterprises (SMEs) to significantly contribute to climate mitigation and adaptation to attain low-carbon and resilient development as well as empowerment of women, youth engagement and job creation.

This framework is part of the GCIP Pillar 2 activity addressing Cleantech Innovation and Entrepreneurship Ecosystem (CIEE) strengthening and connectivity. Pillar 2 supports the strengthening of national cleantech ecosystems of GCIP partner countries, the identification of synergies across national ecosystems, and the connection of different ecosystems for knowledge exchange and partnership building.
The purpose of this framework is to guide project executing entities (PEEs) in the GCIP partner countries in defining, implementing and recommending activities to develop successful and inclusive regional innovation clusters, capable of producing high-growth cleantech companies. The framework does this by analyzing learnings from standout clusters globally to identify actions, success factors and milestones to replicate success.

Section 1 looks at how clusters work towards boosting start-up and scale-up growth, details defining characteristics of cleantech innovation clusters and some key differences with regards to generic innovation clusters.

Section 2 examines existing cluster activity in GCIP countries as well as national characteristics and priorities for development of cleantech sectors.

Section 3 profiles standout cleantech innovation clusters globally. The clusters are located on different continents, are specialized in different sectors and have unique qualities; all have demonstrated success in producing cleantech start-ups and scale-ups.

Section 4 provides recommendations for developing regional cleantech innovation clusters, starting from local advantages, characteristics and objectives, and defining a set of activities to be carried out at local, national and international level.

Methodology

General Approach

In this section we describe our approach, sources, and other key inputs. A full list of sources is available in the appendix.

Mapping cluster activity in GCIP countries

For each GCIP partner country, information was collected on key cleantech innovation and entrepreneurship ecosystem (CIEE) actors and categorized them according to location. Key actors are defined as universities and research institutions, risk capital investors, accelerators, incubators and hubs, government ministries, and start-ups and SMEs. Results are exhibited using a heatmap to show start-up and SME density by region. Universities, Entrepreneurial Support Organizations (ESOs) and Venture Capital (VC) investors are highlighted for key cities. ESOs refer to Entrepreneurial Support Organizations and include accelerators, incubators and hubs.[1] The criteria for inclusion are as follows:

- Start-ups and SMEs developing solutions aimed at reducing emissions or resource usage in energy and power, materials and chemicals, agriculture, transportation, and circular economy;
- Universities and research organizations which produce research into fundamental science, clean technologies, or deep tech (technology based on scientific advances including artificial intelligence, biotechnology, advanced materials, or robotics);
- Risk capital investors which are specialized in cleantech investments, or generalist investors with a significant amount of portfolio companies involved in cleantech activities;
- Entrepreneurial Support Organizations which run cleantech-specific programs or cohorts, or which exclusively accelerate cleantech related start-ups.

The maps in section II show existing cluster activity in GCIP countries. We have also highlighted cities which the GCIP team indicated as strategic for development of future cleantech activity.

The starting point for data collection was Cleantech Group's i3 database, which tracks approximately 45,000 cleantech start-ups, investors, and accelerators globally, together with investment flows and key partnerships.[2] This information was supplemented with desk research and results of written questionnaires circulated to GCIP partner countries to obtain a baseline understanding.[3]

1 The significance and contribution of these organisations to cleantech ecosystems is detailed in the Global Framework for Cleantech Ecosystem Actor engagement.

2 i3 is Cleantech Group's proprietary database, created in 2002 to provide data and insights on cleantech innovation and investment deals for corporates, investors, and start-ups. i3 tracks private investment on around 35,000 high-growth innovative start-ups globally

3 The written questionnaire was developed by Cleantech Group with input from UNIDO's GCIP team and circulated to country PEEs who coordinated responses. The questionnaire includes questions on policy, stakeholders and cleantech ecosystem observations; answers were provided by government officials and representatives of government agencies, university professors and other research leaders, cluster facilitators, other ecosystem actors. A full list of questionnaire responders is included in the appendix.

Baseline datasets were then shared and validated with GCIP partner country PEEs. Where advised by in-country PEEs, additional information was collected from recommended third parties. In applicable countries, alumni companies of previous GCIP accelerator programs were added to the dataset.

After incorporating additional information provided by in-country representatives, datasets and maps were updated. Finally, the updated maps were validated once again with GCIP partner country PEEs.

Additional information on national objectives, priority cleantech sectors and regions was collected directly from PEEs via email, video, or voice call.

Identification and selection of standout clusters globally

Clusters use a variety of metrics to measure success, but the overall aim is to produce successful cleantech start-ups and scale-ups.

The purpose of ecosystem strengthening is to support start-up and SME growth. In this document, we also distinguish between start-ups and scaleups. Start-ups are high growth companies developing innovative cleantech solutions. Scaleup specifically denotes a later stage start-up (Series B onwards)[4]. It is useful to consider scaleups as a separate group (i) as an indicator of cluster maturity, since start-ups in successful clusters will eventually become scaleups; and (ii) because scaleups have specific support needs which differ from those of earlier stage companies.[5]

Cluster success indicators considered include number of start-ups produced, number of scaleups produced, total VC investment attracted and investment per capita. Reason for consideration as a standout cluster is defined for each cluster featured in Section 3. Cluster output indicators were calculated using data from Cleantech Group's i3 database.

We also considered clusters tackling similar challenges to those of GCIP partner countries including transition from oil and gas (Houston, Kazakhstan), renewable energy transition (Estonia, South Africa) and waste management (Chennai, Nigeria).

Definition and characteristics of cleantech innovation clusters

Innovation cluster and cleantech innovation cluster characteristics were determined through desk research using internationally recognized academic and commercial literature. A full list of sources is available in the appendix.

Learnings from standout clusters

We interviewed 17 cluster facilitators and start-ups via video call, phone call, or in person. Interviewees were selected based on their status as facilitators in standout cleantech innovation clusters or start-ups produced by or associated with standout clusters. A full list of interviewees is included in the acknowledgements section. Learnings were analyzed according to local,national, or international applicability and form the basis for the recommendations in Section 4.

4 The OECD-Eurostat Manual on Business Demography Statistics (2007) defines high-growth enterprises with an average annualised growth greater than 20% a year, over a 3-year period, and with 10 or more employees at the beginning of the observation period, where growth is measured by turnover or employment

5 Differing support needs according to start-up stage and ecosystem maturity will be addressed in the upcoming Policy Strategy Framework.

Executive Summary

Cleantech innovation clusters are locally concentrated cleantech ecosystems with a specific sector theme. Successful clusters leverage feedback loops and network effects to boost the success of individual innovators, so that start-ups and SMEs within the cluster grow faster than the market average. Innovation clusters are characterized by participating entities operating, collaborating and networking in close geographic proximity; multiple clusters with different thematic focuses may exist in close proximity and may also interact with one another. Cluster success derives from interactions between the actors within them, with the interaction of these factors producing synergies. Therefore, there is no one blueprint for cluster success. However, there are concrete actions which contribute to cluster development. This framework explains some of these actions and gives examples of where they have led to successful cluster development.

Cleantech innovation clusters have specific needs over and above generic innovation clusters. Because of the hardware intensive, CAPEX-heavy nature of most cleantech solutions, cleantech innovation clusters must provide specific support to enable the start-ups and SMEs within them to flourish. These include access to specialized technical and commercial talent, access to risk capital and debt finance providers with the expertise to evaluate technical solutions and access to markets to allow commercialization of new products and solutions.

Current cluster activity in GCIP partner countries is concentrated mainly around key cities. Start-up and SME density tends to be correlated with proximity to technical universities and Entrepreneurial Support Organizations (ESOs). GCIP partner countries have few examples of sustainable or climate-focused venture capital funds: most venture investment in cleantech companies comes from generalist funds. When formulating cleantech innovation cluster development strategies, GCIP partner countries can consider national characteristics and objectives, strategic regions for developing cleantech innovation clusters, and cleantech priority sectors.

Standout clusters display different characteristics based on local strengths and circumstances. Cleantech innovation clusters may arise within previously established innovation clusters, for example Boston, USA. They may also evolve out of incumbent industries facing a need to decarbonize, for example Green Tech Valley in Graz, Austria. Clusters in areas with a high density of universities and research facilities tend to produce start-ups with high incidence of intellectual property (IP). Clusters in areas with an industrial past may produce start-ups which leverage that knowledge and expertise, for example solid oxide fuel cell (SOFC) component start-ups located in former ceramic manufacturing centers. Clusters may also be driven by national strategic priorities, for example Singapore's foodtech cluster, which is a result of national level prioritization of food security. In many successful clusters, a "cluster facilitator" has played a critical role in driving cluster development by providing services to ecosystem actors and working with local government. The cluster facilitators may be NGOs, social enterprises or government organizations. This report analyzes learnings from cluster facilitators in the standout clusters identified, as well as from start-ups produced by those clusters.

Cluster facilitators can promote a range of activities at the local level to develop clusters. These can be divided into practical support for start-ups and SMEs such as networking and providing information on finding funding and commercial opportunities, and municipal level advocacy activities such as working with mayors to boost demand for cleantech solutions or advocating for smart regulation to ease common growth obstacles such as permitting

processes.

National level programs can create conditions which enable cluster development. These include education and immigration policies to provide sufficient talent, streamlining administration requirements to ease the bureaucratic load on young companies, and financial incentives such as tax breaks and grants. Stable policy and a regulatory framework which recognizes innovative solutions can create long-term market signals which attract companies and investments, and national branding can promote the country as an attractive place to live and do business.

Successful clusters are also connecting with international networks. Cluster facilitators can enable this by providing information to start-ups and SMEs on international opportunities and eligibility criteria, and by attracting international programs to work in the region or country. Facilitators in successful clusters are also joining international cluster networks to share learnings and best practices across different clusters, and to connect local start-ups and SMEs with international demand for their solutions.

I. How cleantech innovation clusters boost start-up growth

In the context of this framework, clusters are defined as "local concentrations of cleantech activity, with a sector or subsector specialization." Cleantech subsectors include energy and power, transport and logistics, materials and chemicals, agriculture and food, and resources/ circular economy. Successful clusters leverage feedback loops and network effects to boost the success of individual innovators, so that start-ups and SMEs within the cluster grow faster than other companies in the same market.[6]

Innovation clusters are characterized by participating entities operating, collaborating, and networking in close geographic proximity. Clusters contain the same actors as cleantech innovation and entrepreneurship ecosystems (CIEEs), but whereas ecosystems include multiple sectors, each cluster is concentrated around one sector or subsector. Figure 1 shows the key actors in a CIEE.

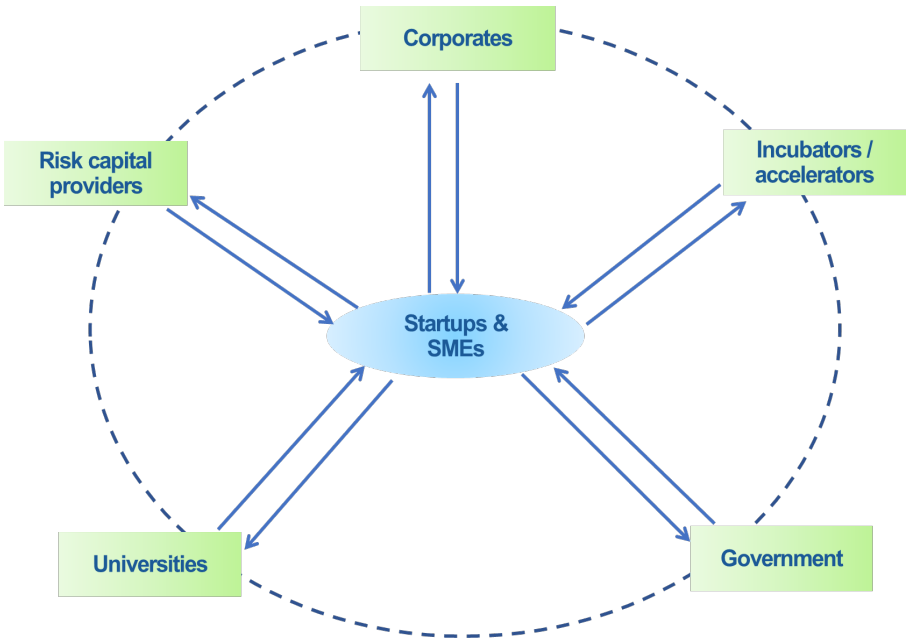


Figure 1: Actors in a CIEE

These actors take on different roles in growing and developing the cluster: start-ups and SMEs are the focus of the cluster, and the key objective of the cluster is to enable them to scale faster to deliver solutions for climate impact. Entrepreneurial support organizations (ESOs) such as accelerators, some government agencies and sometimes universities, play important roles in facilitating cluster development and contributing to start-up growth. Other actors support start-up growth in a less direct, but equally important way, for instance by supplying risk capital, or by acting as first customers or pilot partners to test solutions.

The Economist identifies six key factors which enable innovation clusters to maintain lasting success. These key factors include a skilled workforce, supportive policy frameworks, developed infrastructure, low cost of living, attractive lifestyle to draw talent, and the privilege of

6 The Economist Intelligence Unit. (2016). Innovation clusters: Understanding life cycles. The Economist, 24.

historically being perceived as geographically desirable.[7] While these ingredients are necessary for a cluster to succeed, the interaction between the different factors is essential.[8] For this reason, there is no unique blueprint for a successful cluster: depending on geography, sectoral expertise, industrial history and culture, and the interaction between these factors, different clusters evolve in distinct ways. This report will highlight the synergy of key factors which are driving the success of stand-out clusters where growth opportunities for start-ups and SMEs are abundant. Once the key factors are generating success for the cluster, momentum within a region can lead a city to prioritize cleantech innovation cluster development.[9]

Because of the science-based, CAPEX-heavy nature of cleantech solutions, cleantech innovation clusters have certain needs and characteristics over and above those of generic innovation clusters. The Erasmus Centre for Entrepreneurship, Rotterdam, identifies three factors which are critical for cleantech innovation ecosystems.[10] The first is access to talent: both technical expertise to develop cleantech products and solutions and commercial expertise to market and sell those complex products and services. Capital providers also need technical expertise, to be able to evaluate new solutions and estimate technical and market risk. They must also be willing to collaborate with other investors to mitigate risk and to facilitate hybrid funding mechanisms needed to finance working capital needs for as-a-service business models, or the plant investments needed to transition from commercial pilots to mass production. Finally, new cleantech solutions need to find a market. Here government has a critical role in creating the right policy environment, and in leveraging public procurement to create demand.

Figure 2 summarizes the specific needs of local cleantech innovation clusters.

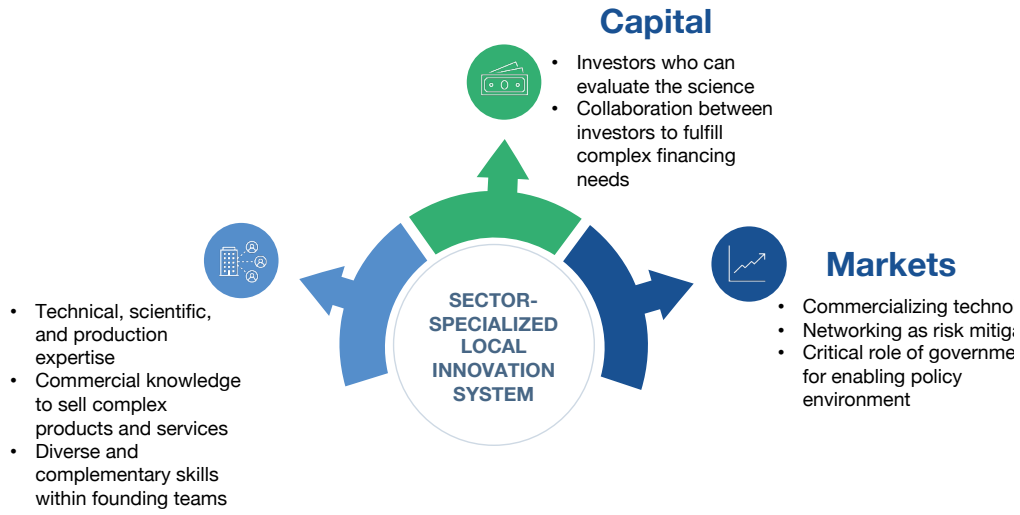


Figure 2: Specific needs of cleantech innovation clusters

Such close interaction creates an ecosystem which fuels research and innovation programs, establishes relations and opportunities, and influences climate policy to promote advantages for cleantech start-ups and SMEs.[11]

7 The Economist Intelligence Unit. (2016). Innovation clusters: Understanding life cycles. The Economist, 24.

8 Ibid.

9 Oyetunde, B. (2022, November 16). The booming Estonian cleantech ecosystem. Retrieved from e-Estonia: https://e-estonia.com/the-booming-estonian-cleantech-ecosystem/

10 Erasmus Centre for Entrepreneurship (November 2020). Study of the(cleantech) innovation ecosystem with a focus onGIST and SCALE-UP.

11 Oyetunde, B. (2022, November 16). The booming Estonian cleantech ecosystem. Retrieved from e-Estonia: https://e-estonia.com/the-booming-estonian-cleantech-ecosystem/

Cleantech innovation clusters have evolved in recent years, benefiting from more availability of tangible data on the cleantech sector, diversity of funding opportunities, and increased technology pilot opportunities.[12] Often, cleantech innovation clusters evolve where there is an engineering-focused education system, high government spending on research and development, economic focus on export markets and policy fostering brain-circulation rather than brain-drain by increasing repatriation and immigration.[13] Cleantech innovation clusters may arise within previously established innovation clusters, for example Boston, USA. They may also evolve out of incumbent industries facing a need to decarbonize, for example Green Tech Valley in Graz, Austria.

At present, there is a global push for cleantech innovation to respond to the need for climate mitigation, adaptation and resilience. For example, demand is driving innovation in the energy sector due to the increasingly urgent need to address the global energy crisis. Cities with enabling environments for cleantech innovation are producing start-ups tackling energy efficiency, clean energy production and storage, as well as green buildings and construction materials.[14]

This report seeks to identify key characteristics of cleantech innovation clusters that can be replicated in GCIP partner countries aiming to develop their own cleantech innovation clusters at the municipal level.

12 Ibid.

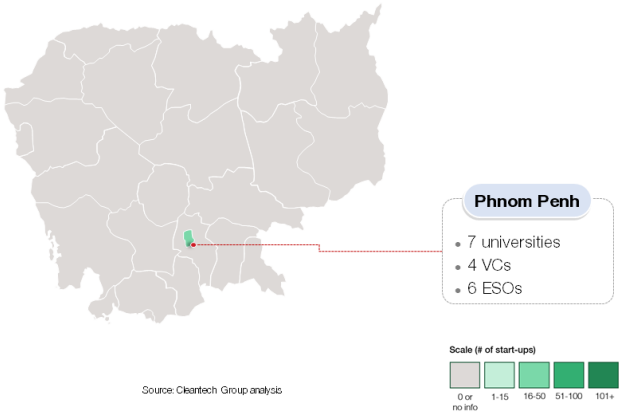
13 The Economist Intelligence Unit. (2016). Innovation clusters: Understanding life cycles. The Economist, 24.

14 Oyetunde, B. (2022, November 16). The booming Estonian cleantech ecosystem. Retrieved from e-Estonia: https://e-estonia.com/the-booming-estonian-cleantech-ecosystem/

II. Existing cluster activity in GCIP countries

This section analyses current cluster activity in GCIP partner countries, and regional and sector-specific intentions for further development of cluster activity.

Cambodia



Current Activity

Cambodia's cleantech start-up and SME activity is concentrated in its capital and most populated city, Phnom Penh, which also counts 7 universities, 6 ESOs, and 4 VCs with some specialization in cleantech investments.

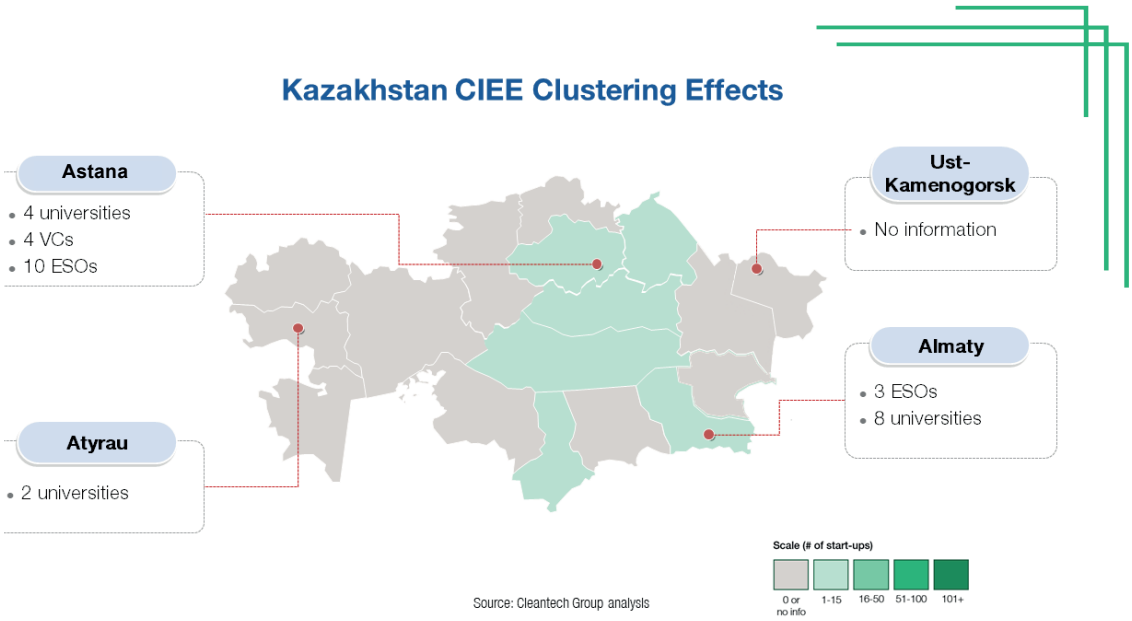
There is an increasing awareness of the importance of cleantech and green technologies. Key sectors of current activity include water solutions, energy efficiency, renewable energy and associated technologies, biomass, recycling of agricultural waste, and plastic replacements.

Objectives for cleantech development

Cambodia has set several national objectives for cleantech development, which are outlined in its National Strategic Plan on Green Growth 2013 – 2030. The country's is focused on efficient use of natural resources, environmental sustainability, green jobs, green technology, and economic reform, placing more consideration into green incentives and green investment. Moreover, Cambodia has published Industrial Development Policy 2015 – 2025 aiming to transform and modernize Cambodia's industrial structure from a labor-intensive industry to a skill-based industry by 2025, by promoting a conducive business environment, developing infrastructure and logistics, building a skilled workforce, and promoting innovation and technology adoption.

The CIEE would benefit from stronger links between ecosystem actors and better access to grant and equity funding for early-stage ventures.

Kazakhstan



Current Activity

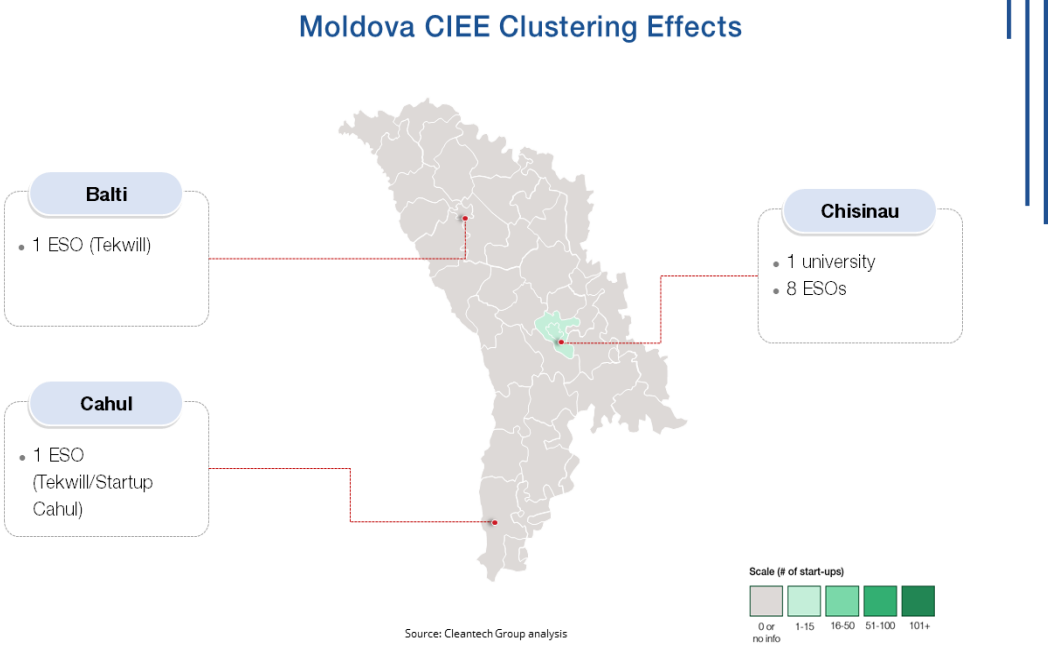
Cleantech start-up and SMEs activity in Kazakhstan is mostly found in Almaty and Astana, with ESOs also concentrated in these two cities. Nur Sultan has 4 VC firms focused on cleantech investments. The country has many scientific universities and research institutes; the most significant for cleantech-related output are included in the map. In general, most of the innovations in the field of clean technologies in the country are imported.

Main sectoral areas of start-up activity include renewable energy, energy efficiency, and waste management.

Objectives for cleantech development

Ust-Kamenogorsk and Atyrau have been identified as priority regions for cleantech development. The PEE for Kazakhstan, International Green Technologies and Investments Center (IGTIC), has identified 9 cities which are transitioning from economic dependence on oil and gas or heavy industry. IGTIC is conducting technology brokerage activities in these areas, with the goal of connecting industrial incumbents with innovative start-ups who bring relevant cleantech solutions to help those industries decarbonize. Kazakhstan also has a national objective to increase share of renewable energy generation to 15 percent from the current 3 percent.

Moldova



Current Activity

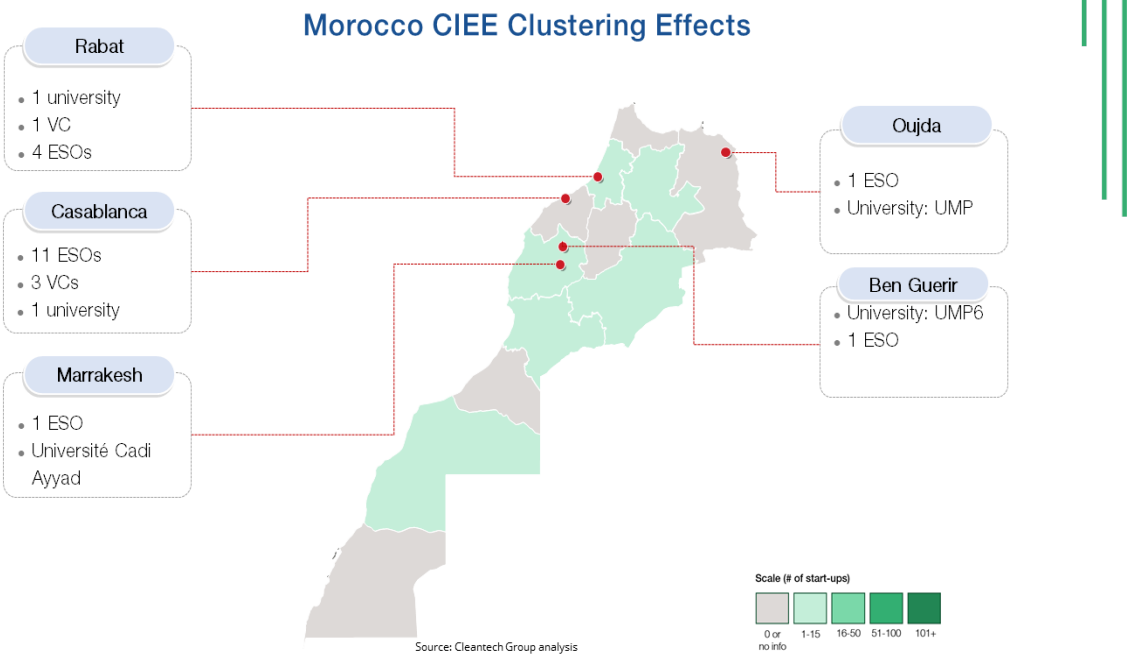
Current cleantech activity in Moldova is concentrated in and around the capital, Chisinau, which also counts one university and 8 cleantech-focused ESOs. The primary cleantech-specific ESO in Moldova, Tekwill, also has branches in Cahul and Balti. Moldova recently passed a law which is expected to result in further rationalization of the university and research ecosystem. Moldova's national credit risk allows limited access to financial mechanisms which could support cleantech innovation, and there is currently no legislation to support risk capital, hence the absence of venture capital firms.

Key sectors of start-up innovation include farmers' marketplaces, energy storage solutions, and solar technologies.

Objectives for cleantech development

Priority areas for cleantech development are energy efficiency and renewable energy. Balti and Cahul have been identified as priority regions for cleantech innovation development.

Morocco



Current Activity

Cleantech innovation activity in Morocco is distributed across Rabat, Casablanca, Marrakesh, and Ben Guerir. Several national universities are producing research in cleantech-related subjects. Rabat and Casablanca have a combined 4 VC firms investing in cleantech start-ups. Lack of access to technology can be a barrier to cluster development in the country's remote areas.

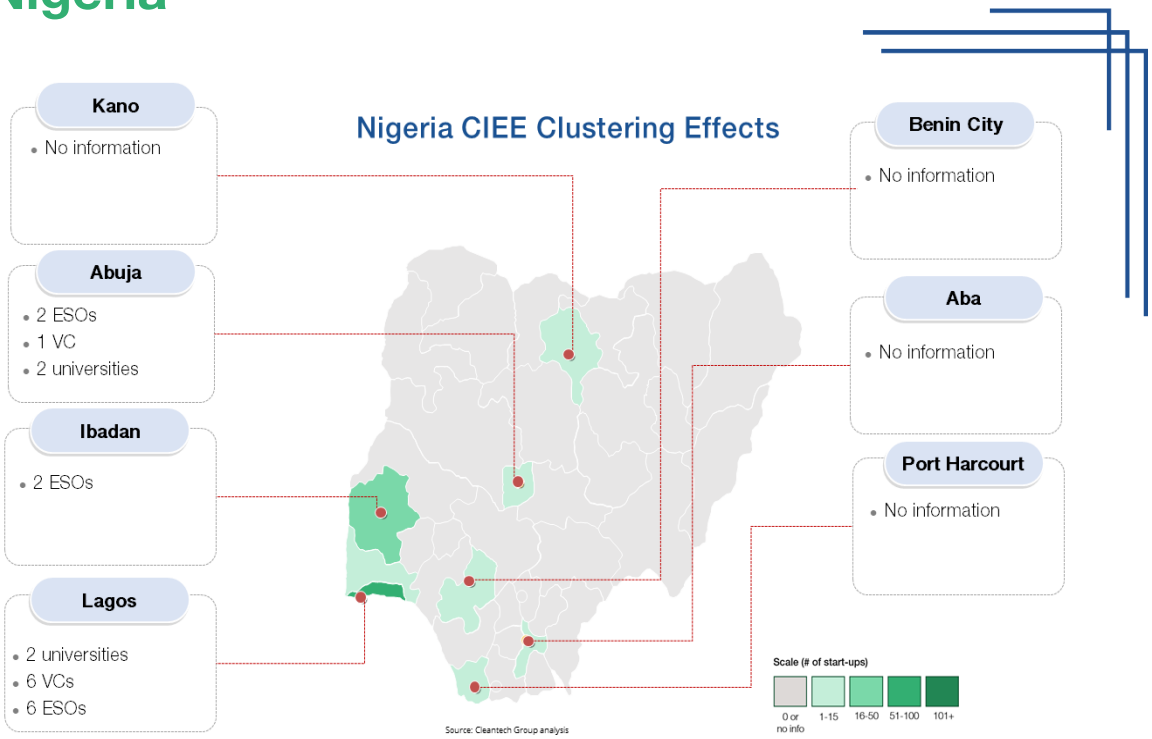
Main sectors of start-up innovation include irrigation technologies, farming robotics, energy services, solar technologies, and waste management and recovery.

Objectives for cleantech development

Oujda has been identified as a priority region for future cleantech development; the region currently houses Mohamed First University (UMP) and one cleantech-related ESO, but ther is little start-up activity.

Priority sectors include smart farming, solutions tackling water scarcity, green buildings, renewable energy and tourism. Morocco hosts around 10 million tourists per year and reducing the environmental impact of the sector is a priority. Additional industries where cleantech solutions could reduce environmental impact are the textile industry (centered around Casablanca and Tangiers), automotive (Northern Morocco), food processing, and fisheries.

Nigeria



Current Activity

Cleantech innovation activity in Nigeria is distributed across the country with the highest concentration of cleantech start-ups and ESOs in Lagos (over 70 start-ups) and Abuja (20 start-ups) followed by Port Harcourt, Aba, Benin City, Ibadan, and Kano (under 10 start-ups in each city).

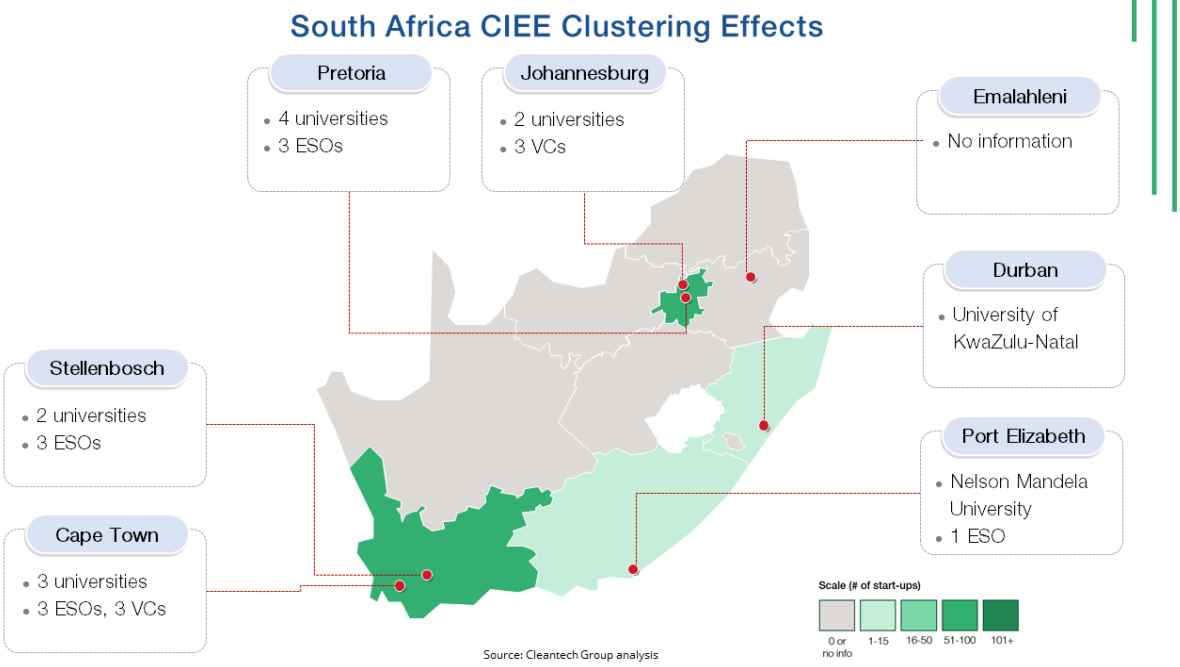
Main sectors of start-up innovation include food marketplaces and delivery services, food processing, renewable energy, energy storage and services, e-mobility, and waste management.

Objectives for cleantech development

Nigeria's Federal Ministry of Science, Technology and Innovation has conducted a technology needs assessment, which concluded that key sectors for development are agriculture, energy, and industry. Other priority areas for cleantech solution development include clean water and waste management. Additionally, work is needed to raise public awareness of the benefits of climate or environmental projects.

There are six ministry hubs which aim to support regional development. Regional competitive advantages will drive cluster activity in the North, South and West.

South Africa



Current Activity

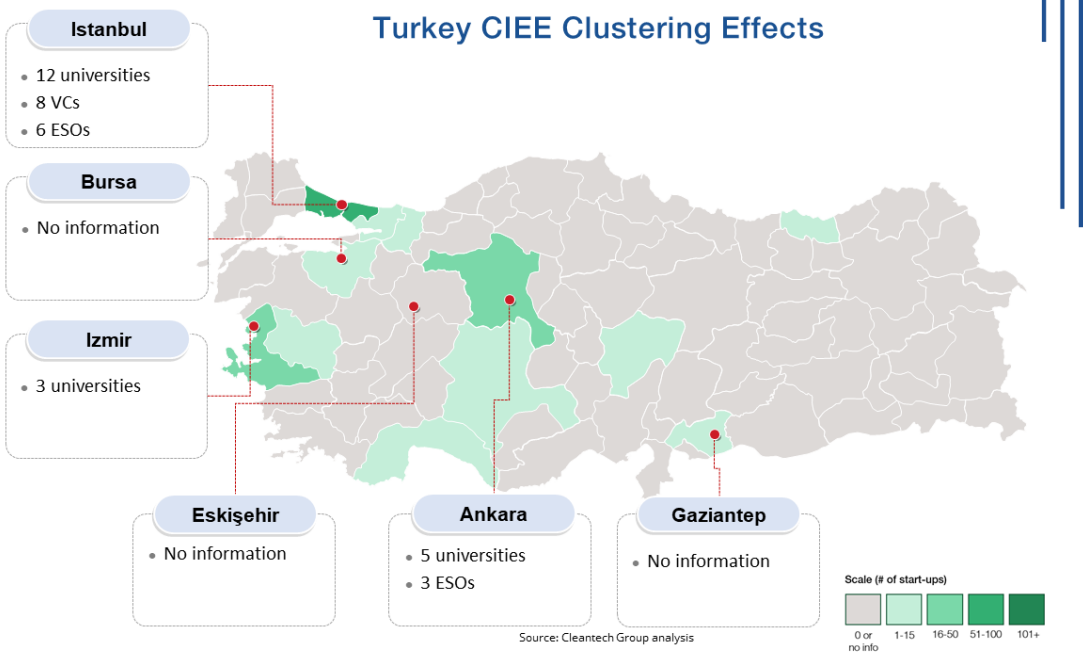
Cleantech innovation activity in South Africa is mainly located in the Western Cape province which includes Cape Town and Stellenbosch, and the Gauteng province which includes Pretoria and Johannesburg. The University of Stellenbosch supports alternative protein and sustainable food innovators with a maker space and test market storefronts. Main ESOs and universities with cleantech activities are concentrated in those cities. There is also a concentration of universities and start-ups in Durban and Port Elizabeth. A combined 6 cleantech-focused VC firms are in Cape Town and Johannesburg.

Main sectors of start-up innovation include agricultural robotics, robotics for spatial analysis, renewable energy, water solutions, waste management, e-mobility, and electric vehicle (EV) charging.

Objectives for cleantech development

South Africa's Technology Innovation Agency (TIA) has identified 9 rural isolated regions which have high innovation but limited means to facilitate start-up and SME growth. With sufficient support, these regions could play a more active role in developing cleantech innovation. Sector-wise, national objectives for cleantech development within South Africa are in line with UNIDO key focus areas.

Turkey



Current Activity

Cleantech innovation activity in Turkey is distributed across the country. The highest concentration of start-ups can be seen in its largest city and the main economic hub, Istanbul, with over 80 start-ups and 3 cleantech-focused venture capital firms, followed by Izmir (20 start-ups) and Ankara (37 start-ups). Risk capital opportunities are increasing in Turkey, although most funds are generalist and invest in cleantech ventures on an opportunistic basis. Ankara and Istanbul have functioning ESOs and major universities with cleantech activities, while Istanbul, Tekirdağ, Ankara, Kocaeli, Bursa and Izmir are the top centers for private research and development activity.

Main sectors of start-up innovation include indoor farming, agricultural robotics, waste management and recycling solutions, wastewater treatment, and energy services.

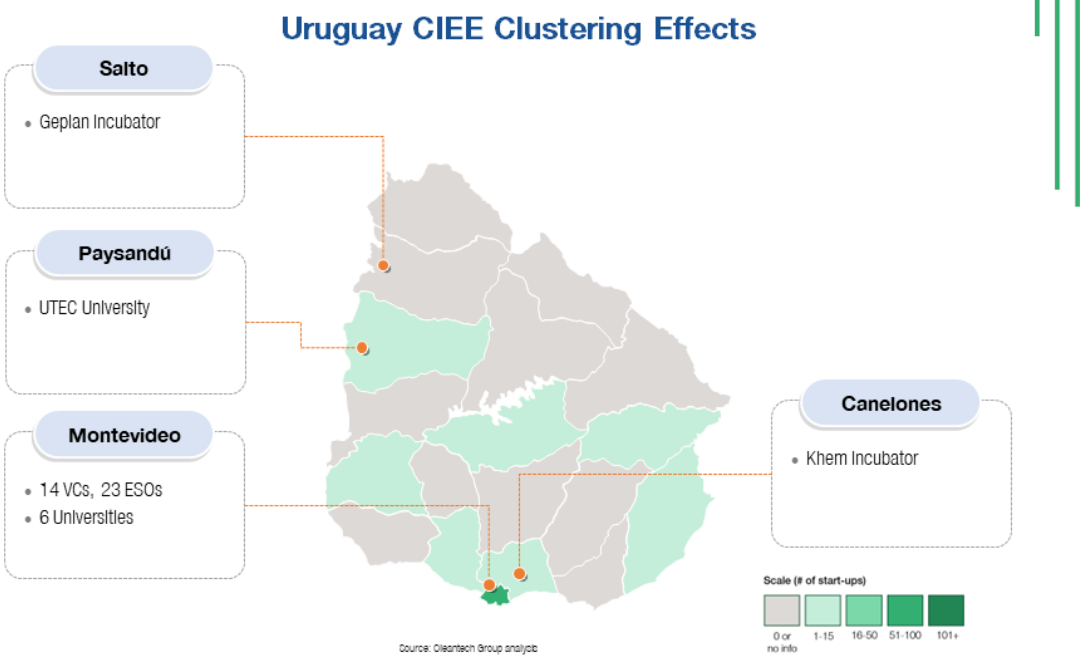
Objectives for cleantech development

All regions are eligible for GCIP accelerator programs; however, Izmir, Gaziantep and Eskisehir have been identified as priority regions for developing cleantech innovation clusters.

Priority sectors for cleantech development in Turkey include energy, waste management, circular economy, sustainable agriculture, transport and logistics. The country has high potential to further develop renewable energy generation. Sustainable agriculture objectives include sustainable irrigation systems, as well as the use of renewable energy in agriculture.

Turkey has identified sectors with high potential demand for cleantech solutions. These include transportation, especially cement transportation, agriculture, housing, energy, manufacturing including automotive, consumer electronics, food and chemicals, textiles, and healthcare.

Uruguay



Current Activity

Cleantech innovation activity in Uruguay is concentrated in its capital, Montevideo, with several active ESOs and VCs. Small concentrations of start-ups are also located in the Canelones, Durazno, Paysandú, Rocha, San Jose, Soriano, and Treinta y Tres departments.

Main sectors of start-up innovation include agriculture robotics, food tech, energy services, and waste solutions.

Objectives for cleantech development

Priority sectors for cleantech development in Uruguay are agriculture and energy. The country has a high percentage of renewable electricity generation and intends to leverage this to develop secondary industries including green hydrogen production and other power-to-X solutions.

III. Global standout cleantech innovation clusters

The following cities host standout cleantech innovation clusters based on the success metrics defined in the methodology and based on attributes that can be replicated for cities in the GCIP countries.

Boston, Massachusetts, USA

Boston is located in the northeast of the United States, sharing regional proximity and time zone with other major U.S. cities like New York City and Washington, D.C. The Greater Boston Area incorporates the economies of suburbs such as Somerville and Cambridge, which are not only host to several world-renowned universities, but also many of the country's largest biotech and tech companies.

The access to research facilities in the Boston area opens the door for many sectors. Most notable cleantech innovation is happening in Electric Grid Energy Storage, Electric Vehicle Batteries and Charging, Energy Efficiency Software and Monitoring, Agriculture, Solar and Renewable Energy, Air and Water Quality, as well as Research and Manufacturing for Climate.[15]

Massachusetts has the highest concentration of colleges and universities of any state in the country. Among those are Harvard University and Massachusetts Institute of Technology (MIT). Consequently, the state has the highest rate of college educated adults.[16] The state's investment in education and technology research has catalyzed the expansion of Boston's cleantech sector and encouraged graduates to join and grow the sector. At the municipality level, Somerville, Boston, and Cambridge have had mayors focused on transitioning outdated infrastructure to updated hubs of cleantech innovation. Prominent cleantech ESO, Greentown Labs, repurposed a warehouse in Cambridge as their first site for emerging founders to share space and equipment to create prototypes.[17] The ESO has a dedicated program for minority founders to address the equity disparities in the industry. Furthermore, the city's top industries of higher education, health care, and financial services generate a high concentration of wealth in the population. Ultimately, the key ingredients leading Boston's success as a cleantech innovation cluster are the robust network of investors, interested industry partners and a diverse pool of talent to pull from.

Boston is a cluster with the highest density of investment in cleantech innovation at over $4 billion invested over the last three years. The cluster has a combined 495 start-ups and scaleups.

Successful start-ups produced by the Boston cluster:

Florrent designs and builds high energy density ultracapacitators to work with electrical grids. Their aim is to address bottlenecks in transitioning to renewable energies, electric vehicles, and net-zero buildings. florrent's mission is a just transition to renewable and equitable energy

15 Unis, S. (2022, November 6). Navigating the Boston CleanTech Startup Scene - Who to Know, Where to Go. Retrieved from Startup Boston: https://www.startupbos.org/post/navigating-the-boston-cleantech-startup-scene-who-to-know-where-to-go

16 Carapezza, K. (2017, August 9). Why Massachusetts Leads Nation In College Attainment. Retrieved from WGBH News: http://blogs.wgbh.org/on-campus/2017/8/9/why-massachusetts-leads-nation-college-attainment/#:~:text=JM%3A%20Massachusetts%20has%20some%20advantages,also%20focused%20on%20workforce%20education.

17 Greentown Labs. (2023). Here's how they unintentionally founded North America's largest climatetech incubator. Retrieved from Greentown Labs: https://greentownlabs.com/about/history/

systems while generating, storing, and using renewable energy with a hybrid system of its ultracapacitators to supplement conventional battery systems for grid electrification. The company has partnerships with research institutions such as University of Massachusetts, University of Washington, and Oregon State University. florrent is affiliated with network and incubator Greentown Labs, accelerator CleanTech Open, and biomass supplier, Genoverde Biosciences.

Mori develops an edible, silk-derived biomaterial coating that extends the shelf life of perishable foods. The biotechnology extends the shelf life of fruits and vegetables by up to 50%, reducing food waste by a third each year. The company not only helps the food supply chain, but also reduces the need for single use plastic packaging. Mori was featured as a Cleantech 50 to Watch company in 2019 and recognized as a Global Cleantech 100 company in 2023.[18]

Houston, Texas, USA

Houston has historically been the energy capital of the world, known as a hub of the traditional oil and gas industry. As the world moves towards renewable energies and away from fossil fuels, Houston is poised to emerge as a model of how cities can make the economic transition towards net zero goals. The largest cleantech incubator in North America, Greentown Labs, is expanding operations from Boston to Houston because of this promising opportunity. Both cities have access to capital in terms of accessible investors, project financing for start-ups, and corporate partnerships. Houston is unique in that many entrepreneurs are coming from corporations rather than universities. Houston's mayor is a co-chair on a bipartisan network of 450 US mayors called Climate Mayors leading the science-based, community-driven reduction of greenhouse gas emissions.[19]

Along with Houston's focus on renewable energy, other cleantech sectors include materials and chemicals, and resources and environment.

There has been over $1.9 billion invested in the last three years. 116 start-ups and 21 scaleups have been founded in Houston.

Successful start-ups produced by the Houston cluster:

Sunnova offers a solar and electric vehicle bundle for residential energy and power storage. Founded in 2010, the company is publicly traded as of 2019. Sunnova has formed strategic partnerships to provide competitive and affordable solar solutions across the US. The company has raised $1.341 billion in equity capital.

Sage Geosystems provides geothermal energy and offers a geothermal modelling tool called GeoTwin. The company aims to make geothermal energy scalable and affordable using existing oilfield technologies and equipment. Founded in 2020, the company is now widely commercially available.

18 Cleantech Group. (2023, January 30). Mori. Retrieved from i3 Connect: https://i3connect.com/company/mori

19 Vargas, J. (2020, June 16). North America's Largest Cleantech Incubator Expanding to Houston in 2021. Retrieved from Greater Houston Partnership: https://www.houston.org/news/north-americas-largest-cleantech-incubator-expanding-houston-2021

Helsinki, Finland

Although Helsinki is a relatively small city, it is ranked among the top 25 most innovative cities globally by the World Economic Forum. A key success factor is the high population of university students and researchers that are bred in this cluster. Over one third of the population holds a university degree. As a nation, Finland is ranked number one in Europe for digital fluency and availability of latest technologies. Finland is also among the top ranked countries for progressive climate policy. The country has a supportive culture and regulations for innovation due to government initiatives encouraging open data for environmental, transportation, and health data.[20]

These factors create a highly skilled talent pool for the cleantech sector and a conducive operating environment. In Helsinki, the public sector readily participates in pilot programs and becomes an early adopter of new technologies. The close collaboration between corporations, start-ups, and universities propels innovation in the cluster, which has produced at least four unicorns as of 2021.[21]

There are 68 start-ups and 7 scaleups in Helsinki. Innovators here have received over $1.495 billion invested over the last three years.

Main sectors of cleantech innovation in Helsinki include Energy, Materials, and Transportation.

Successful start-up produced by the Helsinki cluster:

Carbo Culture is removing CO^2 f rom the atmosphere. The technology converts CO2 from decomposing plants into biochar that can be stored for up to 1,000 years. Additionally, the company produces carbon credits and the process of converting plants to biochar emits usable heat. The company has recently announced collaborations with technology companies, grant funding, and the winning of the EU Accelerator Award from the European Innovation Council.

Norsepower produces its proprietary Rotor Sail technology utilizing wind to improve large shipping vessels fuel efficiency. Founded in 2012, the company modernized a naval technology to transition ocean transportation towards zero carbon emissions. The company has since raised over $20 million through development partnerships, pilot projects, and international corporates to expand commercialization in domestic and international markets.

Stockholm, Sweden

Stockholm evolved organically as an impact hub around companies pursuing innovation. The city hosts several accelerators which are partly funded by the city to drive innovations and provide cleantech focused coaching for new businesses. With major car manufacturer, Volvo, based in Stockholm, it is natural that the city is investing resources in battery storage and cleantech transportation sector. Many start-ups here are focused on the electrification of transport with bikes, cars, boats and even trucks. There is a robust investing community in Stockholm, including former entrepreneurs who have successfully scaled and exited start-ups in other sectors, which seek local investment opportunities before exploring outside of the

20 What makes Helsinki one of the most innovative cities in the world? (2022, November 10). Retrieved from Helsinki Partners: https://www.helsinkipartners.com/article/what-makes-helsinki-one-of-the-most-innovative-cities-in-the-world/#:~:text=Finland's%20capital%20is%20fertile%20ground,innovative%20cities%20in%20the%20world

21 O'Sullivan, J. (2021, June 29). Helsinki-based startups now worth a combined EUR 25.2 billion. Retrieved from Good News from Finland: https://www.goodnewsfinland.com/helsinki-based-startups-now-worth-a-combined-eur-25-2-billion/#:~:text=Furthermore%2C%20there%20are%20eight%20high,functional%20city%20in%20the%20world

ecosystem. Because of this, regional start-ups look to Stockholm's investor network for VC funding.

On a national scale, Sweden is ranked as a top country for climate-friendly policy.
Stockholm hosts more than 143 cleantech start-ups and 11 scaleups. Innovators have raised over $22.5 billion in funding over the last three years.

Successful start-ups produced by the Stockholm cluster:

Volta Trucks delivers full-electric trucks to help cities cut down on polluting emissions. The company collaborates closely with utilities companies, large corporations, and EV charging infrastructure providers. Volta Trucks was founded in 2017 in Sweden but has leveraged international networks for growth: the company received seed funding from US VC investors, carries out R&D activity in the UK to tap into local technical expertise, and has a commercial presence in France because of the favorable market for its products. Along with developing and marketing electric truck technology, the company runs Volta Academy, which is a training program for technicians and drivers to engage and learn how to operate the vehicles.

Northvolt is a developer of battery storage technology and infrastructure solutions. The company is building the world's first and largest battery factory equivalent of a semiconductor foundry. Founded in 2015, Northvolt is now at the stage of wide commercial availability and has over 250 employees. It has partnerships with several major automotive brands; many have also provided investment. Northvolt has also received financing from the European Investment Bank. Northvolt is headquartered in Stockholm and has a research partnership with the University of Gothenburg. It chose to locate its first production site in Skelleftea, thus boosting regional employment while remaining part of the Stockholm ecosystem.

Tallinn, Estonia

Estonia's capital city is a desirable environment for start-ups to thrive for many reasons. The culture fosters encouraging attitudes towards start-ups and businesses. Quality of life in Tallin is high and costs of living are low. The population speaks English, the international language of business, which attracts international talent from other ecosystems.[22]

Tallinn's cleantech innovation cluster is founded on the success of the ICT sector. Cleantech companies started to emerge around 2010, and the early success cases were developing ICT-based solutions. Hardware-based companies developed later. The cluster is showing a lot of success in the renewable energy and energy storage sectors, driven by a need to decarbonize the highly polluting oil shale-based energy sector.

Over the last ten years, Tallin has gained traction as a cleantech innovation cluster based on the momentum of the existing start-ups attracting attention and investment for new ventures and has produced a standout scale up, Skeleton Technologies. The city has 34 start-ups and 5 scaleups with relatively high investment per enterprise at over $2.1 billion in the last three years.

Successful start-ups produced by the Tallin cluster:

Skeleton Technologies is a manufacturer of graphene-based ultracapacitor energy storage solutions. The company is now in the growth equity phase after $171.4 million raised in equity capital. Skeleton Technologies has achieved a global reach through partnerships with Shell, Marubeni, Wrightbus, Medcom and Sumitomo Corporation.

Thinnect aims to minimize the energy buildings consume through maintaining the desired

22 Why Estonia? (2022, November). Retrieved from Startup Estonia: https://startupestonia.ee/why-estonia

indoor climate. Thinnect has raised over $5 million for technology development. The company has been adopted in over 30 countries on around 8,000 devices. The start-up is a spinout of Defendec, which developed and patented the technology. The purpose of establishing Thinnect was to utilize the benefits of the technology which was built for the defence sector to be widely available for everyday use.

Cambridge, United Kingdom

Cambridge is one of the oldest cleantech innovation clusters in the UK, and one of the largest in Europe. Innovation in the Cambridge area tends to be highly research-driven, with IP supplied by the University of Cambridge, University of Anglia, and Cranfield University. The cluster started as an information technology (IT) and life sciences center before developing into cleantech: key sectors include energy systems management, grid services, materials science and built environment.

The cluster has produced at least 12 cleantech scaleups and attracted $660 million in investment over the last 3 years. Start-ups from the Cambridge area command a £2-5 million ($2.4-6m) valuation premium at pre-seed stage over start-ups from other parts of the UK.

Successful start-ups produced by the Cambridge cluster:

Paragraf produces graphene based electronic devices including biosensors with applications in precision farming, food toxicity testing, amongst others. Another product is graphene-based 2D transistors which can reduce the energy footprint of computer data centers. The company received early funding from Cambridge Enterprise, a spinout facility which is part of the University of Cambridge. In February 2022 it raised $60 million funding from the UK government's Future Fund and US strategic defense investor In-Q-Tel, to accelerate production and market launch.

Nujira produces advanced chips which improve the energy efficiency of wireless transmitters, reducing heat dissipation and energy consumption. The company was founded in 2002, and received initial funding from local funds including Cambridge Angels, Cambridge Capital Group and Cambridge Gateway fund, raising later funding rounds from national and international funders. Nujira was acquired by Qualcomm in 2015.

Graz, Austria

Graz, also known as the Green Tech Valley, has a history of industrial manufacturing. More than 100 years of fostering invention in this industry led Graz to be a pioneer in cleantech starting in the 1970s and 80s. The city is host to 14 scientific centers of excellence, which gives it an above average research and development ratio. A culture of innovation has attracted over 800 entrepreneurs to Graz who have founded over 60 start-ups. Furthermore, there is a high concentration of global technology leaders, with 20 such corporations within a one-hour drive. Consequently, there is a high level of employment in this region, as well as notable opportunities for collaboration between start-ups and corporate partners. Around 75-80 percent of start-ups in Graz export their products and services. The high export ratio manifested into international recognition of the Green Tech Valley as a leading cluster of cleantech innovation.

The cluster started around 1998 as a loose network of companies, later incorporating as a public-private organization. It now has 300 members. A former steel production area, during the steel crisis of the 1980s machine plant was transformed into machinery for recycling, renewable energy, solar thermal collectors, and hydropower stations. Graz now specializes in climate protection, circular economy and recycling, green heat, green hydrogen and electrification sectors.
There are 56 start-ups and 6 scaleups in Graz. The combined turnover of companies in the cluster has tripled over the last ten years, and total employees have doubled.

Successful start-up produced by the Graz cluster:

Arteria Technologies provides digital infrastructure for optimizing heating networks. Benefits of the technology include energy efficiency, cost savings and reduced CO^2 emissions. Customers can digitize old plans for heating networks for data management. Data visualization shows projections for temperatures or sales with customers. Companies can use these insights to share relevant information with customers, as well as collect customer data. The software can be applied worldwide with small adjustments. At present, the company is scaling through the German speaking market, as well as Brussels and Finland.

Botres Global GmbH builds and operates bio-refineries to convert organic waste to clean energy, clean water, fertilizer, and protein rich feed and food. In the past ten years, the company has implemented biorefineries across Europe, the USA, Asia, and Australia. The biorefinery and demonstration plant in Austria was built between 2008 to 2012 and investment and operation costs totaled approximately $3.7 million. Botres Global's project to establish twenty biorefineries in Australia raised $25 million in the second stage of funding.

Valencia, Spain

Valencia cleantech was born as a group of renewable energy companies. Collaboration between mayors of over 100 cities and the invested commitment of universities, investors and government have expanded the purview of the city's cleantech industry. There is healthy cross-sector collaboration between entrepreneurs. The city's first cleantech accelerator, Avaesen, has produced 275 companies since 2014, most of which are still operating today. The city has experienced relatively quick growth as a cleantech innovation cluster due to the intentional coordination between mayors, CEOs of large companies raising awareness of this sector and creating opportunities for entrepreneurs to create cleantech solutions. The keys to Valencia's success as a cluster are its agility to transition and develop additional sectors, building the ecosystem from within via participatory leadership, bottom-up approach to scaling, and attracting VC funding to the market with targeted partnerships in the region.

On a national level, Spain has a high population density, top universities, a high national GDP, and is attractive to international talent for its high quality of life and relatively low cost of living. There is a high connectivity between the cities in Spain in terms of infrastructure and interest in sharing learnings between cities. Madrid and Murcia are looking to Valencia to develop their own cleantech innovation as emerging clusters. The city has attracted over $23 million in funding for its start-ups in the last three years.

Successful start-up produced by the Valencia cluster:

Zeleros has created the world's fastest land transportation system of automated electric intercity travel. Their Hyperloop capsules carry 50-200 passengers per vehicle with zero emissions at a maximum speed of 1,000 km/h. The company aims to deploy the infrastructure on a global scale by 2050. The founding team of engineering students from the University of Valencia won SpaceX's Hyperloop Design Weekend challenge in Texas, USA. Their early investments came from accelerators such as Climate-KIC, Lanzadera and Plug and Play, as well as angel investment.

ClimateTrade provides carbon offset solutions using a blockchain platform. The company has raised $9.1 million in seed funding as of January 2022 from funding sources including Valencia-based cleantech venture capital firm, Zubi Capital. ClimateTrade also established a joint venture partnership with Planetwatch to issue carbon credits and catalyze sustainable, carbon emission reduction plans.

Chennai, Tamil Nadu, India

Chennai is a leader in cleantech innovation in the south Asia region. The city has a high population density, and India has a high GPD with strong ties to international markets. The many universities in this region produce a highly skilled workforce with technical skills. The country recently announced efforts to increase the clean energy infrastructure as well as reduced tariffs to reduce barriers to technological innovations. Regionally, there is a push among clean energy sector stakeholders to adopt solar after the Tamil Nadu government instated higher tariffs, increasing energy prices in the state. Major cleantech sectors emerging from Chennai are agriculture and food, enabling technologies, energy and power, and resources and waste management.

Chennai has many centers and labs to foster industries of life sciences, high-tech and robotics, and cleantech. Government funding is available at the federal, state, and municipal level. Accelerators in the region host events and awards, connect start-ups to lab space for prototyping, connect entrepreneurs to local and global markets, and offer mentoring for business, finance, and technical support.

The city has attracted over $310 million in funding over the last three years. Chennai has 42 reported start-ups.

Successful start-up produced by the Chennai cluster:

Sea6 Energy is the world's first ocean operating system, which is a platform harnessing the ocean's limitless potential. The technology can be used for ocean farming, ocean bioprocessing, and developing solutions in the food fuel and feed sectors. The company is making biofuels from seaweed jointly with partner Novozymes. In August 2022, the company raised Series B funding of $18.5 million in equity capital.

Tan 90 seeks to provide farmers with cost-effective and energy efficient cold storage technology. Since starting in 2019 with a 40 liter portable, solar-powered cold storage system for transporting milk sachets, the company has since expanded to other cold chain markets including vegetables, fruits, meat and fish. Tan 90 was part of the Clean Energy International Incubation Centre incubation and acceleration program in 2020.

Singapore, Republic of Singapore

Singapore is on its way to becoming the leading cleantech innovation cluster of Asia. Mounting energy demands in the region are driving the growth of the clean energy sector. Singapore has attracted investments in research and development and has a workforce with technical expertise in engineering and project development. The market in Singapore is well connected and values public-private partnership to spur innovation. The city state is producing start-ups focused on grid communication, data analytics, renewable energy solutions and waste management.[23]

The city has become a regional hub for Asia's leaders in cleantech to convene at events. Singapore is an attractive business location due to its international population, highly educated workforce, mild climate, and US-friendly time zone. The city introduced specialized technology parks and positioned itself as a center of commerce for multinational corporations wanting to expand to Asian markets.

Singapore is home to 224 start-ups and 21 scaleups, with over $2.8 billion invested within the last three years.

23 Cleantech Group. (2023, January 30). Data - Singapore. Retrieved from i3 Connect: https://i3connect.com/company?country=Singapore&filtered=done

Successful start-ups produced by the Singapore cluster:

EcoWorth Tech has commercialized a Carbon Fibre Aerogel technology with waste-to-worth uses for industrial wastewater treatment and oil and gas refinement. The technology converts waste materials into usable products. The company was developed at Nanyang Technical University and has received awards and recognition as a leading cleantech company in Asia. The founders formerly worked at multinational companies before starting this entrepreneurial venture.

Singrow is an urban farming and architecture technology company that has developed vertical farming systems. Their proprietary seedlings and patented growth practices allow farmers to produce high quality crops at higher yields in a climate-controlled environment. The company has raised $10 million in seed funding and plans to expand beyond Singapore across Asia and the Middle East.

IV. Steps for building successful cleantech innovation clusters in GCIP countries

This section describes practical steps PEEs can implement at local and national level to develop local cluster activity while building on specific existing strengths. We talked to accelerators, cluster managers, and start-ups from the standout clusters identified in Section 3, as well as other clusters globally. The main learning is that all clusters are different, and each has a different development history, building on local resources, industrial past and knowledge pools available in the area.

We also observed that leading clusters are plugging into international networks and connecting their start-ups to international opportunities from an early stage. Therefore, we also include suggestions for enhancing international connectivity.

Local and regional actions

Help founders to understand support opportunities

Increasing founders' local knowledge of the environmental policy and cleantech initiatives in the cluster is vital. The most effective founders have a good understanding of how these factors relate to the city's existing industries, resources and culture. Cluster leaders can provide information to start-ups on which programs and opportunities are available. Since eligibility depends on the start-up stage, among other factors, start-ups also need help to understand which opportunities are right for them.

Facilitate connections between actors in the cluster

Facilitators in successful clusters actively promote collisions and serendipitous exchanges that help the flow of knowledge and increased collaboration between companies in a cluster. Green Tech Valley in Austria organizes regular events where start-up founders meet their peers and can share experiences and learnings with each other. If one founder has a problem, it is likely someone else in the group has already solved that problem. Some facilitators provide a physical space where start-ups and other companies can meet each other. The Techstars Cities of the Future accelerator in Turin, Italy, hosts start-ups in glass-walled offices for increased visibility. The space also includes one long table for eating (instead of many small ones) so that people are forced to talk to each other over lunch.

Create specific initiatives to involve women, youth, and other under-represented groups

Women, youth, and minority founders experience a significant gap in funding and support in the cleantech industry. These groups need dedicated opportunities to increase representation in leadership positions, on boards of directors, and within VC firms to change the status quo. ESOs bridge barriers to attain this representation for such groups more easily on a local level than a national scale. ESOs in Toronto and Boston have created Women in Cleantech accelerators and accelerators specifically for start-ups with minority founders. A government funded initiative in New Zealand allocates resources for indigenous Māori entrepreneurs, which ensures investments are both culturally and financially impactful. Universities support young founders with research and development resources, access to funding, business development strategies, and incubators.

Choose locations in proximity to technical universities and research organizations

Innovation is bred in highly collaborative ecosystems which incorporate universities, local labs and opportunities to share ideas with other start-ups. Proximity of technical universities and research institutions focused on cleantech innovation and entrepreneurship opportunities for students produce a high number of successful start-ups. To build on the collaboration within the industry, some ESOs are measuring success by the quality and size of events bringing together cleantech companies and the number of flagship projects have been initiated in the cluster. Strategic location of ESOs is also highly valuable. The city of Toronto recently launched a cleantech innovation cluster mapping initiative to improve coalition building between ESOs and nearby universities and corporations.

Involve mayors and CEOs of local companies to match demand with solutions

Cities can become the first customers for cleantech solutions and set an example using green public procurement. Cluster facilitators can help to raise awareness among municipal staff of the potential solutions they could be using and can connect purchasing teams with CEOs of companies with suitable solutions. Avaesen in Valencia, Spain, has built trusted partnerships with many local municipalities in this way. Where there is demand for a solution that does not yet exist, Avaesen works together with local start-ups to cocreate one. Fees from this service provide an important revenue stream and help to support other cluster activities.

Work with local administration for smarter regulation

Start-ups have a lean staff and few resources, so founders are looking for the most straightforward path to grow. Therefore, agile and fast processes for permitting, funding, building and operating a manufacturing site are essential. In Valencia, ESOs create working groups to analyze current regulations, advocate cleantech positioning to public administration, share experiences, and discuss business and innovation opportunities.

Work with local administration to promote livability to attract talent

Supportive cleantech policy, live ability, and culture of the city are also highly valuable. Support from municipal leaders not only unlocks more resources for cleantech entrepreneurs, but also creates brand awareness of the city to attract talent and investment. Small cities with technical universities, local government support, and corporate presence can appeal to a national and international talent and investment pool for their low cost of living and quality infrastructure. Valencia is one example of a small city urging talent from Madrid to consider making the 1.5-hour high speed rail trip to the historic coastal city to join its growing cleantech sector. Driven by accelerator Avaesen, Valencia's growth process has operated much like a start-up, starting small and strategic with few resources while focused on scaling what works. With a supportive mayor, increased availability of public funding, and a rebranding of Valencia from a historic tourist destination to a modern hub of cleantech innovation, more students are staying in the city after founding their start-ups, and in turn, attracting more talent to the cluster.

Have a clear strategy for cluster development

To improve agility and productivity, successful clusters have a clear strategy for development. For example, Graz, Austria has experienced lasting success converting its steel industry to cleantech. When the cluster started, it had a research strategy, economic strategy, renewable energy strategy and environmental strategy.

Challenges

At a local level, cluster development runs into many challenges. There are silos between the municipal government, research parties, and industry within clusters. Breaking down silos is possible to overcome with regularly held events for these key actors to meet and form partnerships.

Supply chain logistics delay and impede progress in some localities. SMEs can overcome these challenges by being clear with investors and buyers about the impact of funding availability and supply chain delays on production timelines. If VC funding within the cluster is scarce, this pushes entrepreneurs to seek investment externally, where they may have less established connections. Applying to accelerators and grant funding is time consuming and sometimes complicated, leading founders to forgo certain local opportunities.

Availability of talent to work on the highly specialized technology the start-ups and SMEs are producing is another concern. The technology emerging in the cleantech sector is often quite niche and usually only a small talent pool has the necessary skills. It can be hard for clusters to bring in new talent from the region and internationally due to high competition for this skillset as well as prohibitive policy for immigration and work visas. Establishing an education system which integrates science and technology from primary school through university will improve the digital and technical literacy of the population. Favorable policy for immigration and work visas would increase opportunities for start-ups to hire international talent and attract more technically skilled workforce to the cluster.

National actions and conditions

Create a culture of innovation and favorable attitudes towards cleantech

National attitudes towards cleantech innovation and a culture of integrating sustainability and business are at the core of cluster success. In Estonia, for example, an entrepreneur can easily establish a new company online in 15 minutes, and complete taxes in 3 minutes. Furthermore, Estonia's tax system has zero corporate income tax. The school system in Estonia incorporates computer science and technology starting in primary school, which lays the foundation for a highly technology literate population. The government's advanced online tools facilitate start-ups working closely with the government to help them grow with few barriers. Such factors reduce barriers to starting a business and encourage innovation.

Provide stable market signals

Setting long term policy intentions and delivering on targets provides the market stability needed for companies to develop strategies and business models, and the confidence for investors to finance those business models. Finland is known for having a stable government, which decreases perceived risk for investors and carbon credit customers to confidently invest in the country's ventures.

Enable close collaboration between government and innovators

Strong support and close ties to government ministries perpetuate success. Founders with familiarity of the national policy and government programs can tap into resources and propel the national push for cleantech companies. Countries such as Finland, which provides programs and grant funding through the Ministry of the Environment and Ministry of the Economy, create a positive national branding which supports companies' ability to engage with export markets. Visibility is a challenge for start-ups but having a positively recognized national branding helps broaden international visibility for small businesses.

Become a leader in the global push for cleantech innovation

The global energy crisis has many countries driving renewable energy solutions. Government can bring down costs and improve market conditions for cleantech innovation. Collaboration across different cities in the country supports sharing of information and expertise. Online tools for sharing information and building coalitions increase innovation in the market and bring VC investors to the clusters. This encourages a bottom-up approach to information dissemination to national and regional policymakers.

Challenges

Challenges at the national level include reliance on international markets for essential parts of the value chain. Luxembourg, for example, is dependent on energy production from Germany and France. Global oil and gas supplies are depleted, and the country must focus on scaling up renewable wind energy production to meet 70 percent of the national demand.
Regulation which is not designed with innovation in mind is another barrier. In Austria, the energy sector is overregulated; access to data requires formal agreements resulting in extremely high barriers for the cleantech industry. In identifying the need to respond to climate targets and prioritizing a clean energy transition, countries can work to reduce bureaucratic barriers to cleantech innovation and expand resources for entrepreneurs in this space.

Another challenge is a lack of consistent national level meetups and networking events, especially for sourcing talent. Where start-ups are looking to hire employees with technical skills, there is insufficient talent supply within the country. However, it is also difficult to source talent internationally because employment laws make it hard to take on international employees. ESOs can host national events and networking opportunities, while also creating accelerator and incubator programs for students emerging from local universities to stay in the cluster and build cleantech enterprises.

Some countries offer less national level funding than other countries. When innovators do not receive support from government institutions, they may attempt to tap into international networks for financing. Additionally, expanding to mass production has been difficult for many cleantech start-ups because of difficulty financing manufacturing plants. If governments are unable to dedicate funding to growing the cleantech sector, creating initiatives to attract international VC and debt funding and expose innovators to opportunities in export markets is an alternative.

Leveraging international networks

Success factors

Join international cluster networks

Network organizations such as the International Cleantech Network[24] provide opportunities for managers of different clusters around the world to share learnings and best practices, and to create international connections that generate new business opportunities and create value for their cluster members. Many leading clusters are linked internationally with other clusters.

24 International Cleantech Network. (2022). Retrieved from International Cleantech Network: https://internationalcleantechnetwork.com/

Expand talent search globally to overcome local and national shortage of skilled labor

Resources at the international level can offset challenges at the local and national level. In many clusters with high-growth innovators lacking sufficient talent supply on the national or local level, they must expand recruitment globally. Networking websites such as LinkedIn alleviate the burden in sourcing talent for start-ups and SMEs. As previously mentioned, favorable immigration policy is essential for this strategy to work.

Align with internationally aligned targets for climate impact

International agreements such as the Paris Agreement spurred legislation favoring start-ups focused on the Sustainable Development Goals (SDGs) and Fit for 55 targets. The European Union (EU) has been a leader in this space. The EU offers non-dilutive public funding, created the European Innovation Council, and provides opportunities for EU based research and development. Europe also has a wide network of venture capital and private equity. Europe created the first funding schemes for renewable energies as well as the first incentives for solar and thermal with pioneering legislation in the 1990s. Out of around 7,000 clusters globally, 3,000 are in the EU. One in four EU jobs is linked to a cluster. International market trends such as electric vehicles, hydrogen, and renewable energy are helping the market gain traction. Paris is an example of a city emerging as leader for catalyzing its cleantech market following a diesel ban imposed due to global pressures.

Advertise international events online and networks

International events & funding are easily accessible online, making it very simple to connect to international VC funding sources. There are many global networks for cleantech. ESOs that work across the carbon removal industry can meet competitors and collectively push global policy agenda in favour of this industry. The International Cleantech Network facilitates many connections across the top cleantech innovation clusters in the world. The clusters receive financing from ICN, meet once a year, set up ways to work across cluster working groups, do service exchanges, and get free services of all clusters as a member. There are many networking opportunities for connected companies. During international events, attendees discuss topics on cleantech from different business viewpoints.

Promote international funding opportunities

International innovation grants are hugely important for newly developing clusters. International Non-governmental Organizations (NGOs) such as the World Economic Forum, the World Bank and GIZ offer grants to finance pilot interventions. Through international NGOs, start-ups have access to global partnership opportunities and open data on the cleantech industry to aggregate opportunities. There are also many opportunities to access private equity abroad through global VCs and pilot projects with international corporates and foreign governments.

Challenges

The cleantech sector is under a lot of pressure to deliver solutions for climate mitigation, adaptation, and resilience. Funding pilot projects with high risk of long wait times for profitability is a common challenge across clusters. Global competitors who are receiving more funding from international sources inevitably scale up faster. International NGOs, multinational companies, and international VCs can expand funding opportunities which fall short at the national and local level.

Women and minority founders often face higher barriers to entry than non-minority, male founders, which is difficult to overcome on a global scale. Barriers for these groups are rooted in high costs for technical education, limited opportunity to attend training due to family

commitments, challenges accessing funding, persistence of workplace biases, and lack of mentors. These barriers for women and minority entrepreneurs often result in limited secure access to official financial resources, a lower capacity to win competitive based funding. To address funding disparities, funding providers should revise gender- and minority-biased processes to overcome regulatory constraints, complex loan application processes, and prohibitively high interest rates which discourage and exclude these groups. Focusing these efforts locally can take the form of specialized scholarships, incubators and accelerators designed to include these groups.

Geopolitics and associated repercussions are currently the cause of major challenges for innovators. Energy prices have skyrocketed with the war in Ukraine and inflation is putting pressure on supply chains and other costs of doing business. While governments are under pressure to respond quickly, they can also consider ways to transition away from dependence on critical inputs, and to formulate measures which will enable innovative start-ups in the country to take advantage of new areas of demand for cleantech solutions.

Conclusion

The cluster development framework of GCIP Pillar 2 takes learnings from leading global cleantech innovation clusters to derive best practices for strengthening of national cleantech ecosystems. PEEs in the GCIP partner countries have defined the national priorities for cleantech innovation. With the national priorities defined, PEEs can use this framework to replicate success factors from leading clusters and implement activities to develop regional innovation clusters with high-growth cleantech companies in their own countries.

References

BCG Global. (2021). “Deep Tech and the Great Wave of Innovation,” February 20, 2021.https://www.bcg.com/publications/2021/deep-tech-innovation.(2022). Retrieved from International Cleantech Network: https://internationalcleantechnetwork.com/

Carapezza, K. (2017, August 9). Why Massachusetts Leads Nation In College Attainment. Retrieved from WGBH News: http://blogs.wgbh.org/on-campus/2017/8/9/why-massachusetts-leads-nation-college-attainment/#:~:text=JM%3A%20Massachusetts%20has%20some%20advantages,also%20focused%20on%20workforce%20education.

Cleantech Group. (2023, January 30). Data - Singapore. Retrieved from i3 Connect: https://i3connect.com/company?country=Singapore&filtered=done

Cleantech Group. (2023, January 30). Mori. Retrieved from i3 Connect: https://i3connect.com/company/mori

Feld, B. (2012). Startup Communities: Building an Entrepreneurial Ecosystem in Your City. Hoboken, New Jersey: Wiley.

Greentown Labs. (2023). Here’s how they unintentionally founded North America’s largest climatetech incubator. Retrieved from Greentown Labs: https://greentownlabs.com/about/history/

Helsinki Partners. (2022). What makes Helsinki one of the most innovative cities in the world? Retrieved from Helsinki Partners: https://www.helsinkipartners.com/article/what-makes-helsinki-one-of-the-most-innovative-cities-in-the-world/#:~:text=Finland’s%20capital%20is%20fertile%20ground,innovative%20cities%20in%20the%20world.

O’Sullivan, J. (2021, June 29). Helsinki-based startups now worth a combined EUR 25.2 billion. Retrieved from Good News from Finland: https://www.goodnewsfinland.com/helsinki-based-startups-now-worth-a-combined-eur-25-2-billion/#:~:text=Furthermore%2C%20there%20are%20eight%20high,functional%20city%20in%20the%20world

Oyetunde, B. (2022, November 16). The booming Estonian cleantech ecosystem. Retrieved from e-Estonia: https://e-estonia.com/the-booming-estonian-cleantech-ecosystem/

Sagar, M. (2017, October 27). Singapore leading Cleantech innovation in Asia. Retrieved from Open Gov: https://opengovasia.com/singapore-leading-cleantech-innovation-in-asia/

Startup Estonia. (2022). Why Estonia? Retrieved from Startup Estonia: https://startupestonia.ee/why-estonia

The Economist Intelligence Unit. (2016). Innovation clusters: Understanding life cycles. The Economist, 24.

Unis, S. (2022). Navigating the Boston CleanTech Startup Scene - Who to Know, Where to Go. Retrieved from Startup Boston: https://www.startupbos.org/post/navigating-the-boston-cleantech-startup-scene-who-to-know-where-to-go

Vargas, J. (2020). North America’s Largest Cleantech Incubator Expanding to Houston in 2021. Retrieved from Greater Houston Partnership: https://www.houston.org/news/north-americas-largest-cleantech-incubator-expanding-houston-2021