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CLIMATE INNOVATION CENTRES

A NEW WAY TO FOSTER CLIMATE TECHNOLOGIES IN THE DEVELOPING WORLD?

An infoDev publication in collaboration with UNIDO and DFID

Prepared by Ambuj Sagar and Bloomberg New Energy Finance

October 2010

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infoDev (Information for Development Program) is a multi-donor sponsored program housed at the World Bank in Washington DC that explores the link between technology and development. infoDev manages a global network of more than 300 business incubators in over 80 developing countries. In 2009 infoDev partnered with DFID (below) to develop a network of Climate Innovation Centres (CICs) in developing countries. Feasibility studies have already been conducted in India and Kenya.
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EXECUTIVE SUMMARY

INTRODUCTION

Climate Innovation Centres: A New Way to Foster Climate Technologies in the Developing World, was commissioned by infoDev in collaboration with DFID and UNIDO to develop practical recommendations on the design of Climate Innovation Centres (CICs). Based on rigorous analysis by Professor Ambuj Sagar and Bloomberg New Energy Finance, the report shows how CICs can:

1) develop and deploy appropriate technologies to mitigate and adapt to climate change,

2) catalyse competitive domestic industries in clean technologies for job creation and economic growth,

3) deliver ancillary climate technology benefits such as energy security and access, and reduced local pollution.

The report will help a wide audience – including developing country decision-makers, technology entrepreneurs, SMEs, industry, NGOs, and donors – understand and develop CICs as part of a strategy to transfer, develop, and deploy advanced climate technologies suitable for the developing world.

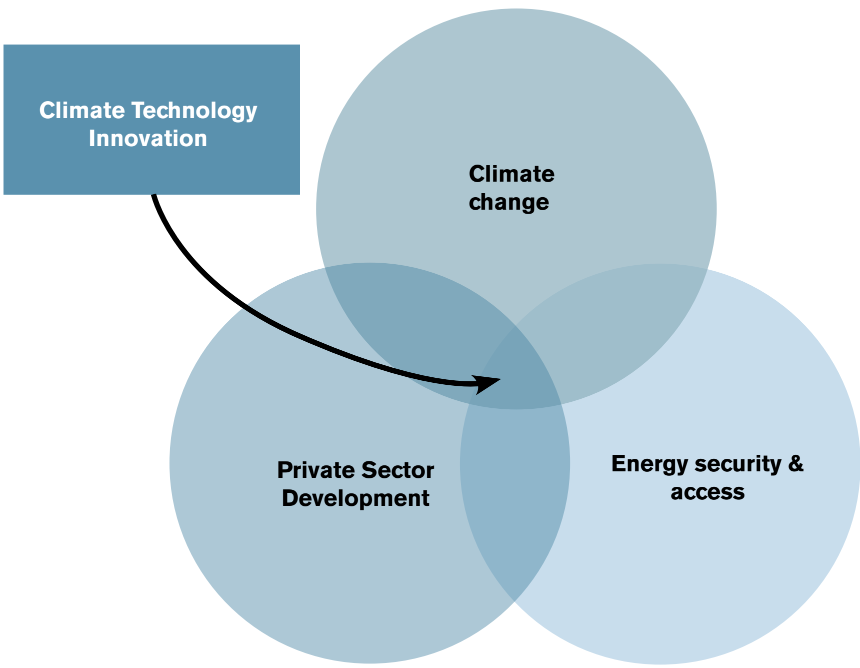
CLIMATE INNOVATION IN DEVELOPING COUNTRIES

Accelerating innovation in emerging technologies is essential to help reduce the current and long-term impacts of climate change. However developing countries, which are most immediately threatened by these impacts, lag in their capacity to transfer, develop and deploy innovative climate technologies.

This capacity lag results from barriers to technical and business innovation that are greater in the developing world than in industrialized countries. These barriers are compounded by additional pressures on developing countries such as high poverty rates, large infrastructure gaps, and the urgent need for economic development and job creation.

Taken together these factors often make developing countries the passive recipients of technologies developed elsewhere. This can lead to the deployment of technologies unsuited to local conditions, and also prevent developing countries from exploiting the economic potential of one of the most promising sectors of the 21st century.

Figure 1: Climate technology innovation delivers many potential benefits



Source: infoDev

"The Climate Innovation Centre (CIC) has a role to play in transforming Kenya to a middle income country as called for in the Government's Vision 2030. Specifically to achieve the essential technological advancement and catalyze innovative technology among SMEs."

Alex Alusa, Office of Prime Minister, Kenya

CLIMATE INNOVATION CENTERS

CICs are intended to address the barriers that impede developing countries from the transfer, development and deployment of advanced climate technologies for both domestic use and export. Many developing countries lack the public and private sector bodies that support innovation, and as a result support for locally appropriate climate innovation in developing countries is often weak or absent.

The concept of the CIC has been developed in recent years by bodies such as the Carbon Trust, the UNFCCC's Expert Group on Technology Transfer (EGTT), and the Indian government. While there is no single definition of what a CIC should look like, there is an understanding that a CIC would involve a wide range of functions – see figure 1 below - although the exact design would be tailored to the specific needs of each country.

Figure 2: A graphical depiction of CIC functions

A more detailed breakdown of possible functions of the CIC can be found in Table 7
Source: Ambuj Sagar; infoDev.

ADDRESSING GAPS IN EXISTING INNOVATION CAPACITY

To further inform design of CICs, this report analyses the existing capacity for such centres around the world, and the major gaps in that capacity which CICs can fill.

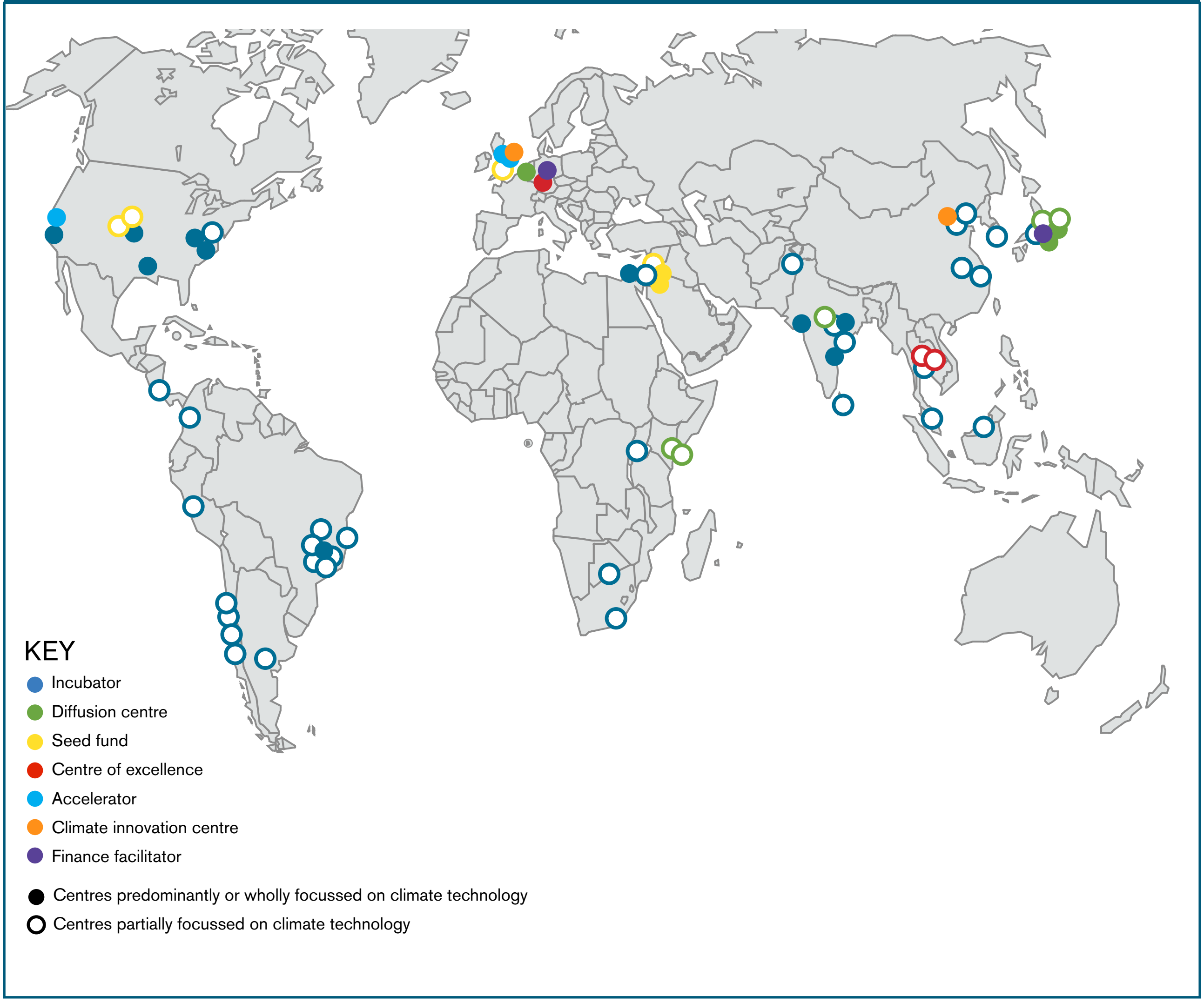
550 relevant organizations were analysed in 68 countries including business incubators, seed funds, multilateral organizations and others. Of these, 67 were found to support or facilitate some level of climate innovation while only 25 dedicate more than half their effort to climate technologies. Of the organisations that were mostly climate focused only 10 operate in the developing world.

Among these organizations, a wide range of gaps and barriers was found across all functions.

Case Studies:

- Baoding New & High Tech Industrial Development Zone, China, page 31
- UNIDO-UNEP Cleaner Production Programme, page 34
- CIETEC, Brazil, page 38
- Consultative Group on International Agricultural Research, page 41
- NVI, India, page 43

Figure 3: Institutions that facilitate climate technology innovation



NB This map does not show all the institutions that engage in climate innovation, only those that facilitate it through the kind of activities envisaged for the CIC. R&D organizations are excluded, for example, as are most types of investor. Multilateral programmes that operate in many developing countries are represented by their headquarters only.
Source: Bloomberg New Energy Finance

Access to Finance

There was a widespread shortage of funding for climate innovation, along with a lack of capacity amongst most organizations to bridge this gap: two thirds could not help companies gain access to private capital, and many were unfamiliar with more innovative early-stage funding options.

Technology Information

Many centres acknowledged they did not fully understand climate technologies, and in some regions a significant proportion were unable to offer help with product development. None undertook national technology assessments to prioritize the most promising options for their country.

Business Support

In enterprise creation and support, most climate-focused incubators in developing countries tend to concentrate on late-stage companies, with only a handful supporting early-stage companies, potentially restricting the pipeline of innovative technologies.

Market Analysis

Many centres acknowledged that understanding markets for climate technologies – where there may be no expressed consumer demand – is challenging. In some regions a majority of centres offer no market analysis or information to client companies.

Policy for Innovation

Most centres do not engage with policymakers, despite the vital role of governments and regulators in driving climate technology markets. Few centres are involved in setting standards and regulations for technologies they support.

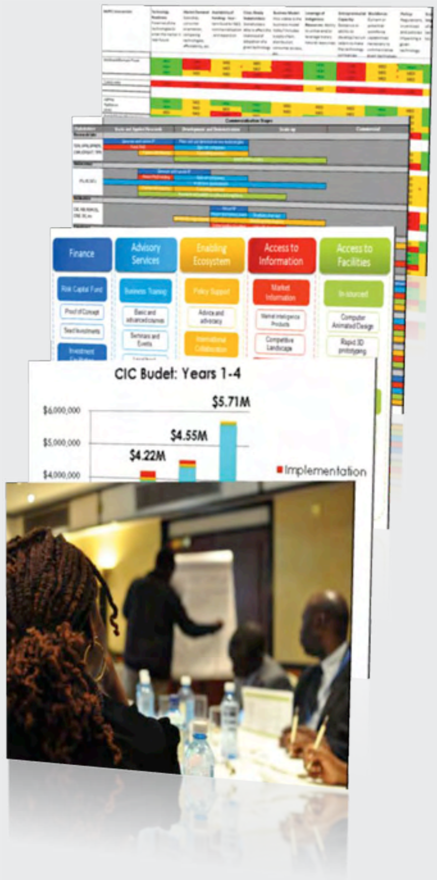
CONCLUSIONS AND RECOMMENDATIONS

The report identifies a number of lessons about design and implementation of CICs.

- Climate technology innovation is vital to address climate change, meet growing energy needs, and advance sustainable economic development.
- The barriers to climate technology innovation in developing countries are more numerous and more challenging than those in the developed world.
- There is a critical need to enhance support for locally relevant climate technology innovation in developing countries.
- While there are up to 70 institutions globally that support climate innovation, their geographical distribution is patchy, their technical focus biased towards mitigation rather than adaptation, and there are large gaps in the services they provide compared with what is needed.
- Although the design of each CIC will need to reflect local conditions to have the greatest chance of success, common functional areas will include: facilitating technology development and demonstration; helping develop markets; providing support services to firms; enhancing access to finance; assisting in the development of appropriate policy and regulatory frameworks; and coordination, networking, and capacity-building.
- Some countries and regions may not have the capabilities or resources to create a successful CIC without significant external help. There may be countries where CICs are only viable as part of a combined regional effort.
- CICs should concentrate resources and expertise by specializing in the technologies most appropriate to local conditions rather than spreading their efforts too thinly.
- CICs could be developed individually, but there is much greater benefit in building a network of connected centres.

BOX 1: IMPLEMENTING PILOT CICs IN KENYA AND INDIA

As part of infoDev's plans for a global network of CICs, it has produced Business Plans for centres in Kenya and India, detailing the specific functions, services and financing each centre will deliver over 4-5 years. These have been developed in collaboration with over 150 stakeholders in each market representing a range of backgrounds in the public and private sectors. Under the plans each centre aims to recover 70% of yearly costs after 10 years from investment returns and fee-for-service. Implementation of the centres in Kenya and India is expected to start in 2011, and plans to develop CICs in a number of other countries will be pursued concurrently.



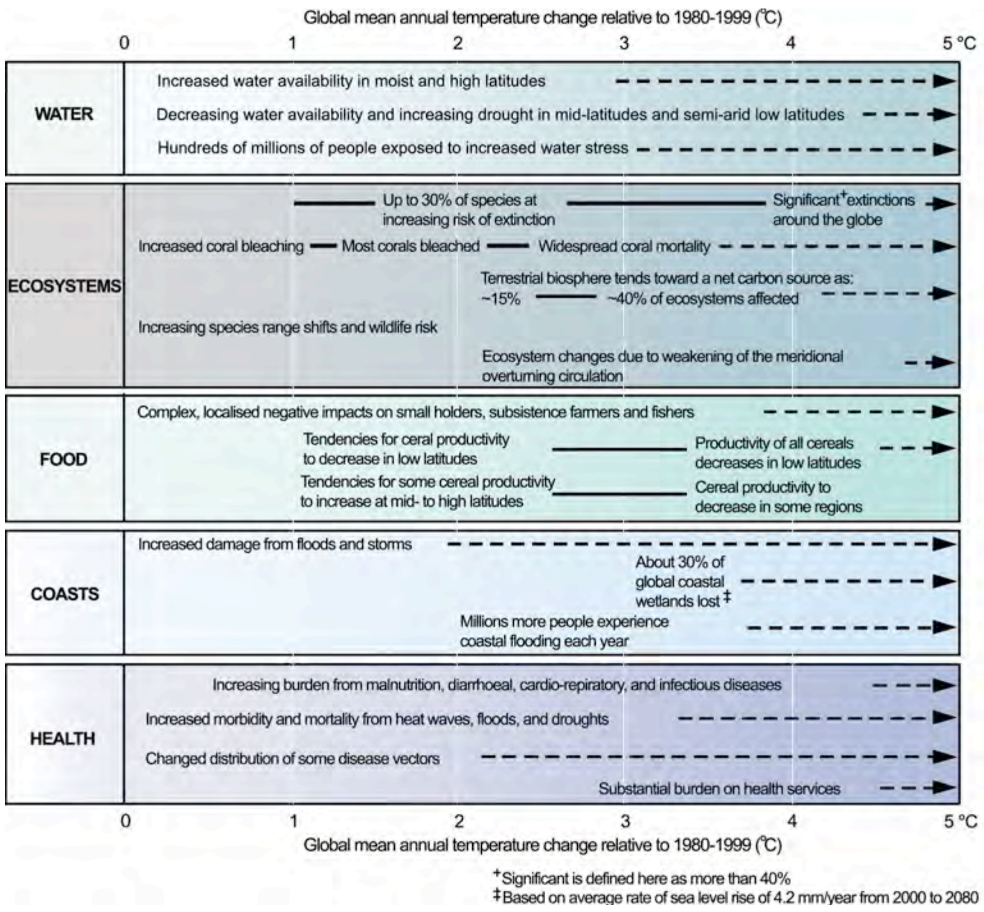
infoDev's vision is to build a global network of 30 Climate Innovation Centers that will create over 2,400 enterprises, generate 240,000 direct and indirect jobs, install 3000 MW of off-grid energy capacity, provide energy access to over 28 million people, deliver clean water to over 10 million households and mitigate 65 million tons of CO2.

1 CLIMATE TECHNOLOGIES – NEED AND OPPORTUNITY

THE CLIMATE THREAT

"Warming of the climate system is unequivocal", says the Intergovernmental Panel on Climate Change (IPCC)[1]. Many natural systems are already being affected by regional climate changes, the latest report of the Panel indicates, and a range of further major impacts are anticipated – affecting agriculture, forestry, and ecosystems, water resources, human health, as well as industry, settlements and society[2]. Large-scale abrupt changes are also possible. So too are tipping points that may lead to irreversible climate change.

Figure 4: Key Impacts as a function of Increasing Global Average Temperature Change



Source: IPCC Fourth Assessment Report, 2007

Climate technologies are key

Under the UN Framework Convention on Climate Change (UNFCCC), the overarching treaty intended to tackle climate change, countries have agreed to stabilise GHG concentrations at such level as to avoid "dangerous" climate change. But no consensus yet exists on how far and how fast we should reduce our emissions, to say nothing of how the burden of this effort will be shared. There is, however, widespread agreement that climate technologies will play a crucial role.

According to the IPCC Special Report on Technology Transfer (SRTT), to achieve the UNFCCC goal will require "technological innovation and the rapid and widespread transfer and implementation of technologies, including know-how for mitigation of greenhouse gas (GHG) emissions. Transfer of technology for adaptation to climate change is also an important element of reducing vulnerability to climate change".[3]

The concept of 'climate technologies' embraces two main categories: mitigation, meaning the reduction of GHG emissions from energy production, industrial processes, transport, agriculture, deforestation and so on; and adaptation, meaning the development of technologies to help cope with climate impacts, such as water conservation, crop development, infrastructure reinforcement, and disaster management.[4]

Adaptation has tended to receive less attention than mitigation in global and even national climate discussions, yet climate impacts are already evident and these trends are only likely to accelerate in the coming years (see Figure 4 for the kind of climate impacts that are projected by the IPCC). It is clear that greater attention needs to be paid to adaptation.

In practical terms this will mean developing technologies for managing water stress through enhanced storage, conservation, and recycling; technologies for increasing the resilience of agricultural systems, including modified crops, improved cropping systems and practices, and land management; infrastructural technologies to protect against climate impacts, such as seawalls and dykes for coping with sea-level rise, floods, and storm surges, or improved building techniques to increase resilience to coastal storms; and disaster management technologies such as advance warning systems.

But adaptation is not enough — many of the climate impacts may well become unmanageable if the build-up of GHGs in the atmosphere is not slowed and reversed. Avoiding such 'dangerous' climate change will demand a huge effort to mitigate emissions.

Here, the energy sector is critical, since it accounted for almost 70% of total GHG emissions in 2005 (excluding land-use changes)[5]. As a result, the emissions profile of energy technologies will need to be drastically different from business-as-usual if significant cuts are to be achieved. This will require huge investments in the developing world as well as the developed (see Figure 5), and include harnessing renewable energy sources such as solar, wind, and biomass; more efficient transmission and distribution systems to reduce losses; more efficient end-use technologies in buildings, industry, and transport; and improved planning and practices.

In some sectors, mitigation and adaptation may both be needed. Agricultural systems, for example, will need to be modified to both reduce their GHG emissions from fertilisers and livestock, and also help them adapt and be resilient to higher temperatures and changing pest and precipitation patterns. Appendix 1 shows a more comprehensive list of potential mitigation and adaptation technologies.

Developing countries – climate risk and opportunity

While the UNFCCC obliges developed countries to "take the lead in combating climate change", it is clear that eventually developing countries will also have to mitigate their emissions. But in the near term, adaptation will be more important for these countries since they host the world's most vulnerable populations and societies, and for the most part lack adequate financial resources with which to respond.

However, the need to deploy climate technologies could also represent opportunity for developing countries. Much of the required adaptation will happen in these countries, and since many are in the early stages of development, they will construct a huge amount of infrastructure in the coming decades in any case.

The International Energy Agency (IEA) suggests that 90% of the growth in global energy demand over the next two decades will come from non-OECD countries, mainly Asia.[6] The IEA also estimates that a global energy-supply system will need investment of about $26 trillion between now and 2030 under a reference scenario, and an extra $11 trillion if we want to keep GHG concentrations below 450 ppm CO2-e (parts per million carbon dioxide equivalent), and that as much *as half of this investment will be needed in developing countries.*

This raises the prospect of developing countries creating entire new industries based on climate technologies, with positive impacts on employment and their wider economies. A recent report by the United Nations Environment Program suggests a large potential for 'green jobs' worldwide, including developing countries.[7] It estimates that wind energy alone could create 2.1 million jobs worldwide, a seven-fold increase over 2006. For solar and biomass, the numbers are 6.3m (40-fold increase) and 12m (10-fold increase) respectively. With the right policies, developing countries should be able to capture many of these jobs.

In principle it should be possible to craft an approach that could at once supply local people with basic energy and other services, achieve development and climate goals, and perhaps even allow developing countries to leapfrog the fossil-based economies of the developed world to achieve a genuinely sustainable energy system. However, realising these potential opportunities is likely to present enormous challenges.

Understanding climate technologies

Exploiting technology to meet climate change goals presents two fundamental problems: scale and complexity. Given that climate change affects large swathes of developing-country populations, and straddles many commercial sectors, solving it will require a major effort where 'scale-up' is critical. But since a wide range of technologies must be applied across a range of sectors, it will also involve a variety of different approaches and strategies. So the problem is big and complicated.

Climate technologies can involve the highest and most complex technology, such as nano-structured photovoltaic cells to harness sunlight more efficiently, or the application of biotechnology to develop drought-resistant crops. Even seemingly simple technologies such as wind turbines may be based on cutting-edge materials and engineering. Similarly some planning and management processes can require significant technological backup as in the case of transport management systems.

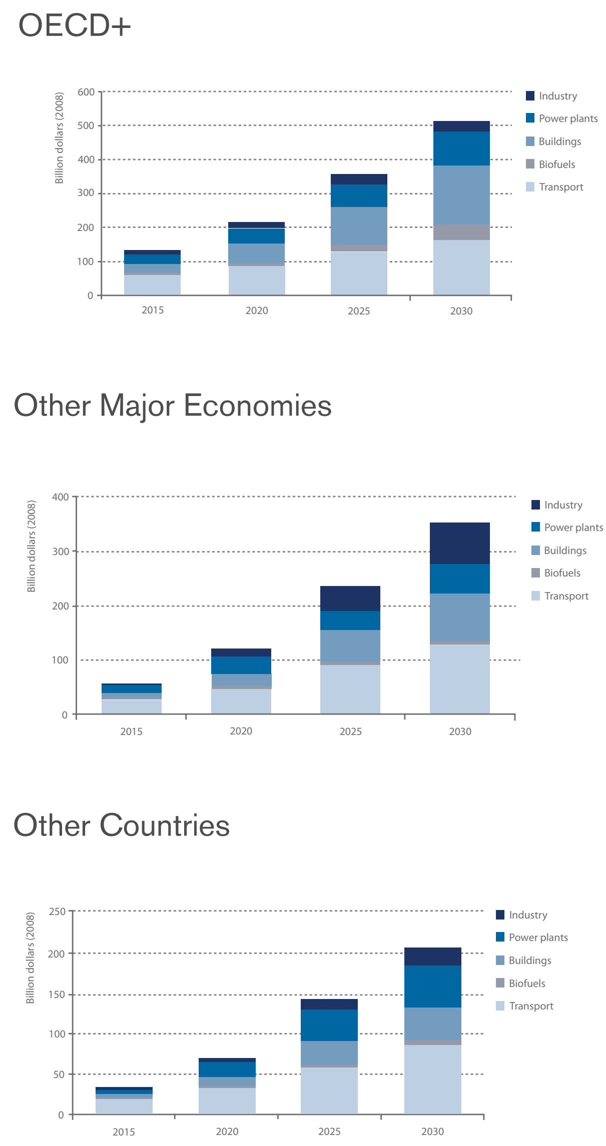
It is not only in the development of these technologies and products but also their manufacture that requires deep technical expertise. This is true for advanced batteries, for example, where the production of the storage material may require exacting procedures, or wind turbines, where blades may be made of advanced composite materials.

But not all climate technologies need be high-tech or complex: drip irrigation systems that can greatly help in increasing the efficiency of water use in agriculture are relatively simple.

There are also large differences among the countries where these technologies will be deployed. This is particularly important for developing countries, where technological capabilities are often limited; where financial, institutional, and other constraints make the innovation challenge starker; and where other energy challenges – such as enhancing energy access and security – are equally pressing.

This makes the process of climate technology innovation - the development and commercial deployment of climate technologies - that much more complex and challenging in developing countries, and yet more so in the Least Developed Countries (LDCs). And that is why it is critical to understand the underlying processes of successful innovation, and the institutions that underpin them.

Figure 5: Regional investment in carbon abatement required to meet IEA 450 Scenario



Note: The IEA's 450 Scenario is devised to limit to 50% the probability of global average temperature increase of more than 2C, by stabilising the atmospheric concentration of GHGs at 450 ppm CO2-eq. The IEA's modeling shows achieving this requires substantial investment in all regions.

OECD+ = all OECD countries plus those that are part of the EU but not the OECD. Other Major Economies = China, Russia, Brazil, South Africa, Middle East. Other Countries = all other countries.
Source: IEA World Energy Outlook, 2009

UNDERSTANDING THE TECHNOLOGY INNOVATION PROCESS

How innovation happens

The process of technology innovation is well understood – in the developed world at least – and broadly comprises a set of activities that include research, development, demonstration, and deployment. Figure 6 illustrates the key stages to energy-technology innovation in a market economy. Mapping innovation in the real world is clearly more complex, and is highly specific to the technology and players involved, but the broad phases include:

- **research:** basic and applied
- **technology:** translation of the original concept/ invention into technology which can involve developing a 'proof of concept', and demonstrating a prototype outside the laboratory;
- **product:** development of a product and business model taking into account market conditions and consumer needs based on market research and consumer analysis;
- **deployment:** products are brought to market – often niche or subsidised at this stage – either by start-up companies created to exploit the technology, or established firms that have adopted it;
- **diffusion:** in which the use of the technology expands in scale

Successful innovation involves not just the development of new and improved technologies or adaptation of existing ones, but also their introduction into the marketplace through specific products. So we have to ensure not only that products are available ('supply push'), but also that a market exists to absorb them ('demand pull'). A technology that exists elsewhere but is introduced into a new country through 'technology transfer' can also contribute to 'innovation' in the receiving country. Technology transfer can occur at any pre-market stage in the value chain.

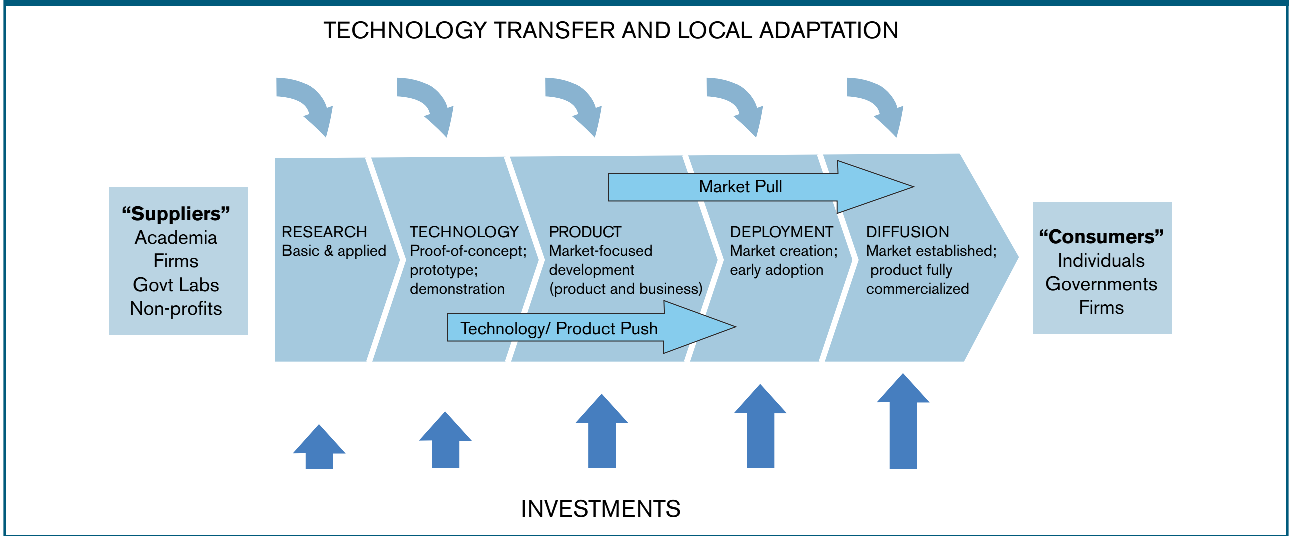
It is also important to recognise that the innovation process is non-linear – there is interaction between its various stages. For example demonstration projects can result in significant changes to the product, and this might be as true for a coal-based power plant as a solar lantern, where the use of the product under real-world conditions suggests modifications that would improve performance. But the relationship is not one-way: just as products are modified to suit market circumstances, markets need to be developed with reference to the emerging products, and the social and financial conditions that exist within the country or region

The players

Innovation also requires a range of actors that play different roles in different stages. In the earlier stages, for example, R&D organisations play a key role, whether these are government, industrial, or academic laboratories. But as we move along the innovation chain, a different set of capabilities become more important. At the later stages, product firms become the key actors, creating a bridge between the scientific and technical advances in research laboratories and the markets. These may be small entrepreneurial ventures or established engineering and manufacturing firms. In many cases, the start-ups and the engineering firms themselves may be doing R&D, and in some cases, the start-up firms may partner with or be absorbed by larger players.

In addition, there is a gamut of other actors - including marketing and consumer research companies, law firms, and technical consultants - that also support

Figure 6: Main steps in the innovation chain



Source: Ambuj Sagar; Grubb, 2004

and advance the innovation process. Governments play a key role by shaping the rules of the game, and the institutions under which markets operate.

These actors, along with the institutions that form the backdrop of the innovation process, are referred to as 'systems of innovation'. While these systems vary from country to country, as well as among sectors and technologies, it is generally agreed that successful innovation requires the right combination of actors, policies, and institutions acting in concert.

Paying for innovation

Funding innovation is risky, but the risk declines the further one travels along the innovation chain. For example, it is more difficult to predict the outcome of R&D than of demonstration. However, as the risk declines the funding requirements increase. That means each step of the process requires actors with different-sized pockets, and different appetites for risk.

Public funds support the earliest and the highest-risk activity – research and development – and sometimes the translation of resulting technologies to prototype products. Venture capitalists and angel investors that have a good appetite for risk will be involved in the next stage of innovation where the products are being developed or even in the market demonstration stage. As a technology moves towards commercialisation, private equity investors, banks, and even the financial markets start to get involved.

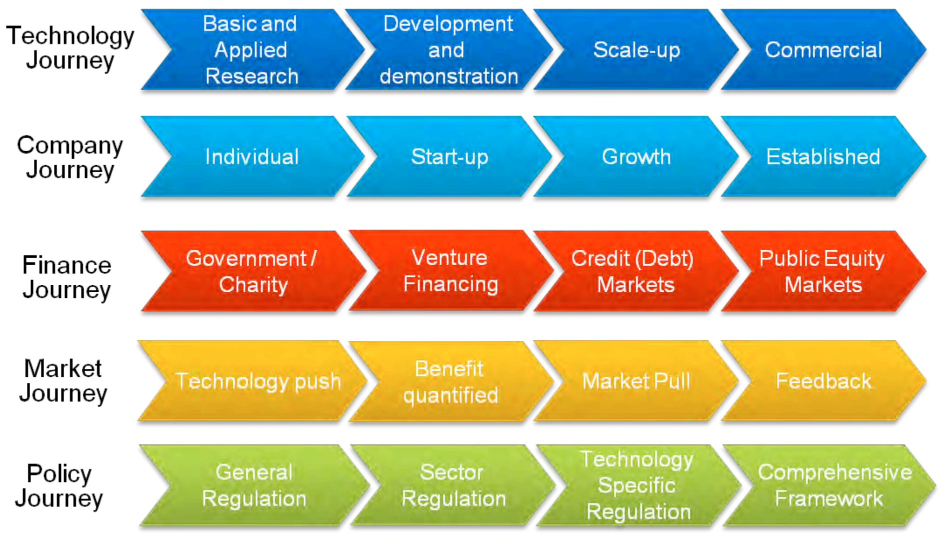
There are many barriers to overcome in this process, but one stage is particularly difficult. Known as the 'valley of death', this is the stage between demonstration and commercialisation, which requires significant investments in product and business development but before cash flow has started. Companies need external funding to survive this period but it is often hard to obtain because investors are deterred by the obvious risks, meaning many firms fail at this stage – hence the name.

The five journeys of technology innovation

Moving from concept to commercial product availability requires a technology to overcome a diverse range of barriers to do with technology, business, market, and regulation. Broadly, they must travel five 'journeys' (Sagar, Bremner, Grubb, 2009[8]), all of which have to occur to deliver fully commercial technologies deployed at scale (see Figure 7). Again, the process is more complicated in the real world, but together these journeys provide a useful sketch-map:

- The technology journey: the technology proving itself and being able to compete at cost with the market equivalent;
- The company journey: growing a successful business, either a new enterprise or within an existing firm, by translating the technology from lab/pilot-scale to product development and manufacturing, or transferring to a firm that has such capabilities;
- The finance journey: where the various stages of the innovation process are funded by a series of organisations with different appetites for risk;
- The market journey: where markets begin to consume and 'pull' new technologies, and feed back into their development;
- The policy journey: where policies and regulations are put in place to support the early stages of demonstration through to general application of the technology in the local market.

Figure 7: 'Journeys' in different arenas for successful technological innovation



Note the 'company journey' could represent an existing firm embarking in a new area
Source: infoDev; Carbon Trust

TECHNOLOGY INNOVATION IN DEVELOPING COUNTRIES

Why the developing world is different

While innovation is well understood, the process differs between technologies and countries, and the needs and conditions of developing countries are quite different from those of the developed world. A simple classification of technology needs for developing countries includes: [9]

- Accelerating transfer of commercial and emerging technologies, which can be used in developing countries without much significant modification, e.g., consumer electronics, lighting solutions
- Adapting technologies to local conditions, e.g., energy-efficient buildings, power plants
- Development of technologies for sustainable development needs that are not seen as priorities by the global technology markets, such as improved cooking stoves, small-scale biomass gasifiers and solar lanterns
- Meeting long-term technology needs, which will require some R&D
- Advancing deployment of relevant technologies by overcoming economic, financial, information and trust, market organisation, infrastructure, human and institutional capacity barriers.

Given this range of technology needs, a simple transfer of technologies from the developed world to developing countries is unlikely to be adequate. Successful uptake of new and improved technologies generally requires the adaptation of existing technologies for local conditions (see Box 2); in many cases, meeting local needs may even require the development of altogether new technologies. Deployment models tailored to local conditions may also be required. And development of local innovation and manufacturing capacity can also be crucial to deliver jobs, growth and exports, to cut the cost of climate mitigation and adaptation technologies, and support economic and social progress. So meeting these multiple goals effectively is likely to require the expansion of climate innovation capacity in developing countries.

'Supply push' is weak…

Although developing countries have specific needs and circumstances, their innovation systems tend to be much weaker than those of industrialised countries: the actors (technical, financial, and others) are often not as strong or as numerous; and government policies are often less robust, and may suffer from weak implementation[10]. As a result the barriers discussed in the previous section become even more formidable.

One particular problem is that developing countries require products that have very different specifications from their equivalents in the industrialised world. So there is a need to adapt products invented in developed countries to make them suitable for developing ones, even though the core technology may remain the same: car suspension systems may have to be modified for rougher roads; household appliances adapted for poorer-quality electricity supplies or patterns of use; or air conditioners designed to operate in the extreme heat of tropical climates (see Box 2 below).

Another problem is that international technology markets often ignore products that meet the specific needs of developing countries such as cleaner cooking stoves. So there is a need not only to adapt existing products from the developed world, but also to come up with altogether new ones.

Yet another is that there is often a dearth of private investors – angels, venture capitalists, and private-equity firms – to fund climate innovation in developing countries, particularly in the LDCs. As a result the 'valley of death' is even deeper in developing countries than in the developed world.

BOX 2: TECHNOLOGY MODIFICATION FOR DEVELOPING COUNTRIES

A good example of technology adaptation for the developing world is a portable electrocardiogram produced by GE Healthcare specifically to meet the needs of India.

The electrocardiogram is an essential piece of medical equipment, but typically quite heavy and not built to operate in the conditions found in many developing countries.

In 2009 GE Healthcare modified its standard device and produced the MACi, which is a third lighter than the original version, and able to operate in the hot dusty conditions of remote Indian villages. It is battery operated, and capable of taking 250 readings on a single charge, which is very useful in a country where power cuts are a chronic problem.

The device should also bring down the cost of tackling heart disease in India, since it is built mostly using locally-produced components, and is only half the price of the original device.

That in turn has produced a surprising additional revenue stream. GE reports that 80% of its earnings from the MACi come from exports to markets including Italy, Germany and the US.

…but so is "demand pull'

Developing countries suffer not only from an inadequate pipeline of adapted and/or new products to suit their needs, but also from markets incapable of exerting the kind of 'pull' that might solve that problem without intervention. Bluntly, developing market consumers generally do not have the collective purchasing power that would stimulate such innovation – a classic 'Catch 22'.

All this makes large-scale deployment of climate technologies yet more challenging, and may demand innovative policies and delivery models to support the work of entrepreneurs such as ESCOs (Energy Service Companies, where the firm is responsible for the delivery of the energy service rather than just the technology or the fuel, and typically paid out of the savings achieved). In these circumstances, it is essential for developing countries to develop domestic capacity to analyse policies and markets, so they can devise suitable approaches.

Lastly, since climate technology innovation in the developed world tends to focus on mitigation or cutting greenhouse gas emissions at source, adaptation is often overlooked, and this again does not reflect the immediate interests of developing countries.

The urgency of climate change, and the formidable range of barriers to climate innovation in developing countries, suggests the need for these countries to better understand how they might best advance such innovation. The next section discusses a specific institutional mechanism that has been proposed as way to bridge the gap between needs and capabilities for climate innovation in developing countries.

CLIMATE INNOVATION CENTERS

What is a Climate Innovation Centre?[11]

The concept of Climate Innovation Centres (CICs) has been introduced recently as an institutional approach to help overcome the innovation-capability gap that exists in many developing countries and promote climate technology innovation appropriate for local needs. It has been developed by Ambuj Sagar of IIT Delhi, and Michael

Grubb, Cath Bremner, and Stefania Omassoli, of the Carbon Trust, based on their work exploring institutional mechanisms to promote and accelerate innovation to meet climate challenges in developing countries.[12] It also has been introduced into the climate negotiations by the Indian government. [13]

The CIC concept draws on both existing models of international collaboration as well as research on the technology transfer and innovation processes. These include the Consultative Group on International Agricultural Research (CGIAR, featured in one of our case studies, page 41); a large body of work on the need and approach for technology transfer to meet climate challenges[14]; and other proposals on international energy technology collaboration.[15]

The concept extends these earlier approaches with the explicit recognition that successful climate innovation in developing countries will require support for a whole host of activities beyond technical cooperation. It is based on the understanding that climate innovation in developing countries faces a range of barriers in addition to those faced in the developed world, which the CIC is intended to help break down.

While the CIC concept has been the topic of much discussion, there is not yet a unified understanding of what such an institution would need to look like. And it could be argued that no real examples yet exist. However, it has been suggested that the CIC will need to play the role of a 'one-stop-shop' to foster rapid innovation in climate technologies in developing countries, to both mitigate and adapt to global warming.

The notion of a 'one-stop-shop' suggests the CIC will potentially undertake a broad range of functions designed to overcome the wide variety of barriers to climate innovation, and that the technology focus of each CIC will depend on the specific circumstances of its host country or region. That means not only is CIC likely to look different between countries, but also between technologies within a single country.

In other words, a CIC that supports a range of technologies would probably engage in different activities to support each of them – although there may well be synergy across projects. And the functions of the CIC should also evolve over time, as the host country's technology capacity improves. So the 'core competence' – to borrow a management term – is to facilitate climate innovation with a suite of functions determined by local needs and capacity.

One critical distinction is that the CIC will focus on technologies often ignored by the innovation process in the developed world – stressing adaptation as well as mitigation, and development as well as climate needs. In this way, the CIC is intended to transform the threat of climate change into an agent of technology innovation, helping to tackle both global warming and sustainable development challenges in the developing world.

The CIC in context

There are already many organisations that support innovation, such as incubators, seed funds and industry associations, but these tend to focus quite narrowly on one aspect or another of the challenge. CICs would need to take an approach that is both broader and yet in some senses even more targeted (see Box 3). The CIC may incorporate some functions of existing organisations in some circumstances, but in others the relationship would be very different.

For example, in the LDCs, the CIC's functions might include that of an incubator, because of the need to build up enterprises and whole industries from scratch, and because in these countries, Small and Medium Sized Enterprises (SMEs) are especially significant in job creation. In Indonesia, for example, SMEs employ over 96% of the workforce, and delivered more than half its GDP and GDP growth in 2006[16].

However, in countries that already have relevant industries and/or an entrepreneurial ecosystem such as the BRICs (Brazil, Russia, India, China), the CIC might simply leverage the work of existing players while focusing its own resources on strengthening the innovation ecosystem.

BOX 3: COMPARING CICs WITH EXISTING ORGANISATIONS

A wide range of organisations already exist to support climate innovation, but these tend to focus on specific aspects of the challenge.

For instance, incubators are public or private organisations that provide a range of services to support enterprise creation; technology accelerators do a similar job but with a greater emphasis on technology – rather than company – development; centres of excellence focus more on capacity building in specific sectors; technology development and diffusion centres help companies understand innovative technologies (such as CCS) and adapt them for local markets; technology seed funds invest in new technologies at the earliest stages of innovation; and advisory centres provide either technology or financial advice to entrepreneurs who need help to develop their projects.

The approach of CICs will be both broader and in some senses even more targeted than that of existing organisations. On the one hand they will need to facilitate all aspects of climate innovation within a country through a wide range of services including technical, business-advisory, market analysis, policy analysis and networking. But on the other, these services will be tailored to the specific technologies being supported; the CIC may offer different services and work with a different group of partners for each technology. For instance, advancing solar energy may require working with start-ups while promoting energy efficiency may involve working with established players.

To achieve all this, the literature suggests CICs will need to be widely networked with all key players relevant to technological innovation, including government, industry, companies big and small, universities, and international organisations.

A key purpose of this report is to explore in detail the kinds of functions that CICs will need to undertake and the implications for institutional design. The report has been commissioned by infoDev, a multi-donor programme of the World Bank Group which is already working in Kenya and India to pilot CICs and develop the concept in practice.

The functions of Climate Innovation Centres

CICs are expected to engage in a suite of activities designed to overcome the broad range of market, financial, capacity, cultural and policy barriers that impede climate innovation in developing countries. Some specific key functions of these centres would be to:

- assist in 'technology needs assessment' and prioritisation to better understand which technologies could help meet specific climate challenges for a country/region
- facilitate and support technical collaboration between public- and private-sector researchers from developing and industrialised countries on specific projects to develop technologies and products
- support the creation and incubation of enterprises and business units that can translate technologies into products for local markets
- help firms move technologies and products across the 'valley of death' by supporting product and business development
- support early-stage deployment for these new products through, for example, the development and exploitation of niche markets using appropriate policies
- provide or facilitate appropriate finance during each step of the innovation process
- explore delivery models that are suited to financial and other constraints of different segments of the population
- provide market and/or policy analysis to help firms and governments choose appropriate courses of action and strategies
- identify and solve technology and market barriers to move technologies up the adoption curve, including:
  - helping create a favourable national political and regulatory framework for large-scale deployment of these technologies
  - providing information and raising awareness nationally
- aggregate national initiatives, network internationally with other centres and institutions, and coordinate across all these activities.

Figure 8: A graphical depiction of CIC functions

A more detailed breakdown of possible functions of the CIC can be found in table 7
Source: Ambuj Sagar; infoDev.

The policy context

The CIC would not exist in isolation. National and local governments in the developing world are already planning or enacting a range of policies to support climate mitigation and adaptation. These include low-carbon growth plans, R&D programmes, renewable portfolio obligations, and energy efficiency and other performance standards.

At the same time there are a number of international programmes driven by donor agencies, foundations, the private sector and NGOs, which aim to facilitate a low carbon transition in developing countries. These include sector-specific programmes, such as those aimed at improving efficiency in power generation, market-driven programmatic efforts such as Clean Development Mechanism, and broader collaborative efforts such as the Asia Pacific Partnership on Clean Development and Climate.

Climate innovation will be fundamental to the success of many of these policies and programmes. So CICs could play an important role by strengthening the local climate innovation process. At the same time, by building technical, business, and policy capacity, CICs could also enhance the ability of developing countries to develop their domestic programmes, and strengthen their cooperation with international groups.

BOX 4: CASE STUDIES

Chapter 3 contains five case studies of organizations organisations considered relevant to the Climate Innovation Centre. None is thought to constitute a fully-fledged CIC, perhaps with the exception of the Baoding New & High Technology Industrial Zone in China, but all offer lessons about how such centres should be designed and work in practice.

Among the many issues highlighted by the three business incubators we studied, Baoding (page 31) illustrates some of the problems around intellectual property rights (IPR) in developing countries, and how they can be resolved. The experience of CIETEC in Brazil (page 38) demonstrates the difficulties around funding climate innovation companies, and the emerging trend for incubators to launch their own investment funds in response. And Delhi-based New Ventures India (page 43) highlights the problem of finding enough good quality climate technology start-ups to support, and the importance of extensive networking with other climate innovation partners.

Our analysis of two major multilateral organisations, the UNIDO-UNEP Cleaner Production Program (page 34), and CGIAR (page 41), strongly suggests the design of centres in different developing countries will need to reflect local circumstances.

Taken with our extensive survey of global institutional capacity in climate innovation in chapter Chapter 2, and the financial review in chapter Chapter 4, these case studies form the basis of our analysis and recommendations presented in chapters Chapters 5-7.

ASSESSING THE POTENTIAL FOR SUCCESS IN CLIMATE INNOVATION

Gauging a country's potential for climate innovation, and its potential to host a Climate Innovation Centre, requires an assessment of two key aspects: need, that is the 'demand' or 'market' for climate technologies in that country; and ability, its capacity to deliver such technologies at scale. These factors vary widely according to size, level of development and climate vulnerability, as illustrated in Table 1.

In terms of need, the size of the market for mitigation technologies can be judged by the population of the country or region, which is a measure of the demand for basic energy services, and its GHG emissions per capita (normalised by the average global emissions per capita). A country with high population and high emissions per capita obviously will have the highest need for climate technologies, while a country with a small population and a low emission profile will not have a large market for mitigation technologies. Similarly, the market for adaptation technologies is a function of the total population and the climate vulnerability of the country.

Need is necessary but not sufficient to assure success in climate innovation. A country must also possess technical capabilities, and a supportive business environment and policy framework, to foster successful innovation. In this context, LDCs are clearly less well endowed than the BRICs, even though many are more vulnerable to climate change. However, the absence of such conditions does not necessarily mean a country could or should not support a Climate Innovation Centre, rather that a key role of any centre would be to solve these problems.

Table 1: Country level assessment of climate innvoation potential and need

Country	Climate technology potential: Adaption — Population* Climate Vulnerability Index [1]	Climate technology potential: Mitigation — Population* GHG emissions/ capita	Technical capability — GERD/ GDP* Internet penetration* industrial performance [2]	Business environment — Business regulation index [3]
Thailand	High	Medium	Low	High
Burundi	Medium	Low	Low	Low
Brazil	Medium	High	High	Low

Low | Medium | High

1 For example, the Climate Change Vulnerability Index designed by MapleCroft
2 For example, the Competitive Industrial Performance Index by UNIDO
3 For example, the Doing Business rankings by the World Bank

Thailand: *Medium population, high climate vulnerability; medium GHG emissions/ capita; low GERD/ GDP, low internet penetration, high industrial performance; good very business enviroment*
Burundi: *Low population, high climate vulnerability, low GHG emissions/capita, low GERD/ GDP, low internet penetration, low industrial performance, poor business environment*
Brazil: *High population, low climate vulnerability; medium GHG emissions/ capita; high GERD/ GDP, high internet penetration, high industrial performance; poor business environment*

Source: Ambuj Sagar; infoDev

2 INSTITUTIONAL CAPACITY IN CLIMATE INNOVATION

The Climate Innovation Centre is a relatively new concept, and it could be argued no real examples yet exist. But many existing organisations may be relevant to the development of the CIC. Although the CIC may be seen as a new and unique institution, designed as a 'one-stop-shop' to overcome a range of barriers to climate technology innovation in developing countries, it may leverage many different types of organisations – incubators, multinational innovation networks, development NGOs and others. Therefore it is important to understand the spread and capacity of relevant organisations around the world.

We have undertaken a survey across 68 countries (six developed countries and 62 developing countries) and screened over 550 organisations that were potentially relevant to climate innovation. It is important to note that we did not survey the entire universe of organisations involved in climate technology innovation (government oruniversity labs, companies, investors etc), but only that *promote or facilitate* climate innovation (see Box 5 for methodology).

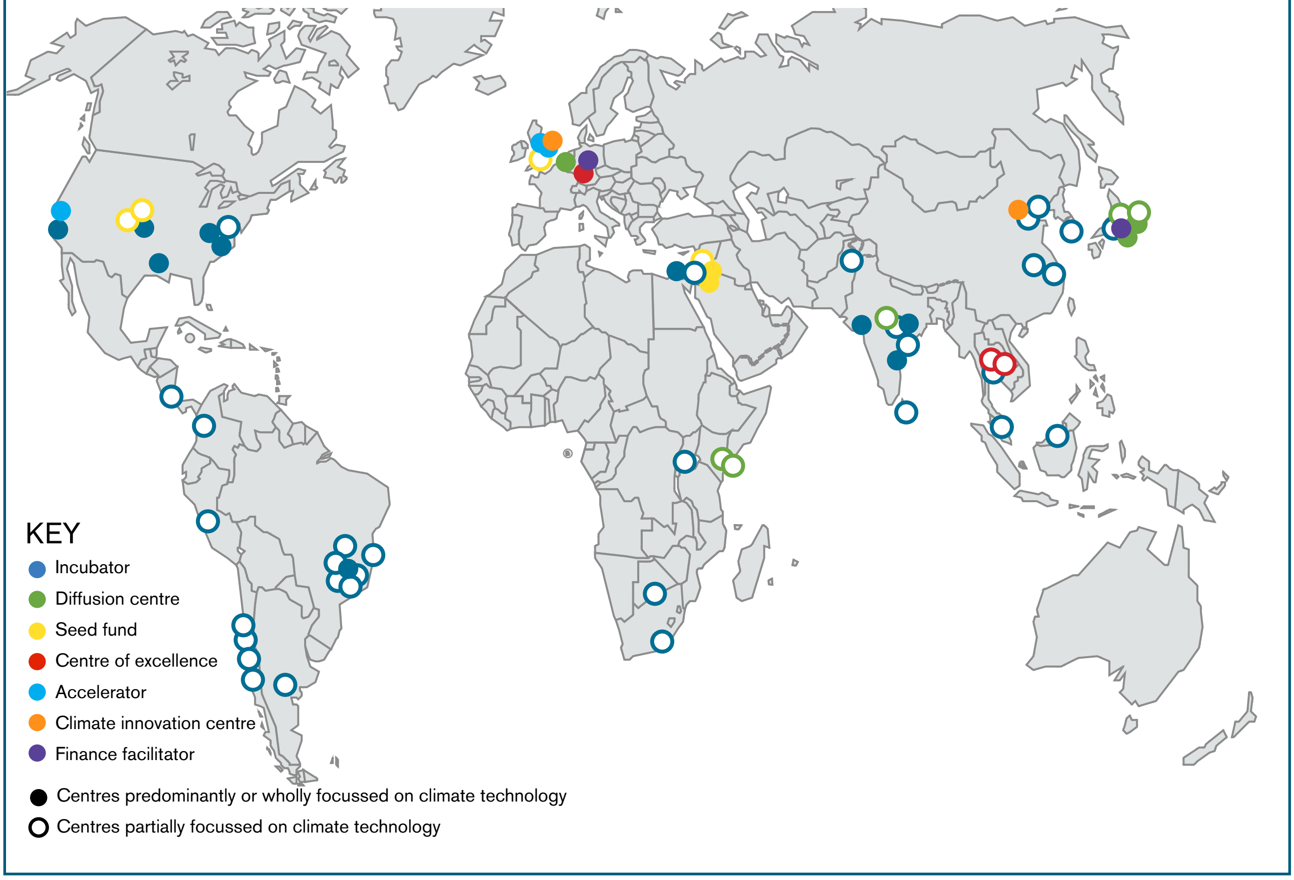
Of the initial 550 organisations, only 67 were considered to be relevant. Of those, well over half (42) were traditional business incubators, followed by eight diffusion centres, six technology seed funds, four centres of excellence, three accelerators, two Climate Innovation Centres and two finance facilitators (see Figure 10, for definitions see Box 3). Seven comprised multinational innovation networks and programmes such as CTI PFAN and REEEP, involving activities ranging from business and financial advisory to capacity building and other functions. The locations of the 67 organisations are shown in Figure 9.

BOX 5: METHODOLOGY

Analysts at Bloomberg New Energy Finance researched 550 organisations considered potentially relevant to climate innovation, through a mix of questionnaires, interviews and interrogation of the BNEF database. It is important to note that we did not survey the entire universe of organisations involved in climate technology innovation (government or university labs, companies, investors etc), but only those that *promote or facilitate* climate innovation, such as incubators or centres of excellence for example.

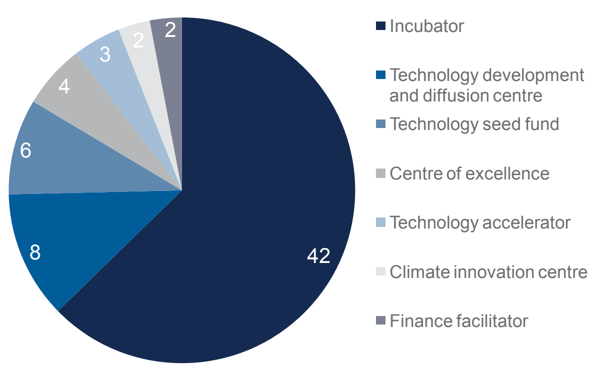
Potential candidates were initially filtered for relevance by the level of their commitment to climate innovation (minimum 25% of activity); and the nature of their work (activities including business incubation, promoting research and development, networks, capacity building, enterprise advice and financial assistance). This produced a long-list of 67 relevant organisations, which was filtered again by commitment to climate innovation (minimum 50% activity), producing a shortlist of 25 organisations considered most relevant.

Figure 9: Institutions that facilitate climate technology innovation



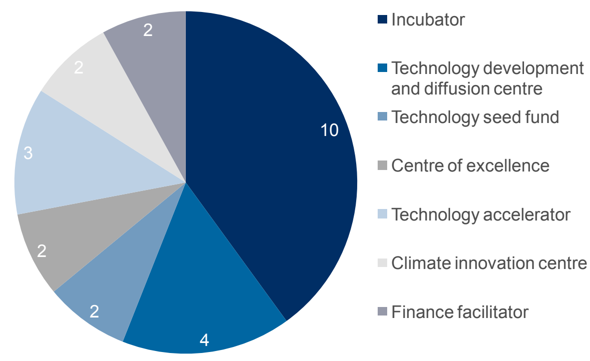
NB This map does not show all the institutions that engage in climate innovation, only those that facilitate it through the kind of activities envisaged for the CIC. R&D organizations are excluded, for example, as are most types of investor. Multilateral programmes that operate in many developing countries are represented by their headquarters only.
Source: Bloomberg New Energy Finance

Figure 10: Type of entity breakdown of the broad list of 67 centres



Source: Bloomberg New Energy Finance

Figure 11: Type of entity breakdown of the list of 25 centres that are wholly or predominantly focused on climate-tech

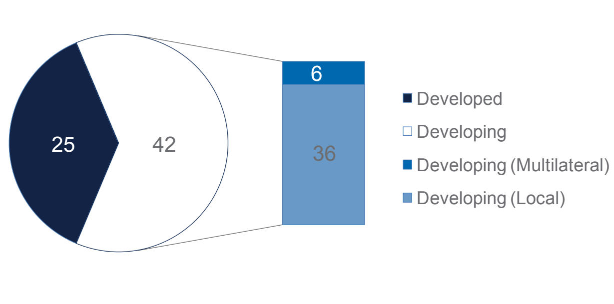


Source: Bloomberg New Energy Finance

Of this initial selection, just 25 organisations were predominantly or wholly focussed on climate technologies (50% to 100% by activity), and these are listed below (see Table 2). Of the 25, only 10 operate in the developing world, where need is greatest, and none of these is privately funded. Only two organisations were judged to be close to fully-fledged CICs: the UK's Carbon Trust and China's Baoding National New and Hi-tech Industrial Development Zone (see case study, page 31).

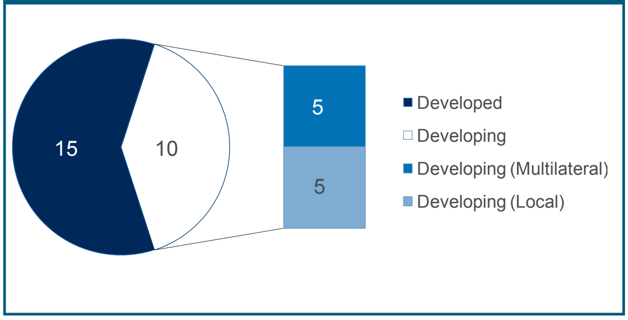
Among the initial selection of 67 organisations, the geographical coverage is patchy. As shown in Figure 12, the developed world claims over one third of the centres (25 in six countries), while the developing world hosts two thirds (42 in 22 countries). However this means 40 of the 62 developing countries have no identified organisation that focuses on promoting climate innovation. Excluding the four multilateral organisations which have multiple offices in all developing regions, Asia has 17 centres, Latin America 15, and Africa just six.

Figure 12: Regional breakdown of the broad list of 67 centres



Source: Bloomberg New Energy Finance

Figure 13: Regional breakdown of the list of 25 centres wholly or predominantly focused on climate-tech



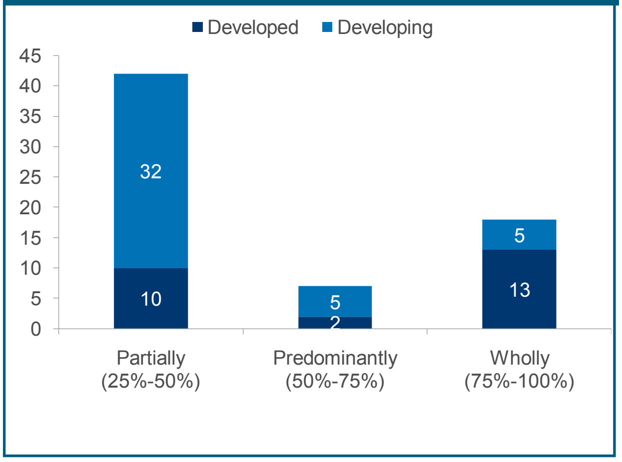
Source: Bloomberg New Energy Finance

In terms of the depth of commitment, only a quarter of the centres (18) are wholly focused on climate technologies, and of these less than a third (5) are in developing countries, all of which are funded by multinational organisations (Figure 14).

In terms of technology focus, half of the 67 organisations concentrate exclusively on mitigation technologies and only six on adaptation, while the rest cover both categories (Figure 15). Most centres in Asian developing countries (16 of 17) focus wholly on mitigation, while organisations in Latin America and Africa split more evenly between mitigation and adaptation.

Asian centres are also more likely than those in other regions to be predominantly focused on climate, and to offer 'cradle-to-grave' support from R&D right through to technology diffusion.

Figure 14: Number of centres in developing and developed countries by 'exposure' to climate-tech

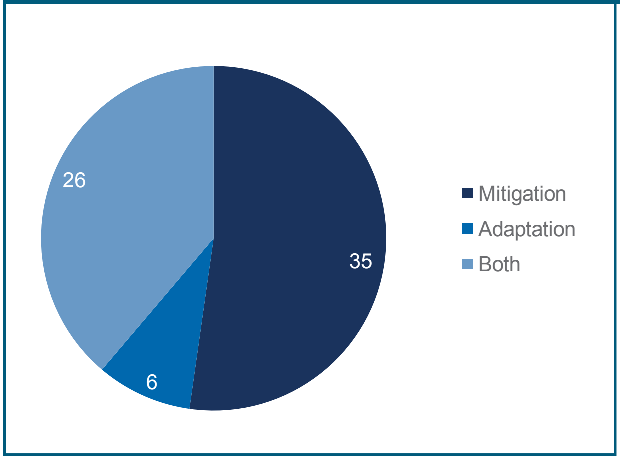


Source: Bloomberg New Energy Finance

Among the narrower group of 25 centres, the story is similar. Three quarters are stand-alone business and technology support organisations of various kinds, and the rest multilateral organisations. Among the developing countries, and excluding the multilateral programmes that have multiple offices in all developing regions, Asia has four relevant organisations, while Latin America and Africa have one each. However, it should be noted that the African centre is provided by an Africa-focused multilateral organisation; not a single climate technology incubator was identified on the entire continent. None exist in the Middle East outside Israel, but this is perhaps unsurprising given the region's large reserves of oil and gas.

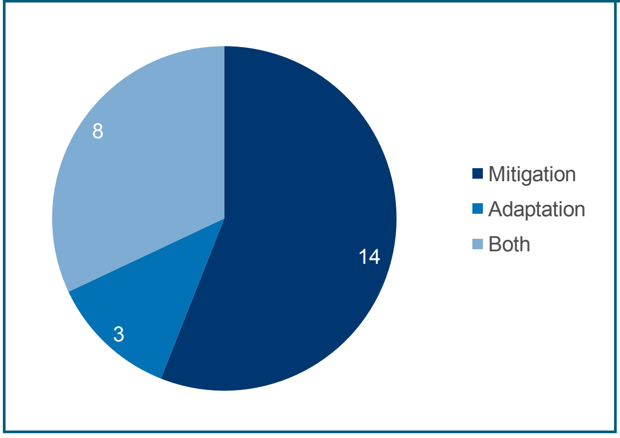
The focus of this narrower group of relevant organisations is mainly on mitigation rather than adaptation (Figure 16). Of the 25 centres, 14 focus solely on mitigation and only three on adaptation, while the remaining eight cover both categories. The centres in Africa and Latin America cover both mitigation and adaptation, but those in the Pan-Asia region (including China, India and Southeast Asia) focus almost exclusively on mitigation. The centres in China, India and Brazil are mostly traditional incubators, while those in Africa are more focused on capacity building. Only the Carbon Trust in Britain and Baoding New & High-Tech Industrial Development Zone in China (see Case Study, page 31) were thought to approach fully-fledged CICs.

Figure 15: Technology breakdown of the broad list of 67 centres



Source: Bloomberg New Energy Finance

Figure 16: Technology breakdown of the list of 25 centres that are wholly or predominantly focused on climate-tech



Source: Bloomberg New Energy Finance

Table 2: 25 selected relevant organisations

NAME	HQ	GEOGRAPHICAL REACH	TYPE OF ENTITY	OWNERSHIP	ADAPTATION/ MITIGATION	TECHNOLOGIES	INNOVATION PHASES	FUNDING
UNIDO-UNEP National Cleaner Production Centres	Austria	Developing Markets	Centre of excellence	Public	Both	Cleaner industrial production	Transfer	N
REEEP	Austria	Developing Markets	Finance facilitator	Public	Both	Renewables, efficiency	Transfer	Y
European Energy Research Alliance	Belgium	Regional	Technology development and diffusion centre	Public	Mitigation	Clean energy	R&D, Demonstration	Y
Prospecta - Incubadora de Base Tecnológica Voltada ao Agronegócio, Ambiente e Biotecnologia -SP	Brazil	Local	Incubator	Public	Both	Genetic engineering, native flora research, water management, disease control	R&D, Demonstration, Commercialisation	N
Baoding National High & New Technology Development Zone	China	National	Climate innovation centre	Public	Mitigation	Solar, wind, power management	All	Seed capital
Centre for Innovation Incubation and Entrepreneurship	India	National	Incubator	Public	Mitigation	Energy efficiency, solar lighting, biofuel, wind	All	Seed capital
New Ventures India	India	National	Incubator	Co-financed	Mitigation	Clean innovation	All	N
Tiruchirappalli Regional Engineering College Science and Technology Entrepreneurs Park	India	National	Incubator	Public	Both	Environmental, biomass	All	Seed capital
L.N. Green Technological Incubator	Israel	National	Incubator	Public	Both	Water, LED lighting, biodiesel	R&D, Demonstration	Y
Kinrot Ventures	Israel	Global	Technology seed fund	Private	Adaptation	Water	R&D, Demonstration, Commercialisation	Seed capital
Precede Technologies	Israel & US	National	Technology seed fund	Private	Mitigation	Solar, wind	R&D, Demonstration	N
The Climate Technology Initiative's Private Financing Advisory Network	Japan	Developing Markets	Finance facilitator	Public	Mitigation	Clean energy, efficiency	Demonstration, Commercialisation	N
Japan CCS	Japan	National	Technology development and diffusion centre	Private	Mitigation	CCS	Demonstration, Commercialisation	Y
NEDO (New Energy and Industrial Technology Development Organization)	Japan	National	Technology development and diffusion centre	Co-financed	Both	Biomass, solar, battery, landfill, energy and water conservation, mini-hydro, clean coal	All	N
TTP Plc	UK	National	Technology accelerator	Private	Mitigation	Emissions reduction Emissions reduction	All	Y
Carbon Trust	UK	National	Climate innovation centre	Public	Both	Clean energy	All	Y
LIFE-IC	UK	National	Technology accelerator	Private	Mitigation	Low Carbon	All	Y
CGIAR, the Consultative Group on International Agricultural Research	US	Developing Markets	Centre of excellence	Public	Adaptation	Agriculture, bioenergy, water	R&D	N
African Rural Energy Enterprise Development	US	Regional	Incubator	Public	Both	Solar, efficiency, lighting	R&D, Commercialisation	Y
The ATI Clean Energy Incubator	US	National	Incubator	Public	Mitigation	Bioscience, clean energy, IT	Commercialization	N
Rutgers EcoComplex	US	National	Incubator	Public	Both	Water, landfill gas, recycling, anaerobic digestion, bioreactors, biodiesel, ethanol hydrogen, biomass gasification, CHP	R&D, Demonstration, Commercialisation	Y
Saratoga Technology & Energy Park	US	Local	Incubator	Public	Mitigation	Efficiency	R&D, Demonstration	N
MAREC	US	Local	Technology development and diffusion centre	Public	Mitigation	Efficiency, electricity storage	R&D, Demonstration	Y
CleanStart	US	Local	Technology accelerator	Co-financed	Mitigation	Solar, efficiency, ethanol, CCS, wind, fuel cells	R&D, Demonstration, Commercialisation	Y
Environmental Business Cluster	US	Local	Incubator	Public	Mitigation	Solar, wind, waste to energy, electric vehicles, biomass, efficiency, water management	Commercialization	N

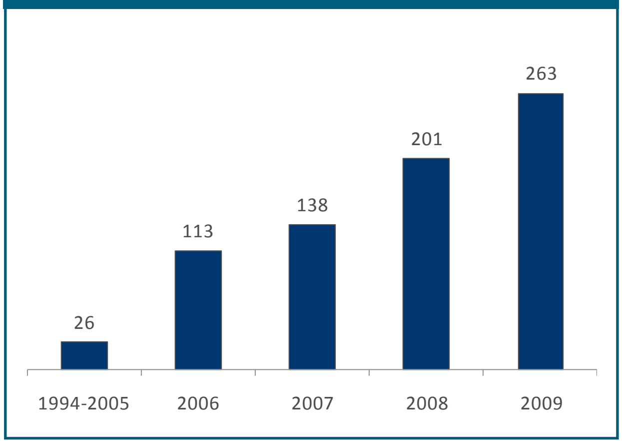
Note: HQ= headquarter. Y=Yes, N=No. 'Private' is defined as corporates and private investors. 'Public' is defined as governments (both national and foreign), government agencies and multilateral development programmes such as USAID, UNDP, UNEP, and etc. 'Funding' means whether a centre provides funding to portfolio companies.
Source: Bloomberg New Energy Finance

3 CASE STUDY: CHINA

Baoding National New and Hi-Tech Industrial Development Zone has incubated climate technology companies since 1992 with great success. Two of its best known graduates, Yingli Green Energy, a photovoltaic panel manufacturer, and HT Blade, which makes blades for wind turbines, now rank top in their respective industries. Between 2006 and 2009 the combined turnover of Baoding's incubatees more than doubled to 1.8 billion yuan ($266 million).

Baoding is the only development zone in China to focus entirely on climate technologies, and it now fulfils many of the functions of a fully-fledged CIC. Like many traditional incubators, Baoding supports all stages of innovation from R&D through to technology, product, deployment and diffusion, but unlike most, it also has its own venture capital firm that provides both debt and equity funding to incubatees. It is also tightly networked into government, universities and banks, and its work on patent protection, policy development and strengthening the local financial infrastructure make it an excellent illustration of how a CIC could operate in practice.

Figure 17: Baoding incubatees' turnover 1994-2009



Source: Bloomberg New Energy Finance

Baoding Development Zone aims to become 'China Electricity Valley', a high-speed development area that fosters 'new energy' industries to combat climate change – a kind of one-stop-shop for climate tech in China. The industries it supports currently include solar and wind generation, power transformation, storage and management equipment, and energy conservation.

The zone focuses on a few key proprietary technologies and this gives it a distinct competitive advantage, says Lian Shujun, vice-director of the Administrative Committee of the Baoding Development Zone. Others among China's 55 national development zones may generate more GDP by focusing on Original Equipment Manufacturing business (OEM, where foreign products are mass produced under licence), but Baoding should generate a higher rate of return.

Active funding approach

Baoding uses a wide range of funding techniques to support companies at different stages of development – even risking its own capital. At the earliest stage of incubation, the Zone offers unconditional financial assistance with no expectation of being repaid, simply to keep its start-ups afloat. The sums are not large – ranging from $74,000 to $147,000 – but can support a vital technology patent, or help a firm to survive its 'death period', says Lian.

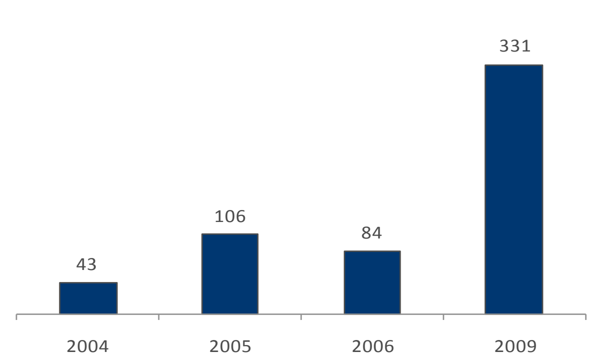
The zone has established a company called Baoding National New and High-tech Development Co. (BNNHD) to manage its own capital, seek necessary investment for incubatees from banks or governments, and to carry out the construction of production plants in the zone. BNNHD will invest in either debt or equity, and the largest amount that has been offered to a single incubatee so far is $4.4 million. The idea is for the Baoding Zone to take on the earliest and riskiest stages and replace itself with external investors once the projects have been established.

As firms start to grow, the Zone helps them to secure loans or venture capital to support production. Baoding has established long-term partnerships with several state-owned and commercial banks, and the banks regard this as a direct and reliable channel through which to meet potential new high-growth customers.

In order to strengthen investment conditions, Baoding has pushed banks to open branch offices in the Zone, along with investment funds and companies offering credit guarantees. Baoding has signed an agreement with China Development Bank to establish a financial service platform for small and medium companies, and will partner with Hebei Economic and Technological Investment Guarantee to secure loans for firms with growth potential.

Baoding has also solved the long-standing obstacle to debt financing in China, which results from the inadequate system for valuing intangible assets such as brands and patents. Since Chinese law on the appraisal of intangibles is weak, banks use a variety of different standards, and are usually reluctant to lend on this basis. But the Zone has coaxed banks to relax their limits if firms can offer guarantees in the form of any existing contracts. A firm can now secure a loan of 3 million yuan ($441,000) if it can show contracts worth 5 million yuan ($736,000), says Lian.

Figure 18: Patents won by Baoding incubatees 2004-2009



Source: Bloomberg New Energy Finance

At the same time, Baoding has worked to improve incubatees' understanding of the importance of copyright protection – which some have tended to neglect. The Zone has launched a fund offering subsidies to companies that take out patents – worth 2000 yuan ($295) for each domestic patent acquired, and ten times that much (20,000 yuan, $2954) for every foreign patent. Between 2006 and 2009, the number of patents secured by Baoding incubatees almost quadrupled to 330.

Government subsidies also play a significant part in financing climate change technologies at Baoding. The Ministry of Finance will provide an 'innovation fund' of 20 million yuan ($2.9 million) annually over three years 2010-13. The fund will be used for 20 projects to be selected by the Zone, with about 1 million yuan ($147,000) spent on each project. When Yingli was starting up, Baoding helped it secure a subsidy of 30 million yuan ($4.4 million) from the National Development and Reform Commission to help pay for a 3MW photovoltaic panel production line.

Another popular financing method is to encourage companies to issue shares on stock exchanges, either in China or abroad. Baoding's local government awards 2 million yuan ($295,000) to any firm that lists successfully overseas, and 1 million yuan ($148,000) to those that do so at home. Yingli is currently traded on the New York Stock Exchange, while HT Blade intends to launch an initial public offering in China to fund five projects.

Communication and co-operation

The Administrative Commission has recently placed greater emphasis on Baoding's Investment Promotion Bureau, which attends exhibitions every year to promote products and technologies developed in the Zone. Other divisions including Treasury, Planning and Construction have been established to help the Investment Promotion Bureau attract companies to Baoding. The Investment Promotion Bureau adopts a system called 'supervisory and agent' to avoid overlapping work among these divisions. For example, when a newcomer to the Zone arrives, the Investment Promotion Bureau can work as an agent to carry out all the necessary registration procedures on the firm's behalf, or alternatively, act in a 'supervisory' capacity and simply advise the firm on what actions to take.

Baoding has close relations with the Chinese government, and its incubatees have been active in the development of national policy on climate technology. Fine Silicon, a Chinese polysilicon maker and subsidiary of Yingli, took part in a symposium to draft standards for polysilicon manufacturing, for example, as did HT Blade for the wind turbine industry. This approach in turn gives the Zone and its clients the benefit of the 'inside track' on policy development. Zone officials also give presentations at renewable energy conferences.

Baoding also backed Yingli, and Chinese wind turbine maker Guodian United Power, to set up 'state key laboratories' for their respective industries. State key laboratories are intended to promote the integration of industry, schools and research institutes, and considered an essential part of the national technology innovation system. They are usually established under a university, but the Ministry of Technology chose Yingli and Guodian to host the laboratories because they would be better able to commercialise products than academic institutions.

The role of municipal government is also important. Baoding's local authority has issued several regulations to accelerate the development of China Electricity Valley (CEV) and encourage international businesses to invest in 'new energy' equipment manufacturing. For example, the Baoding will remove all the local government charges for newly-launched CEV projects worth more than 50 million-yuan ($7.4 million). Foreign firms will enjoy priority access to land leasing for renewable energy projects.

Baoding has close links into education as well as government, and recently signed deals with several local universities including Huabei Electricity University to ensure a good supply of vocational graduates. The municipal government has also signed an agreement with Beijing-based Tsinghua University, one of the top two universities in China, to arrange internships and full-time career opportunities in the Zone for graduates. However, Lian said it is difficult to retain senior professionals in the city, partly because incomes are so low – barely a quarter of the levels available in Beijing.

Lessons for Climate Innovation Centres

On the basis of the Baoding experience, Lian concludes that a successful CIC must focus not only on incubating climate innovation companies, but also on strengthening the local financial infrastructure to develop multiple financing routes for all stages of innovation; formulating renewable energy technology standards; and partnering closely with universities and government agencies to clear any remaining barriers. It should also be prepared to risk its own capital to back climate technology companies if necessary to fill funding gaps.

CASE STUDY: UNIDO-UNEP CP Programme

In 1994 the United Nations Industrial Development Organisation (UNIDO) and the United Nations Environment Programme (UNEP) launched a joint initiative, the UNIDO-UNEP Cleaner Production Programme. The aim was to develop a network of National Cleaner Production Centres (NCPCs) in developing and transition economies that would help them build the local capacity to implement cleaner production (CP) practices and technologies, to increase efficiency and reduce risks to people and the environment. As a major international network designed to promote CP in a wide variety of countries and industrial sectors, the Programme offers valuable lessons for the Climate Innovation Centre.

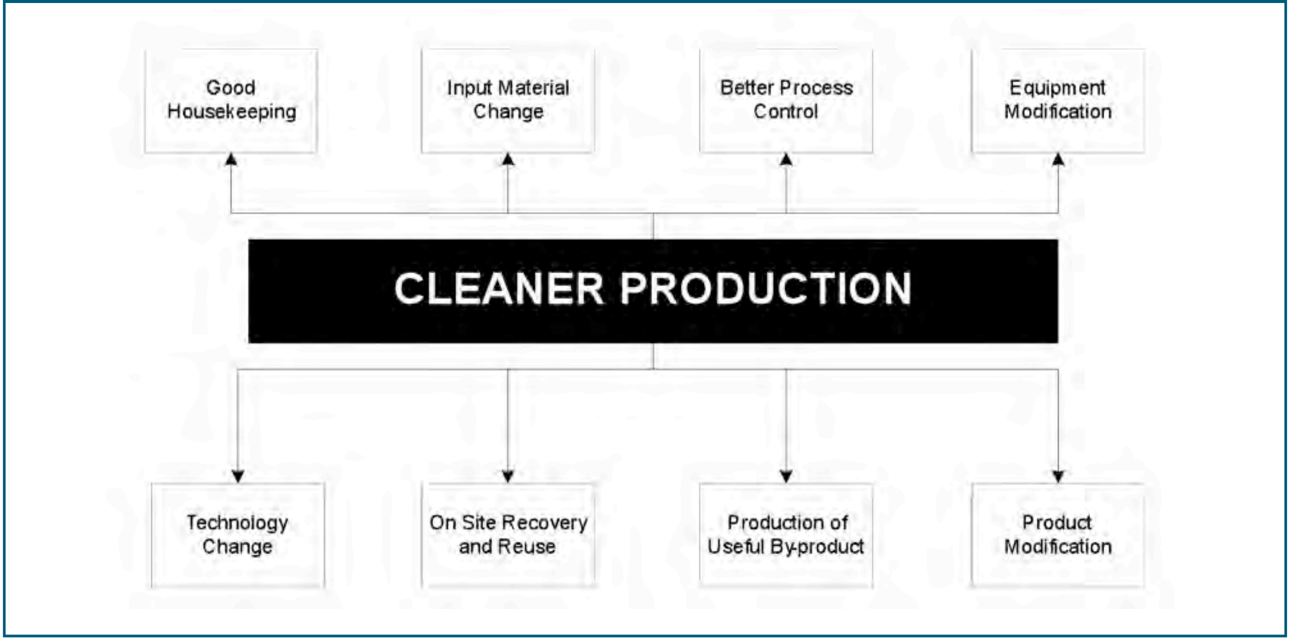
The initial aim of the Programme was to spread the use of CP practices and technologies in manufacturing industries – such as pulp and paper, textiles and leather, metal fabrication, and food and agriculture – through a series of National Cleaner Production Centres. These were later supplemented by National Cleaner Production Programmes (NCPPs), for countries with insufficient capacity to operate an NCPC, or countries where substantive CP expertise was already held in existing organisations. By 2010 Centres and Programmes were present in 47 countries (see Table 3 below), and the companies they helped typically implemented one or more of the CP techniques shown in Figure 19.

Table 3: UNIDO-UNEP National Cleaner Production Centres and Programmes worldwide

Africa and Arab Region (13)	Cape Verde, Egpt, Ethiopia, Kenya, Lebanon, Morocco, Mozambique, Rwanda, South Africa, Tunisia, Uganda, United Republic of Tanzania and Zimbabwe
Asia and Pacific (7)	Cambodia, China, India, Lao People's Democratic Republic, Republic of Korea, Sri Lanka and Vietnam
Europe and Central Asia (15)	Albania, Armenia, Bulgaria, Croatia, Czech Republic, Hungary, Montenegro, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, The Former Yugoslav Republic of Macedonia, Ukraine and Uzbekistan
Latin America (12)	Bolivia, Brazil, Colombia, Costa Rica, Ciba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Peru

Source: UNIDO

Figure 19: Common CP techniques



Source: UNIDO[17]

History and development

NCPCs were designed to be funded and guided by UNIDO and UNEP at first, and become administratively and financially independent from those organisations after 3-5 years[18]. They were initially expected to perform a relatively uniform set of functions. The stated core functions of the NCPC are:

1. **Information dissemination and awareness raising.** NCPCs developed and distributed promotional materials and delivered awareness workshops to put CP on the national agenda

2. **Training.** NCPCs created training programmes to teach professionals to help companies identify and implement CP practices

3. **CP assessments/in-plant demonstrations.** NCPCs provided direct technical assistance to companies, helping them to identify, evaluate and implement CP practices

4. **Policy advice.** NCPCs worked with governments and other stakeholders to identify and catalyse the adoption of strategies and policies that fostered uptake of CP practices

5. **Transfer of, and investments in, environmentally sound technologies (ESTs),** through activities including benchmarking, technology gap analysis, investment planning, and capacity building.[19]

However, over time the approach began to diversify, according to a comprehensive independent programme evaluation undertaken in 2007.[20] By then, the NCPCs were not pursuing the five stated functions equally, nor were they limiting their activities exclusively to these stated functions. Of the Centres for which information is available, 80% were engaged in only the first three of the five core services; just over half were providing policy advice; and just under half were facilitating EST transfer (Table 4). In addition, one third of the Centres were involved in non-core service areas, including support for corporate social responsibility, environmental impact assessments, life-cycle assessments, hazardous waste management, and research and development.

Table 4: Core services delivered by the 36 NCPCs/NCPPs

Service category	Centres active	Centres not active	No response
Information dissemination	81% (29)	8% (3)	11% (4)
Training	81% (29)	8% (3)	11% (4)
In-plant assessments	81% (29)	8% (3)	11% (4)
Policy advice	56% (20)	33% (12)	11% (4)
EST transfer	47% (17)	42% (15)	11% (4)
Other	36% (13)	50% (18)	14% (5)

Note: The number between brackets indicates the number of respondents in each category (N= 36)
Source: Adapted from (UNIDO 2008) [21]

In countries with a well established manufacturing sector, such as South Africa, Vietnam, Morocco, and Colombia, NCPCs have typically focused their CP assessment services to some three to five priority sectors, standardising delivery and increasingly the likelihood of impact through replication of well demonstrated successes. However, NCPCs in countries with a small manufacturing sector, such as Mozambique and Sri Lanka, have not been able to develop or maintain a clear sector focus.

The diversification in the Centres' focus could be interpreted as valuable flexibility, but also indicates "mission drift," since their original goal of spreading CP practices widely across the manufacturing sector of the countries where they operate has not yet been achieved.[22] While demand for CP services has risen, especially in China, countries have failed to implement CP practices systematically.

In 10 out of the 18 NCPCs reviewed in detail in 2007, 25% to 75% of all the CP options assessed through in-plant demonstrations — such as installing insulation on a heater — were implemented. This implementation rate can be considered reasonably high — the "CP options assessed" include all options considered, not just the options assessed as feasible or recommended for implementation by the NCPC. But the implementation rate in the remaining eight NCPCs was found to be below 25%.

The evaluation also found evidence suggesting this diversification had in some cases taken resources away from the provision of classic CP services, because of the small staff and limited funds of most NCPCs. This could imply an inefficient use of resources: if, for example, staff engaged in CP services are retrained to provide life-cycle analyses, their previous training in CP services is likely to be under-utilised.

Performance

In one sense it is difficult to measure the overall impact of the CP Programme because historically most did not collect data on 'real-world' outcomes, a task that is not trivial given the large number and types of interventions of the Centres. Most centres involved in delivering the top three core functions did have a system for measuring the output of their work, such as the numbers of people who came to seminars, people trained, and assessments performed, but they did not collect data on impacts, such as the number professionals active in CP following training, the implementation of the recommendations from the CP assessment, and the size of the environmental and economic benefits catalysed by the assessments.

The need to improve information collection on impacts at enterprise level is now well understood, and Programme management has developed a core set of environmental and resource productivity indicators, which have been tested by NCPCs in Kenya, Macedonia, Peru, and Sri Lanka.[23] But although company-level information is now increasingly being collected, there is still no assessment of the total benefit achieved by the Programme overall.

The evaluation was able to get a sense of the NCPCs' impact on policy. About two-thirds of the centres were engaged in policy advice activities linked to demonstrable policy change. The China NCPC, for example, made significant contributions to the 2003 China CP Promotion Law, which has created a system of mandatory CP audits for polluting enterprises and sector-specific CP technical guidelines. The NCPC in Sri Lanka also contributed to the National CP Strategy, which makes all ministries responsible for developing and implementing CP strategies.

However, in a few cases such as Costa Rica, Nicaragua, and Peru, some significant efforts of NCPCs to advocate CP-conducive policy change have achieved little impact. In all countries, the information regularly gathered on activities and impacts relating to government policy advice was minimal, and Centres may benefit from a more strategic approach.

About half of the Centres evaluated in 2007 had made contributions to technology transfer, mostly through activities such as advising governments on standard setting, information dissemination, and capacity development. There were fewer examples of bottom-up technology transfer, where the Centre aided the import of best available process equipment by developing or transition economies. One example of this was in Morocco, where the NCPC pioneered the introduction of the two-phase pressing of olives, which allows a higher oil recovery, the use of olive pressings as a biofuel, and the reduction of waste water and waste.

There were few examples of capital-intensive technologies being implemented, partly because of the difficulty in raising funds. In response to this gap, some countries have tested different financing mechanisms to support the implementation of medium-cost CP technologies. For instance, the Swiss-funded SECO Green Credit Trust Fund has worked with NCPCs and local banks to part-finance projects[24], most notably in Colombia, Peru, and Vietnam. This approach has not yet been replicated, but since many CP investments have good rates of return, further cooperation between NCPCs and financial institutions is to be encouraged. NCPCs do not generally pursue R&D in CP technologies, but Mexico is a notable exception.

The 2007 evaluation confirmed the Programme's success in: (a) putting CP on the agenda of business and government; (b) training of CP professionals; (c) implementing low- and intermediate-technology options in assisted enterprises; and (d) catalysing technology transfer and policy change in selected sectors and countries. It also identified a range of options for improvement. In response, UNIDO and UNEP reformulated their programme and launched in 2009 the joint Resource Efficient and Cleaner Production (RECP) Programme, to address the points listed above and others.[25]

Lessons learned

The NCPC experience offers several key lessons for the development of Climate Innovation Centres.

1. The design of multinational institutions must take account of local conditions. When there are significant differences between host countries, standardisation in centre design — whether NCPC or CIC — is unlikely to last long.

2. Combining policy advice with other services can lead to a virtuous circle. In some countries where NCPCs contributed to national policymaking, the result was increased demand for CP services, improving the centres' prospects for long-term sustainability.

3. Formal structures to ease the flow of information between a programme and its centres — especially once they become self-sustaining — is vital to accelerate the diffusion of best practices throughout the network.

4. Centres should systematise the gathering of data on their 'real world' outcomes. In the past, NCPCs have tended to measure their outputs but not their impact, although the Programme is taking steps to improve in this area. CICs should apply this lesson from the outset, since gathering accurate data about impacts will allow them to become more effective and take advantage of new opportunities.

5. Centres with a mandate to help companies obtain financing for implementing advanced technologies and process modifications will require not only additional training for their staff, but also a financial community with the willingness to provide credit for profitable CP investments.

CASE STUDY: BRAZIL

Centro de Inovacao, Empreendedorismo e Tecnologia, or CIETEC, is the largest incubator in Latin America and one of the most successful in Brazil. Although it covers a range of sectors, CIETEC's focus has shifted recently, says International Business manager Oscar Nunes, and the centre now hosts some 20 climate technology companies, more than any other incubator in Latin America. With a clutch of renewable energy success stories in its portfolio - including wind, hydro, solar hot water and fuel cells - CIETEC offers valuable insights for the CIC.

Founded in 1998 with funding from government microfinance programme SEBRAE, CIETEC is a 'full-service' incubator that provides assistance to companies at all stages of innovation – from R&D through technology and product to deployment and diffusion. Based in the Nuclear Research Institute (IPEN) of the University of Sao Paulo (USP), the centre provides incubatees with office space, laboratory use, and consultancy services at heavily discounted prices. It also helps to arrange financing from public and private sources, and is thinking about creating its own investment fund. The centre has grown rapidly in recent years, and is building a Technological Park to house post-incubation firms, with 11 already in residence as construction continues.

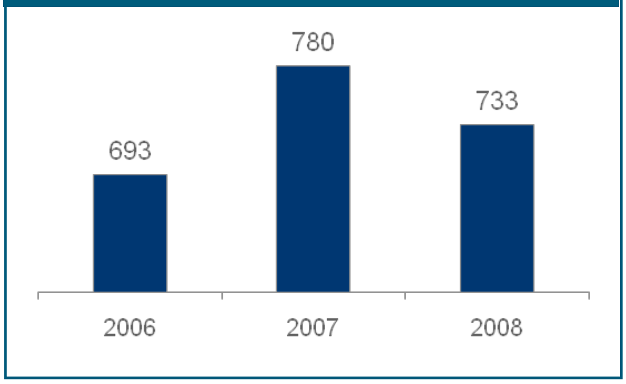
Measuring success

The CIETEC model is proving successful on a wide range of measures. In its first decade, the number of companies under incubation has grown from 15 to 140, of which 28 have secured patents for their technology, while another 49 have applied for one. For comparison, Brazilian companies registered 585 patents in 2006.

The revenues of incubated companies rose from under BRL 30m in 2006 to BRL 40m in 2009, while funding from state support agencies such as SEBRAE, FAPESP and FINEP tripled over the same period (see Figures 20 and 21). CIETEC also helps its incubatees secure private sector equity investment – rising to BRL 10m in 2008. That same year its portfolio companies created 733 new jobs and exported goods worth almost $100,000.

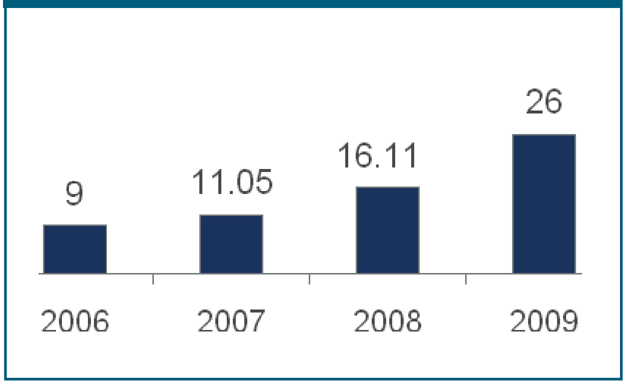
CIETEC's success rate is also impressive: while 75% of Brazilian start-ups fail within three years, for CIETEC companies the rate is just 30%. And the centre's work clearly represents value for money: according to its 2008 annual report, for every BRL 1 the government furnished CIETEC companies with, it received BRL 6.72 in taxes. A total of 90 innovation companies have already graduated from CIETEC, of which some 30 continue to be associated with the centre, and achieved revenues of BRL 24m in 2008.

Figure 20: Jobs created by CIETEC incubated companies



Source: Bloomberg New Energy Finance

Figure 21: CIETEC incubated companies' funding from agencies (BRL m)



Source: Bloomberg New Energy Finance

Among CIETEC's biggest climate technology success stories is Eletrocell, which has developed a fuel cell to produce hydrogen from sugarcane ethanol. CIETEC helped Eletrocell secure funding from FINEP and FAPESP, power distributor AES Eletropaulo and a venture capital fund, and the company went on to win an award from the Brazilian National Confederation Industry. Electrocell is now in the later stages of incubation and could soon move into CIETEC's new Technology Park.

Another success story is Care Electric, which developed a run-of-river hydro turbine that, unlike all similar-sized projects, does not require a reservoir. CIETEC helped the company apply for grants, and it went on to become one of 26 companies to win the coveted title of 'Technology Pioneer' from the World Economic Forum in 2010. Since then Care Electric has been inundated with approaches from potential customers and investors. One of the company's founders, Edson Abuchaim Marques Figueira, told us the funds would soon be used to start commercial production of the technology.

Sociedade do Sol is an NGO that has developed a low cost solar water heater that can be supplied to low-income families for less than $150 per dwelling. The project was started in 1999 with funding from the Sao Paulo-based research foundation FAPESP, CNPq, an agency of the Ministry of Science and Technology and FINEP, the state-run innovation grant and soft-loan provider, facilitated by CIETEC. Sociedade do Sol estimates its system cuts emissions from a typical house by 541kg of CO_2e per year. The organisation continues to distribute the water heater, has released guidance notes on the internet for people who want to build one themselves, and is developing a solar oven and a home water recycling system. Other CIETEC graduates, including Lotus Quimica Ambiental, RB Recursos Hidricos and Engenharia Ambiental e Meio Ambiente, have also developed water conservation technologies.

How they did it

CIETEC's success is founded on a rigorous selection process, conducted three times a year. Proposals are first evaluated by university professors in the relevant specialism for technical and business feasibility. Companies that pass this test are put through a two-week course to help draw up a business plan, which they must then present within a month. Typically 25 applications are received in each round, of which roughly half are successful.

Once selected, incubatees receive extensive training in accounting, administration and managing staff. Companies are obliged to attend networking events and present their projects at or on the sidelines of conferences. "Usually these people are engineers and excellent at developing technology but not endowed with the necessary marketing and people skills to run a business," Nunes said. Companies that develop technology successfully but fail to market it well are asked to leave.

Technical help from the University's various scientific departments is also vital, along with access to low-cost laboratories. Sao Paulo University is the best known academic institution in Brazil with excellent resources, and home to technology research institution IPT. This allows technology transfer between the University's R&D and CIETEC companies, helping to overcome technology gaps.

CIETEC also has strong relationships with other incubators, and is the flagship of a 10-strong Brazilian network called RAITEC. Also based in Sao Paulo, RAITEC offers training, lectures, conferences and newsletters to spread best practice among its members, and raise their success rate. CIETEC, as the network's largest member, is a regular presenter at such events.

One intangible benefit to incubatees is the presence of the CIETEC logo on their business cards, which reassures prospective investors that this firm has at least managed to pass CIETEC's rigorous selection process. CIETEC member companies "are automatically given a competitive advantage for funds," Nunes said.

Funding

Funding is of course fundamental to successful innovation. Around 90% of CIETEC incubatees (126 firms) rely on public funds, which comprise government grants and subsidised loans, while the rest (14 firms) are completely funded by private capital. The centre's role in securing both is pivotal.

Applying for public sector funds in Brazil can be complex and bureaucratic, and CIETEC guides companies through the process, alerting them when funding rounds are coming up, and making sure their business plans are robust. Virtually all state funding comes through four organisations: FINEP, FAPESP, CNPq and CRIATEC, the venture capital arm of national development bank BNDES.

These funding bodies generally provide grants and soft loans, but FINEP also pays the cost of patent registration for all incubatees in the RAITEC network. Unlike the other state-owned funders, CRIATEC will take an equity stake in young companies and sell out once they have become commercially established. Commercial bank lending is almost unheard of, however. "A much more common strategy is to strike up equity investments from private companies," says Nunes.

Funding for R&D is still difficult in Brazil, where spending on science and technology is 1.15% of GDP, barely half the 2% spent by OECD countries. So CIETEC is thinking of creating and managing a fund through which outside investors could buy shares in a portfolio of its most promising incubatees.

Because early stage funding is difficult in Brazil, CIETEC has plans to launch a $57 million stock market mutual fund through which investors could buy shares in a portfolio of the most promising climate innovation companies. The fund would focus wholly on climate technologies – a first for Brazil - but would take a multi-sector approach. It would concentrate on the seed and venture capital stages, helping to commercialise technologies after the basic R&D has been completed, and work with CIETEC and other incubators to select the best projects.

Marcelo Colonno, a consultant to CIETEC who is helping to design the fund, says this approach will have a number of benefits. It will provide targeted funding for climate technologies; bridge the cultural gap between entrepreneurs and investors; and help Brazilian start-ups keep control over their technologies rather than sell out to multinationals. "Our mission is to keep Brazilian technologies under Brazilian control as far as possible", says Colonno, "and so generate jobs and exports"

CIETEC covers half its costs of BRL 1.5m with revenue from the companies it incubates, who pay a monthly fee to use CIETEC premises, and 2% of their annual income for a period of time after they graduate, depending on the length of their incubation. The other half is funded by SEBRAE. CIETEC is mulling increasing its commercial income by charging a fee to every investor who takes a stake in one of its incubatees that turns a profit.

Lessons learned

Since three quarters of start-ups fail at the first hurdle, but 70% of CIETEC's succeed, it is clear the centre is doing something right. This judgement is also supported by the fact the presence of the centre's logo on incubatees' business cards helps them secure funding. CIETEC attributes its success to its rigorous selection process; intensive training programmes; close links to the University, which allow technology gaps to be filled; membership of an extended network of incubators; and the presence of an array of state institutions prepared to fund the bulk of its incubatees, in a region where access to finance is limited and can be bureaucratic. One disadvantage is that, unlike in the US, incubated companies do not receive significant tax breaks from the government.

The Consultative Group on International Agricultural Research (CGIAR, CG for short), established in 1971, is a strategic partnership of diverse donors that support 15 international centres, working in both developing and industrialised countries, in collaboration with governments, NGOs, businesses and private foundations. In 2009, CGIAR expenditures amounted to $572 million, the single largest investment made to mobilize science for the benefit of the rural poor worldwide

CASE STUDY: CGIAR

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History of CGIAR

The CG started as a 'loose association of autonomous research Centres and independent donors[26]' in response to widespread concern about food insecurity in developing countries. The basic objective of the CG at the time of its establishment was to improve sustainable food production in lesser developed countries through international agricultural research, in order to raise the nutritional level and general economic well-being of their low-income peoples. The immediate target population was the rural poor - low-income, semi-subsistence farmers - and the mandate was to overcome technological constraints so as to increase output of agricultural commodities. The CG was built on four existing international agricultural research centres that already had been established in different parts of the world with the support of the Ford and Rockefeller foundations. As a result, the CG focused initially on breeding improved cultivars of the dominant staple grains – rice, wheat and maize – for the smallholder farming systems under which these and other staples are grown in the South, and on how to manage the soil, water and genetic resources that support their productivity.

In the 1980s, the CGIAR strove to maximise the impact of agricultural research on alleviating hunger and poverty among rural producers and urban consumers; enhance national policy and research capacity to leverage international research inputs; and ensure the conservation of the natural resources upon which sustainable and equitable rural development depends. In the 1990s, the CGIAR expanded its effective definition of agricultural research to include forest and fishery management, agro-forestry, and aquaculture.[27]

While many of the original CG centres have clearly played an important role in agricultural development they have increasingly come under criticism as not being truly fit for purpose in an era of rapid globalisation.

Shortcomings of CGIAR approach

CG centres have tended to take a 'science push' approach, and failed to engage with technology development in practice. One historical example is the case of ILRAD (the International Laboratory for Research on Animal Diseases, now merged into ILRI, the International Livestock Research Institute). Here, a deliberate decision was taken to concentrate exclusively on a science-centred bovine immunological approach to certain livestock African diseases, as opposed to a broader animal health approach. This narrow focus on the development of a vaccine, which turned out to be unsuccessful, rather than on livestock problems of the poor, ultimately limited the effectiveness of the programme. Examples such as this suggest that traditionally structured scientific organisations need to change their operations if they are to effectively fulfil developmental mandates. And they need to do so by being much more institutionally innovative.

The key issues that have limited the effectiveness of CGIAR may be summarised as follows:

1. Technology push: CG centres have consistently seen themselves as strategic research bodies separate from actual development activities. In other words, they produce generic technological solutions for agricultural development but the actual implementation of these is not held to be their responsibility even where downstream bodies may need their assistance. In the case of the Africa Rice Centre (WARDA), for example, the centre refused to ensure brand quality after sending out foundation seed, which allowed unscrupulous dealers to adulterate bag content, which, in turn, reduced consumers' confidence in the product.

2. Incentives: The CG governance structures provide incentive systems to buttress the 'science push' approach. That is their Science Council behaves very much as a traditional science regulatory body, valuing mainly straight scientific outputs such as publication of peer-reviewed papers in international journals.

3. Partnerships: Although many institutes are happy to act as partners in development ventures these tend to be peripheral to core business.

4. Scientific Focus: There is a strong tendency to employ mainly biological scientists to work on specific problems of agricultural science. At the same time links with international best practice in Northern universities and research institutes tend to be weak. Social scientists are now recruited but these are likely to be economists who are inclined to carry out narrow research.

5. Interdisciplinarity: Little attention is paid to building linked cross-disciplinary capacity in centres. Inevitably concentration is on disciplinary analysis of a narrow issue since this leads more easily to acceptable science publications. Often projects are chosen for precisely this reason.

Potential for success

Yet a number of examples illustrate the significant potential for success if the CG mandate is appropriately broadened. The case of the IRRI, the International Rice Research Institute, its Poverty Elimination Through Rice Research Assistance (PETRRA) programme emphasised people rather than technology and focused on capacity strengthening, development of participatory skills and poverty analysis alongside the 'core business' of supporting rice research in Bangladesh. This encouraged the best researchers to engage with the demand side and frame their research in terms of innovation.

Similarly, the Papa Andina Network of the International Potato Centre, funded by a number of donors, supports institutional decentralisation and regionalisation through a network of partners in Peru, Bolivia, and Ecuador. Papa Andina has facilitated 'collective learning' among its partners in order to share experiences and refine approaches, therefore building network-wide capacity. This has included the development of the Participatory Market Chain Approach (PMCA), multi-stakeholder platforms that link farmers and providers of agricultural support services, and a set of methods for gauging smallholder demand and tying this with the supply of technology.

In India, ICRISAT (International Crops Research for the Semi-Arid Tropics) understood that in order to meet the demands of the farmers in the country, the private sector must become an active research partner, a source of funds, and a distribution network for ICRISAT's products. This was achieved through the creation of a new institutional mechanism which meant multiple companies could participate in a consortium that coordinated private funding for ICRISAT and also helped share materials and results. This public-private partnership benefited both sides: the private sector got access to new seed varieties that would meet market demands; the Centre received research grants to support the innovation process.

Lessons learned

There are some wider lessons to be drawn from the CG's experiences:

1. Simply 'following the CG model' is not feasible, partly because there is a no simple, single model – different CG centres have followed different models that have evolved over time and have had mixed results.

2. Successful dissemination of a technology also requires partnerships and networks with a range of organisations that engage in mutual learning through shared experiences. While public-private partnerships can be a great vehicle for the development and deployment of technologies, the institutional arrangements need to be thought through and designed carefully. While such partnerships have the potential to increase the efficiency, the results of the partnerships are highly dependent on their objectives and on the distinct accountabilities and obligations of the partners. [28]

3. Strong National Agricultural Research Systems (NARS) are critical to ensure CGIAR's impacts.[29] These NARS are essential for testing, adapting and disseminating the products of CGIAR research.

4. Since there is no widely accepted view of what precisely a climate technology innovation centre might look like, it is probably best to focus on building institutional capacity to enable developing countries to respond flexibly to climate change challenges rather than around a specific approach or project.

However the main lesson from the CGIAR experience must be that CICs cannot be seen simply as 'technology providers', and their role must involve meeting the needs of the local population. In order to achieve this, their work programme needs to go well beyond technical research and focus on understanding local social, economic and institutional contexts that will determine the uptake of the technology. Institutions that do not have commercialisation at the heart of their activities, and are principally based around 'technology push', cannot be seen as a useful model for CICs.

CASE STUDY: INDIA

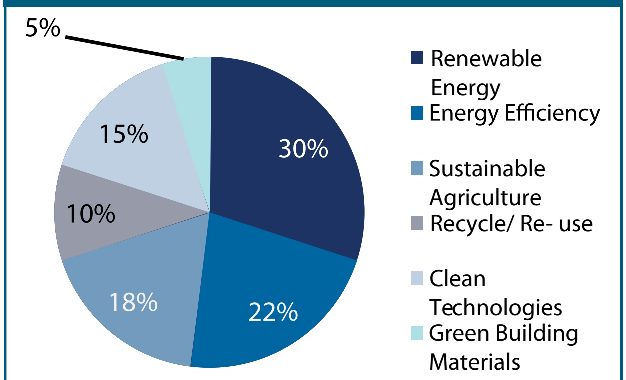
New Ventures India (NVI) was founded in 2005 by the World Resources Institute (WRI) and the Confederation of Indian Industries (CII) as a not-for-profit programme to bridge the financing gaps between investors and young companies. NVI is distinctive in that it focuses wholly on climate technologies, but does not support the very earliest stages of innovation. It considers itself an enterprise accelerator, intended to support companies that already have a commercial product but need funding in order to grow. It is one of six New Ventures projects run by WRI with local partners around the world, and its extensive local and international networking is a key feature of an approach that could be instructive for CICs.

Because NVI supports small but established companies seeking funds for expansion, it operates as a 'virtual' incubator - meaning incubatees are not housed in NVI buildings but in their own. As well as offering the usual training, consultancy and investor matchmaking services, NVI works to clear barriers to investment by developing new relationships and funding techniques with local banks and international investors. NVI's networking also serves to increase the flow of entrepreneurial companies into the incubation pipeline, which it identifies as the other major constraint to climate innovation in India.

Every year NVI evaluates around 150 business plans from companies engaged in renewable energy, green buildings, water technologies, sustainable agriculture, energy efficiency, recycling and eco-tourism, and selects only 10. So far all of its incubatees have survived and many have thrived. Currently the centre supports 40 companies, of which 14 have secured private sector funding – totalling $28 million between 2007 and 2010.

NVI's biggest success is Nandan Biomatrix, a jatropha-based-biodiesel company that has secured four patents for its technology and won seven business awards, and which has increased its turnover four-fold to $20 million in as many years. Others include Husk Power Systems, whose equipment generates electricity from rice husk, and now supplies power to 50,000 villages from 12 plants and employs 50 people. HMX Sumaya, a maker of energy efficient air conditioning, was bought out by ATE Enterprises and no longer needs external financing.

Figure 22: Distribution of NVI incubatees by sector



Source: Bloomberg New Energy Finance

Partners and networks

NVI modestly attributes much of its success to rigorous portfolio selection and the fact it mentors companies that are already in business, which reduces risk. But we believe much of its success is also due to its emphasis on developing partnerships and networks. This helps the centre reach beyond the traditional functions of an incubator and begin to tackle the main barriers to climate innovation in India: constraints on funding and a dearth of good quality entrepreneurial companies.

Because its parent organisations are WRI and CII, NVI has been plugged into extensive networks from birth, but it has since developed many more, which it exploits in a number of ways. Its partners and networks include:

- WRI and CII: NVI works closely with both parent organisations when selecting incubatees. As an industry association CII lends great credibility to NVI.
- WRI New Venture network: NVI also works closely with sister centres in Brazil, China, India, Mexico, Indonesia, Columbia to improve services through shared learning.
- NVI "Coaches Network": Mentoring of NVI incubatees is conducted through a network of experts and entrepreneurs created by the centre.
- Incubators network: NVI has links with physical incubation centres such as CIIE, RTBI, NSRCEL, and ICRISAT, which it uses to source new incubatees. For example; EnNatura, developers of ecofriendly inks, started in IIT-Delhi and are now under the NVI portfolio.
- NVI also partners with NGOs such as YES, Youth for Entrepreneurship Sustainability, and collaborates with entrepreneur networks such as TiE (The Indus Entrepreneurs).
- Investor networks such as Private Financing Advisory Network (PFAN).
- Banks such as ICICI, YES Bank and others. NVI has worked with several banks to develop financial products and business models. For instance NVI worked with IDBI and Axis banks to provide loans to support the Energy Service Company (ESCO) model, and with YES Bank to develop loan guarantees.

- R&D centres, such as ICRISAT, where NVI arranged for Nandan Biomatrix to develop its jatropha plants for biodiesel production.

Funding issues

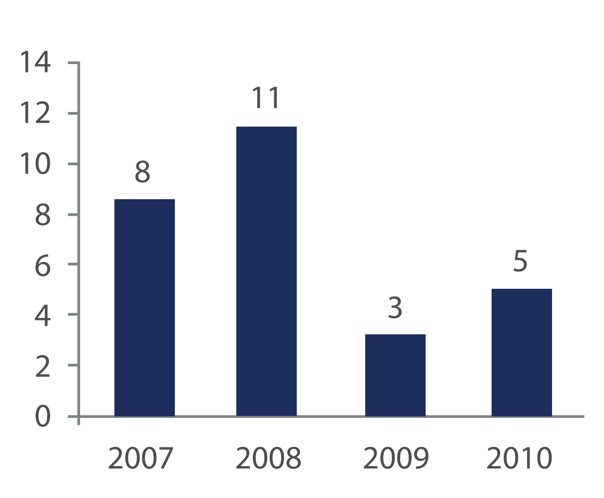
Funding climate technologies has remained difficult in India since 2008, when the global financial turmoil reinforced the difficulties that already existed. Early stage financing from individual investors and pension funds remain untapped. Public procurement from climate technology companies is uncommon. Buyouts are possible – HMX Sumaya Systems, maker of eco friendly air-conditioning, was bought out by ATE Enterprises in 2008 – but not frequent. And at the moment there are no tax breaks available to start-ups.

Since 2008, venture capitalists (VCs) have been reluctant to take on technology or contract risk, and are only willing to invest once a company has already secured paying customers for its products. Of 40 companies in the NVI portfolio, 14 have secured financing, and the rest are either very young or still looking for funding.

Since VCs are reluctant to provide funds, NVI has started to concentrate on Seed or angel funds – usually the first source of external finance - and is also talking to overseas investors to join its network for promoting young companies.

Earlier stage incubatees can also draw on funds sponsored by Technology Development Board (TDB), which provides funds for proprietary technology commercialisation through grants and soft loans. Oriental Aquamarine received TDB funding before being take on by NVI.

Figure 23: Funds received by NVI portfolio companies ($ millions)



Source: Bloomberg New Energy Finance

For later stage companies, NVI is also working with banks to roll out alternative business models better able to secure funding. For instance, the centre has signed an agreement with Axis Bank and IDBI Bank to promote the ESCO model, where the ESCO supplies energy saving equipment to its clients for no upfront charge, and is then paid a share of the resulting financial savings during the lifetime of the investment. Such contracts allow the ESCO to secure bank loans to fund the initial investment if necessary. Two NVI incubatees, GreenTech Aqua, which uses waste heat to turn sea water into drinking water, and Kakatiya Energy Systems, which makes lighting switching and dimming equipment, are considering this model.

Another mechanism promoted by NVI to make bank lending possible is the partial credit guarantee. After studies by NVI, USAID and YES Bank have agreed to collaborate to provide loan guarantees up to 50%, which reduces the risk for financing institutions and means the collateral required is smaller.

NVI's operations are supported by funds from USAID and UK Foreign and Commonwealth Office (FCO), and it also raises funds by organising conferences and events for finance houses such as CITI Foundation and ICICI Bank. It has started to take on commercial consultancy work, and is thinking of charging fees to investors and incubatees, who currently receive its services for free.

Lessons learned

In India, where most of the SME's die within the first three years, NVI has done well to incubate so many companies and is working hard to improve the environment for climate technology companies. Much of its success has been achieved through strong partnerships and networks, which have allowed the centre to develop workarounds to some of the many barriers to innovation.

Funding remains difficult, however, and India is still short of risk capital at all stages of the innovation process. This is not only the result of the weakness of the local financial infrastructure, but also the absence of strongly supportive government policy. The flow of risk capital could be much encouraged by measures such as government grants, soft-loans and tax incentives for investors, and yet NVI has not been involved in policy development.

The NVI experience suggests that building partnerships and networks will be a key strategy for CICs, but in countries where the policy framework is weak, this will be necessary but not sufficient to achieve the necessary progress in climate innovation. In such countries, market analysis, policy development, and advocacy will also be vital functions of the CIC.

4 PAYING FOR CLIMATE TECHNOLOGY INNOVATION

Funding climate technology innovation is difficult even in the developed world simply because it is inherently risky. In the developing countries, on the evidence of our survey and case studies, it is harder still. We found not only a pervasive shortage of risk capital at all stages of innovation – though particularly at the earliest, riskiest stages – but also that three quarters of relevant organisations did not have the means to help their portfolio companies gain access to private capital.

These problems have led a very few forward-looking centres to launch or plan their own special purpose funds – discussed below – but finance remains one of the most obstinate barriers to climate innovation. This suggests funding issues will be a core concern for future CICs, demanding a clear understanding of the process, barriers and potential remedies.

In this section we explore the full range of conventional financing methods currently available in developing countries, along with some newly emerging techniques, and suggest a method for evaluating which are the most appropriate in a range of different circumstances.

BOX 6: A GUIDE TO THE JARGON

Seed capital is a small amount of equity capital used for businesses in the idea or conceptual stage, and is often supplied by friends and family, universities, incubators, and government programmes.

Angel capital fills the gap in start-up financing between seed capital and venture capital and is provided by wealthy individuals.

Venture capital is often provided as growth capital, after seed and angel capital, and seeks to generate a return through an eventual realisation by IPO (Initial Public Offering) or trade sale to another company. For this reason venture capital tends to invest in technologies close to commercialisation or deployment.

Private equity is private capital that seeks to invest in companies expected to enjoy high growth from scaling up their businesses and thus tends to invest in technologies at the latest stages of innovation.

Soft Loans are loans with a below-market rate of interest, provided by state-owned commercial banks and multilateral financial organisations.

Proof of Concept grants are usually supplied by developed world governments via multilateral organisations at the pre-company stage to prove that an idea, invention, process, or business model is feasible.

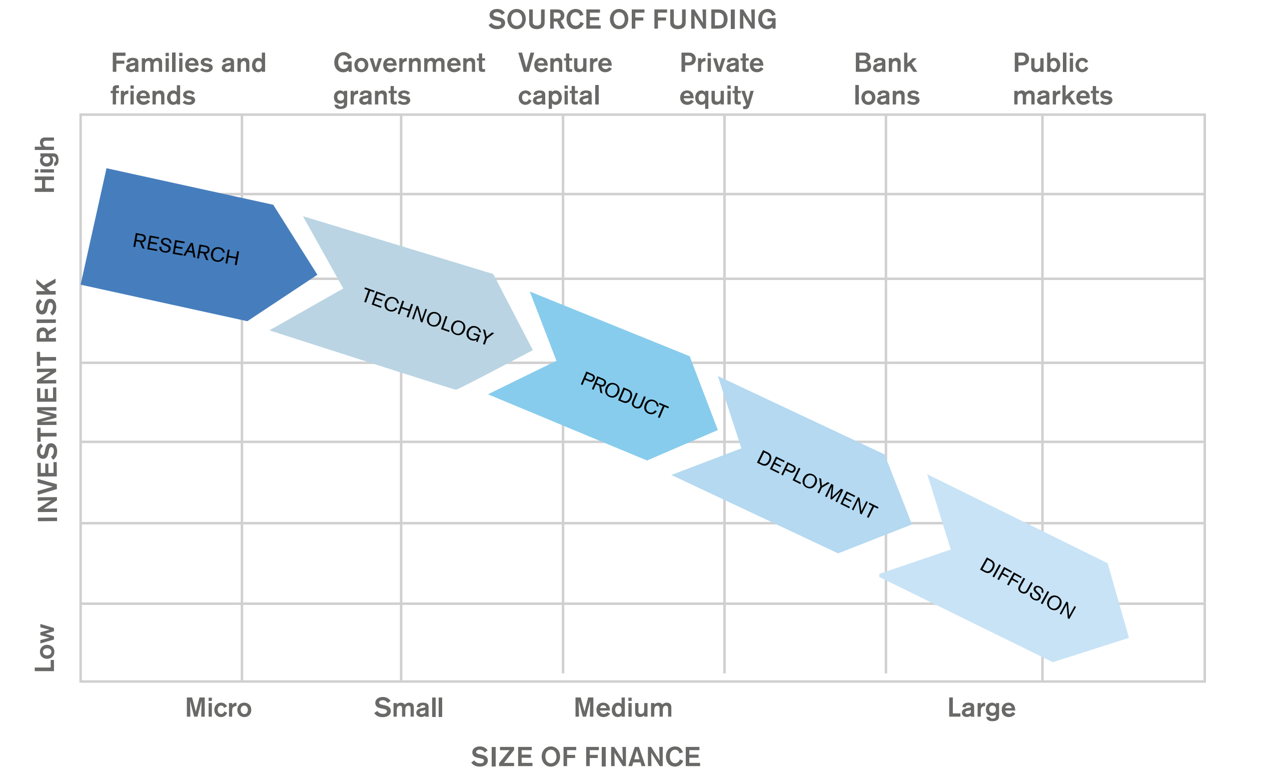
CONVENTIONAL FINANCING SOLUTIONS

Stages of innovation

Our study, which included an international market survey and interviews with dozens of incubators and investors, shows the most popular financing options for climate innovation in developing countries are: government grants; free offices, laboratory facilities, research staff; tax breaks and subsidies; venture capital; private equity; public markets; and bank loans (mainly soft loans).

The choice of financing technique is primarily determined by the stage of innovation because the various stages – from R&D through to commercialisation to diffusion of products in the market – have different risk profiles and different funding requirements, which in turn demand different types of financiers. Generally speaking, as the innovation process advances, the level of risk falls but the size of investment required rises. This leads to a tight correlation between stage of innovation, source of funding, and investment size – but driven by the stage of innovation (see Figure 24).

Figure 24: Interplay between stage of innovation, source and size of funding, and investment risk

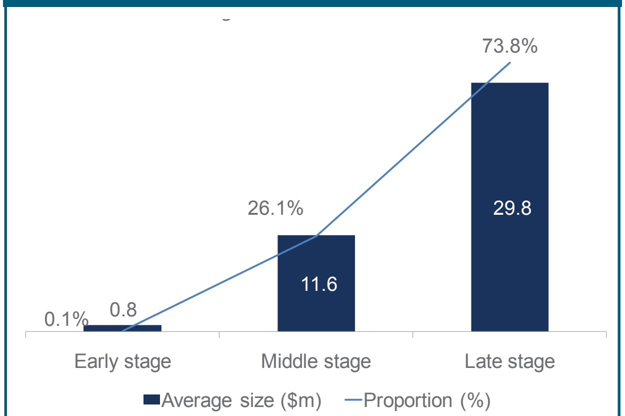


Note: Technology transfer between regions or markets can happen at any stage of innovation
Source: Bloomberg New Energy Finance

Most early-stage climate-tech innovation companies are risky investments simply because, at this stage, it is always uncertain whether the technology will prove viable. As a result, early-stage financing usually relies on government funding – grants, and help in kind such as subsidised office space and laboratory facilities – since governments are willing to fund these services to develop new industries and create jobs. However, public funding in the form of tax breaks and subsidies cannot deliver early-stage funding since companies are not yet generating revenue.

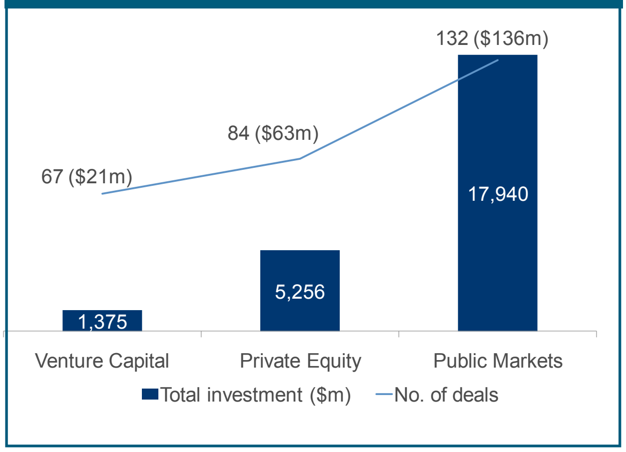
Early stage innovation companies cannot generally draw on bank loans because at this stage they have no significant tangible assets to pledge as collateral. Nor can they access venture capital (see Box 6), which shuns investments with high risks and uncertain returns (as illustrated in Figure 25, which shows that just 0.1% of the total VC investment went into seed capital in the clean-energy sector of developing countries over the past six years).

Figure 25: Proportion and average size of venture capital investment at different investment stages: 2004-2009



Source: Bloomberg New Energy Finance

Figure 26: Total investment in clean energy by asset class: 2004-2009



Note: Values in the brackets denote the average sizes of deals in each category. Source: Bloomberg New Energy Finance

In the middle-to-later stages of innovation, as the risks decline and funding requirements rise, VC becomes more active. Some 26% of the total venture capital invested in the clean energy sector over the past six years has gone into middle-stage companies, while the remaining 74% has supported late-stage companies. Some 45% was committed to pre-IPO investment, the last round of investment in the innovation process by our definition.

Bank loans become a potential financing option for middle-stage companies, although significant difficulties remain, because they may still lack collateral or revenue. Late-stage companies find it easier to secure bank loans, but may not be able to afford interest rates on standard commercial loans. Therefore, soft loans with lower interest rates and more flexible repayment time become the major form of financing for late-stage climate-tech innovation companies. This is particularly true in Brazil where the average commercial interest rate is currently as high as 25.5% (see Case Study on page 38).

Still further down the innovation track, private equity and public markets provide large amounts of capital to fund large-scale climate technology deployment and diffusion. The funding they provide dwarfs that from venture capital – by four and 13 times respectively (see Figure 26). But this is to be expected since by this stage funding requirements are much higher.

However, if the 'exit' route of a stock market IPO is not readily available, then investment in early stage suffers as investors retrench. When the rules imposed by China on companies wanting to float on overseas stock markets were made more complicated in 2006, VC investment in the country's clean energy sector collapsed from $468 million to $137 million in a single year.

Although private capital prevails in late-stage innovation, public sector funding can remain important in the form of tax breaks and subsidies for companies that are by now generating revenue.

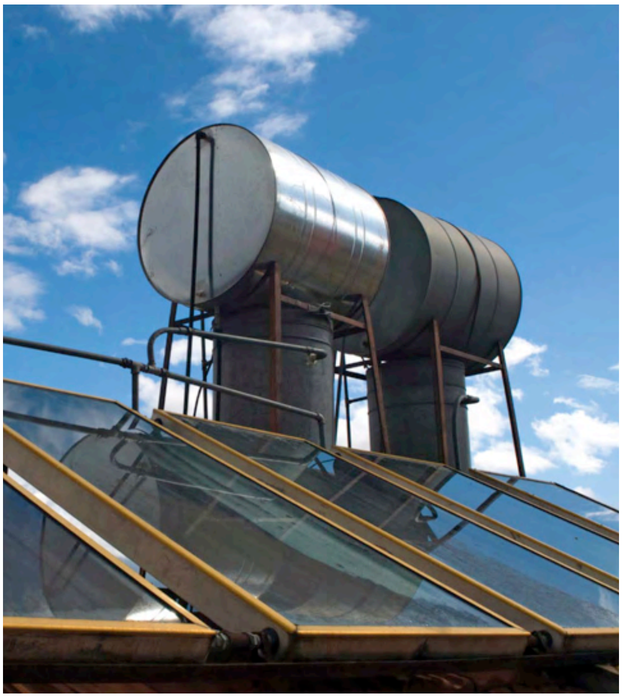


Table 5: Selected financing deals of different sizes

COMPANY	SIZE ($M)	SIZE TYPE	FINANCING TYPE	TECHNOLOGY	DATE	COUNTRY
d.light design	0.25	Micro	Early-stage VC	Solar and LED lighting	Q2 2007	India
Naturol BioEnergy	12.7	Small	Middle-stage VC	Biodiesel transesterifica-tion	Q2 2006	India
NVC Lighting Technology	38	Medium	Late-stage VC	LED lighting	Q3 2008	China
Brazilian Renewable Energy Company	80	Large	Private equity	Bioethanol fermentation	Q4 2008	Brazil
Trina Solar	138	Large+	Public markets	PV modules	Q3 2008	China

Financial infrastructure

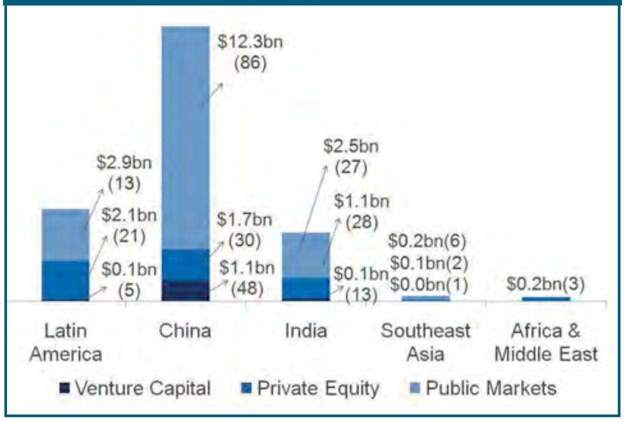
The choice of financing method for climate innovation companies in developing countries is also affected by each country's level of economic development, and the state of its local financial infrastructure. A weak infrastructure that lacks reliable venture capital exit routes, credit rating systems, or the necessary laws to protect investors' interests, can restrict the flow of capital to climate technology innovation.

Economic and financial weakness seems most clearly illustrated in Africa, where not a single country has secured venture capital or public market investment in climate technology innovation and only one, South Africa, attracted private equity – with two deals worth $177 million (see Figure 27). In these circumstances, government grants are probably the only financing solution, and proof of concept grants from the governments of developed countries may be particularly useful.

Where economies and the financial infrastructure are more advanced, in countries such as China, for instance, the funding options are wider. Government grants, tax breaks, subsidies, venture capital, private equity, public markets investment are all common and suitable.

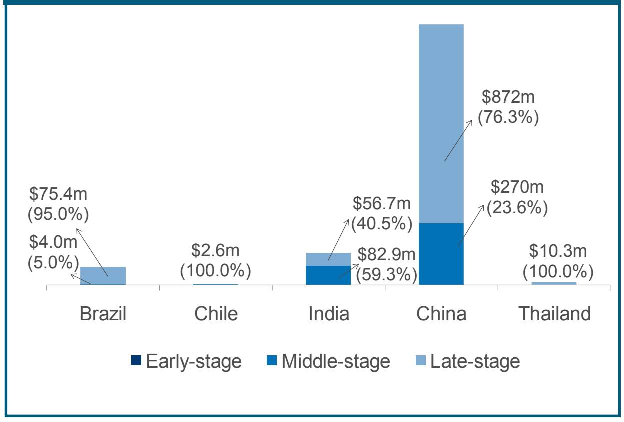
China has the largest investment in climate technology innovation from all sources of private financing (see Figure 27). Perhaps more importantly, it is also the only country to attract significant amounts of venture capital ($1.1 billion), a key financing stage in the climate technology innovation process. Bank loans are relatively more difficult in China, however, due to lack of an effective credit evaluation system for climate technologies specifically, according to local banks (see Case Study, page 31).

Figure 27: Venture capital, private equity and public markets investment by country: 2004 – 2009



Note: Numbers in the brackets denote the number of deals
Source: Bloomberg New Energy Finance

Figure 28: Venture capital investment at different investment stages by country: 2004-2009



Source: Bloomberg New Energy Finance

Innovative financing options

Recently incubators have resorted to a number of more innovative financing ideas to overcome some of the barriers to funding climate technology innovation, and the choice of funding technique has tended to reflect the country's level of development and financial infrastructure. Among the LDCs there is increasing use of microfinance, soft loans and proof of concept grants. Among the BRICs we have seen the adoption of innovative debt financing methods, the ESCO model, public procurement schemes, microfinance and incubator-backed special purpose funds. These techniques are generally well understood in other sectors, but are only now being applied to climate technology innovation. They are primarily suitable for later-stage companies, and some require even more of the local financial infrastructure, and have not yet been widely adopted.

Incubator-backed special purpose funds

Two leading climate incubators have either launched, or are thinking of launching, their own funds to close the persistent funding gap in early-stage climate technology innovation. Baoding in China has established a fund called the Baoding National New and High-tech Development Co. (BNNHD), providing both debt and equity, to help incubatees construct production plant in the Zone when they reach that stage. The idea is for Baoding Zone to shoulder the riskiest stages of innovation (the 'valley of death') and replace itself with external investors once the projects have been established. The biggest single investment so far is $4.4 million (see Case Study page 31).

CIETEC in Brazil has taken a slightly different approach, and has plans to launch a $57 million stock market fund to offer external investors exposure to a portfolio of promising early-stage climate innovation companies. The fund would focus wholly on climate technologies – a first for Brazil - but would take a multi-sector approach. It would concentrate on the seed and venture capital stages, and work with CIETEC and other incubators to select the best projects. This approach should provide targeted funding for climate technologies; bridge the cultural gap between entrepreneurs and investors; help investors spread their risk; and help Brazilian start-ups keep control over their technologies and generate jobs and exports.

Innovative debt financing methods

Since it is still difficult to obtain conventional bank loans for middle-stage climate-tech innovation companies due to a lack of collateral, some leading climate-tech incubators have been working proactively with local banks to develop new debt financing methods to overcome this problem. We found several successful examples in China and India, where:

- some incubators such as Hefei National University Science Park in China pledge their own assets to secure credit lines, and then lend on to late-stage portfolio companies
- some late-stage incubatees at Baoding have used their supply contracts with customers, rather than hard-to-value intellectual property, to secure bank loans
- financial institutions offer innovative credit guarantees. In India, YES Bank guarantees up to 50% of loans that local banks make to climate-tech companies, while in China, the Asian Development Bank covers an agreed portion of each loan up to a maximum aggregated credit guarantee of $118 million.118m

The ESCO Model

The ESCO model, where the ESCO supplies energy saving equipment to its clients for no upfront charge, and is then paid a share of the resulting financial savings during the lifetime of the investment, is long established in the developed world. Now it is beginning to be explored by incubators and climate technology innovators in developing countries to help secure debt finance – since there are assets and predictable earnings to use as security. In India, NVI has signed agreements with two local banks to promote the ESCO model, and two of its incubatees, GreenTech Aqua and Kakatiya Energy Systems, are considering adopting this model (see Case Study, page 43).

Proof of Concept grants

The proof of concept grant is usually supplied by developed world governments via multilateral organisations at the pre-company stage to prove that an idea, invention, process, or business model is feasible, and is usually closely paired with advisory services. Since lack of early-stage innovation is the severest funding gap in the climate innovation process in developing countries, the proof of concept grant could prove especially effective. infoDev is using this mechanism in its design work for CICs in Kenya and India.

Microfinance

Microfinance is the provision of financial services to low-income people in the developing world, often the rural poor, who have no access to mainstream banking. The concept was pioneered in the 1970s by the Grameen Bank in Bangladesh, and usually involves making small loans at low interest rates to local entrepreneurs, consumers or groups of people, where peer pressure ensures repayment.

The technique is now being used by REEEP, the Renewable Energy and Energy Efficiency Partnership, a multinational climate technology transfer organisation operating in China, India, Brazil, and Africa to promote climate technologies among the rural poor. In India, for instance, working with local banks and manufacturers, REEEP has provided microfinance to fund the distribution of solar-powered sewing machines.

Public procurement

Public procurement tends to favour technologies that are relevant to products routinely used by governments and public authorities such as low carbon vehicles and green building technologies. Public procurement is beginning to be used to help support climate innovation, although not yet widely The local government of Shenzhen, a southern city in China, bought 100 hybrid electric cars and buses from Chinese automobile manufacturer BYD in early 2010 to become the first to buy the product.

More recently in July 2010, the government of Argentina awarded 15-year power purchase agreements to a wide range of renewable generators – including wind farms, small hydro, biodiesel plants, and solar photovoltaic projects - totalling almost 1GW. Similar deals have been struck in Uruguay and Peru.

Trade Credit Offsets

The Trade Credit Offset (TCO) is another long-standing funding technique that is now beginning to be discussed in the context of climate technology innovation. Traditionally, TCOs are used when governments let major supply contracts to multinational companies – for anything from weapons to infrastructure - and impose conditions on the supplier to rebate a substantial amount of the contract to the purchasing country by 'offset' spending. For instance, a government awarding a $1 billion contract to supply military radar might oblige the supplier to spend as much as $250,000 in its own territory – buying components and so on – so the buyer reaps some economic benefit from the contract.

Some multinational organisations have now begun to discuss the potential for TCOs in climate technology innovation. In this case, the rebated benefits would include things like education and training, and technology licensing and transfer, precisely to stimulate climate technology innovation in the purchasing country. It is suggested this would promote the transfer of innovative technologies to developing countries at a far greater rate than 'bottom up' measures to stimulate innovation.

Scarcely any incubators are yet aware of this concept, but it is clear that CICs could perform an important role in its future development.

Choosing the right funding solution

The choice of which financing technique is appropriate depends not only on the stage of climate innovation to be funded, but also on the size of the funding requirement, the type of technology, and the state of the local financial infrastructure. Table 6 provides an easy-to-use guide to which options are appropriate in what circumstances. Each sun represents an appropriate financing solution for the factor shown in that column, while a blank cell means the option is inappropriate.

For example, if a young African biofuel company needs $5 million to commercialise its technology, starting at the left hand side of the table we can see clearly that the potential financing solutions include government grants, venture capital and bank loans. But moving one category to the right, we find that since the funding requirement is 'medium', government grants are unlikely to be suitable. Moving right again, since the company is based in Africa, where most countries' financial infrastructure is judged to be 'weak', venture capital is unlikely to be available, meaning the most feasible solution will be bank loans.

In the real world such decisions are more complex than presented here, but the table does provide a quick assessment of the funding solutions most likely to prove appropriate. However, just because a funding solution is considered appropriate does not necessarily mean it will be available. One role of the CIC will be to help fill gaps in provision, which we analyse in more detail in the next section.

Table 6: Evaluation matrix of appropriate financing options

	STAGE OF INNOVATION				SIZE OF INVESTMENT				TECHNOLOGY TYPE/ SCALE*		FINANCIAL INFRASTRUCTURE		
APPROPRIATE FINANCING OPTIONS	R&D	Commercialisation	Deployment	Diffusion	Micro	Small	Medium	Large	Small Scale	Large Scale	Weak	Medium	Strong
Government grants, "POC" grants, free offices, laboratory facilities, research staff	☼	☼			☼	☼			☼	☼	☼	☼	☼
Tax breaks, subsidies			☼	☼					☼	☼		☼	☼
Seed capital, ISPFs	☼				☼				☼	☼	☼	☼	☼
Venture capital, ISPFs		☼	☼			☼	☼		☼	☼		☼	☼
Private equity				☼				☼	☼	☼		☼	☼
Public Markets				☼				☼	☼	☼		☼	☼
Bank loans, soft loans		☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼
Micro finance			☼		☼				☼		☼	☼	
Public procurement			☼	☼			☼	☼	☼	☼		☼	☼
Trade credit offsets			☼	☼			☼	☼	☼	☼			☼

Note: ☼ means appropriate, blank means inappropriate. Micro Investment size = $ 1m, small investement size = $1m - $20m, medium size = $20m - $50m, large size = $50m. "POC" = Proof of Concept; ISPFs = Incubator-backed special purpose funds. "some technologies such as solar PV can be deployed at either large or small scale. Small scale technologies include rooftop solar, anaerobic digestion, efficiency measures etc. Large scale technologies include biofuels, wind parks, CSP etc.
Source: Bloomberg New Energy/ Finance

5 GAPS AND BARRIERS IN CLIMATE INNOVATION

The Climate Innovation Centre is intended to overcome barriers to climate innovation in developing countries. In most cases this will mean filling gaps in the existing provision, since the innovation systems of most developing countries are poorly organised or absent altogether. But there are also barriers that must be removed. These are the problems the CIC is meant to solve.

However, as discussed in Chapter 2, there are currently only two institutions that could be properly described as something resembling a CIC. And among the 'relevant organisations' identified, geographical coverage in the developing world is patchy, and there are significant gaps in the services provided compared with the ideal of a CIC. In this chapter we identify the most significant gaps and barriers in climate innovation as a basis for our conclusions and recommendations. As in Chapter 2, it is important to note that our analysis does not cover all organisations involved in innovation – we exclude bodies that focus wholly on R&D, for example - but only those involved in promoting or facilitating climate innovation.

Gaps in existing capacity

At the moment very few organisations exist that could properly be described as a 'full-service' CIC, perhaps with the exception of China's Baoding National New & High Technology Development Zone and, in Britain, the Carbon Trust. Of the 25 most relevant organisations we identified globally, around 80% are stand-alone business and technology support organisations that focus predominantly or wholly on climate technologies, and the rest are programmes of multilateral organisations such as the United Nations, the World Bank and developed country donor agencies, which focus primarily on R&D (CGIAR), capacity building (UNIDO-UNEP CG), and mentoring young businesses in their search for funding (CTI PFAN). Only 10 of the 25 are based in the developing world, where need is greatest, and none of these is privately funded.

As shown in Chapter 2, the geographical coverage of relevant organisations is patchy. Among the developing countries, and excluding the multilateral programmes that have multiple offices in all regions, Asia has four relevant centres, while Latin America and Africa have one each. However, it should be noted that the African centre is provided for by an Africa-focused multilateral organisation; not a single climate technology incubator was identified on the entire continent. None exist in the Middle East outside Israel, but this is perhaps unsurprising given the region's large reserves of oil and gas (the Masdar initiative in the UAE has been excluded as it is not yet fully operational).

The emphasis among organisations that promote climate innovation is largely on mitigation rather than adaptation. Of the 25 centres, 14 focus solely on mitigation and only three on adaptation, while the remaining eight cover both categories. The centres in Africa and Latin America cover both mitigation and adaptation, but those in the Pan-Asia region (including China, India, Southeast Asia) focus almost exclusively on mitigation. The centres in China, India and Brazil are mostly traditional incubators, while those in Africa are more focused on capacity building. So there are almost no 'full-service' CICs that cover the full range of potential functions.

We also discovered many gaps both among the provision of the existing centres and in the wider innovation systems that must be filled if countries are to succeed in climate innovation. The following breakdown reflects the 'Innovation journeys' described in Figure 6.

Technology

Lack of understanding of climate technologies

Many incubators admit they do not fully understand climate technologies, especially since many of these are significant deviations from conventional technologies and markets. Technical and cost uncertainties are seen as a major concern, and many centres have limited capacity to offer technical guidance or assistance. Our survey reveals only 40% of the climate incubators in South Asia and Latin America provide technical assistance in new product development.

The absence of technology assessments of the sort described in the next chapter means developing countries are unlikely to have a clear understanding of which technology areas offer the best chances of successful innovation in their local circumstances. Policies to support climate technologies may be misdirected or sub-optimal as a result.

Company

Limited capacity for facilitating early-stage innovation

Climate-focused incubators in developing countries tend to concentrate on late-stage innovation companies. This is important, but it is only part of the picture, and supporting early-stage innovation is often vital. Yet only a handful of centres we surveyed, including China's Baoding National New & High Technology Development Zone and Brazil's CIETEC, have experience in supporting early-stage companies. Without a pipeline of early-stage companies, the stream of later-stage companies may be restricted, inhibiting climate innovation.

Finance

Insufficient financial assistance from innovation centres

Over 75% of our broad list of 67 relevant organisations are unable to provide or arrange private funding for their portfolio companies since they do not have strong ties with early stage financiers. The majority of them admit they do not actively seek private investors for the portfolio companies, but mainly help on filling the application forms of soft loans and monitoring the application process. This is particularly true in Latin America, with the notable exception of CIETEC in Brazil. For those incubators that do offer a financial matchmaking service, many admit they do not have the capacity to conduct a rigorous assessment of the business plans they present to investors and banks.

Bureaucracy in applications for public funding

Since climate technology innovation relies heavily on government grants and soft-loans from state-owned banks, the bureaucracy involved in applying for public funding is considered a serious obstacle. This is especially true in Brazil, where venture capital is relatively scarce and the interest rates for commercial corporate loans are significantly higher than BRIC competitors China and India. Climate technology innovation companies cannot afford to borrow except from state-owned BNDES, which offers average interest rates of 12%, less than half of the average commercial rates of more than 25%. The problem here is both a bureaucratic obstacle to state funding, and a lack of reasonably-priced commercial funding.

Shortage of private investment

The widespread difficulty of attracting private capital is a major drawback (see Chapter 5), with risk capital scarce in all regions at all stages of the innovation process. This shortage seems to affect not only climate innovation companies being incubated, but also the centres themselves. Our survey shows just 20% of the relevant organisations are privately funded, 36% are private/public-co-funded, and 44% are publicly funded. All of the privately funded centres are in the developed world. Rapid expansion in developing countries would require far more private investment.

For portfolio companies there is a particular lack of private sector support at the R&D and commercialisation stages. As we discuss in Chapter 4, only 27% of the total venture capital investment during the past six years provided funding for R&D and commercialisation. Early and middle-stage innovation companies rely heavily on funding from family and friends, and government grants. This is a critical issue since public funds for commercialisation are limited, even in richer industrialised countries, and without increased funds for these early stages, a major innovation gap will remain.

Lack of innovative financing options

Climate innovation companies currently rely on government grants, equity investment and bank loans, each of which has its limitations. As we discuss in Chapter 4, there is a pressing need for a range of more innovative financing methods to break through some of these barriers.

Newer financing mechanisms such as proof of concept grants, incubator-backed special purpose funds, trade credit offsets, credit guarantees and intangible collateral may be well understood in other sectors, but are not yet widely used in climate innovation, and for many centres they are unheard of. The lack of these funding mechanisms is sometimes blamed on the absence of local financial infrastructure.

Inadequate financial infrastructure

Banking arrangements and the wider financial infrastructure are generally less advanced in developing countries than in developed ones, and this inhibits climate innovation in a number or ways, the most important of which is the lack of suitable investment exit mechanisms.

At present the main investor exit route in countries such as China, India and Brazil is through an initial public offering (IPO) on domestic or foreign stock markets. There is no sophisticated trade sale market for venture capital investors and the IPO market is only available to late-stage companies able to meet the expense and regulatory demands of a stock exchange listing. This precludes many climate technology innovation companies, who find it difficult to raise venture capital financing as a result. When China tightened its rules on overseas IPOs in 2006, venture capital investment in its clean energy sector collapsed from $468 million to $137 million.

Another structural weakness in developing economies is that commercial banks are reluctant to lend against patents and other intangibles, because there is no standard method of evaluation and legal protection of intellectual property is often weak. In China, Baoding (see Case Study, page 31) has found ways to work around this gap, which could be applied elsewhere.

New innovative debt financing instruments such as credit guarantees and intangible collateral are not yet widely used in developing countries for the same reasons, meaning funding options are restricted. The newly emerged concept of the trade credit offset has also been held back by the lack of a clearing-house function, according to its supporters.

Market

Lack of understanding of consumer needs

Practitioners emphasise that understanding consumer needs is a particular challenge to climate technology innovation. There might be exciting innovative technologies and products, but no significant expressed demand from consumers. The failure to understand consumer needs from the beginning may cause failures later in the climate technology innovation process. Our survey shows only three of the 14 centres selected in South Asia and Middle East provide climate-tech market information and data to portfolio companies. This may suggest some centres do not realise how important understanding markets is to their companies.

Policy

Lack of engagement in policy and standards development

Since CICs are intended to overcome gaps and barriers in existing innovation systems, a key function will be to engage with government and regulators to help develop appropriate policies and standards. Surprisingly, of our incubator case studies, neither CIETEC nor NVI were significantly involved in this area, although Baoding is far more active. For instance, Baoding incubatees have taken part in standard-setting symposia in the silicon and wind turbine industries (see Case Study page 31). This not only ensures that appropriate standards are developed, but also gives the centre and its clients the benefit of the 'inside track'. Future CICs will need to adopt a similar approach to fill the gaps and clear the regulatory barriers to climate innovation.

Filling the gaps

Developing countries must develop a clear understanding of the specific gaps and barriers that exist within their own borders in order to solve them and allow climate innovation to flourish. The gaps and barriers may be different in each country, which in itself will guide the design of any CIC, which we explore in the next chapter. There, we present an extensive list of gaps and barriers to climate innovation, and the potential remedies that could be implemented by CICs (Table 7).

6 DESIGNING THE CIC: A PRACTICAL GUIDE

From the evidence of the preceding chapters we can develop a richer understanding of the potential for CICs in a range of developing countries. On the basis of our survey, case studies and gaps analysis, we can explore in greater depth the potential functions of the CIC, and how its design may differ between developing countries. Finally we suggest a method to help CICs and their host countries identify the technologies most likely to succeed in their particular circumstances.

FUNCTIONS OF THE CIC

Our survey, case studies and gaps analysis all confirm that climate innovation will require the CIC to perform a broad range of functions. For example, from our case studies it is clear that CICs will need to pay close attention to the funding of climate innovation companies, and may need to commit their own capital, or develop innovative new ways to attract investors (see Brazil case study). Other potential functions that will be important for CICs include coordination of R&D across the innovation ecosystem; setting standards; capacity building; policy analysis; and crucially performing technology needs assessments - discussed in more detail below.

Links and partnerships with existing players in the innovation system - business, government, academic and research organisations - will be important. By taking an overarching view of the innovation process, the CICs could ensure appropriate coordination and sequencing of activities across the various innovation stages for any one technology. In each CIC, there may be synergy across projects, especially in areas such as market and policy analysis, and the design of policies and regulations.

And finally, by operating as a global network, the CICs could cross-fertilise each other and bring international expertise to bear on a range of problems. This could include sourcing technical personnel to help with the adaptation of an existing technology, such as biomass gasifiers, for example; sharing the lessons learned from the imposition of policies such as feed-in tariffs from around the world; or advancing technology entrepreneurship by drawing on the experience of developed countries.

We believe that CICs performing this range of functions could help developing countries move beyond business-as-usual by improving the effectiveness, efficiency, and speed of innovation processes and help technology development to 'leapfrog' at the pace needed. Table 7 presents an extensive list of potential CIC functions along with the gaps they are intended to address, based on our survey, case studies and the analysis of the last chapter.

Table 7: Potential functions of the CIC	
CIC function	**Gap/ barrier addressed**
TECHNOLOGY	
Help improve the technology development process to ensure the availability of technologies for local markets	
Undertake technology needs assessment/ options analysis to understand which technologies are best suited to advance adaptation and mitigation in the local context	Lack of understanding amongst firms about the scale and scope of climate challenges and lack of familiarity with technological possibilities and performance of existing technologies; emphasis mostly on mitigation rather than adaptation
Facilitate applied R&D through provision of small grants; improved communication, interactions, and collaboration among actors (entrepreneurs, firms, universities, government laboratories); and international networking and experts-in-residence	Inadequate applied R&D due to lack of market signals, limited existing technical capabilities within firms and other organisations, or lack of coordination among actors
Work with governments to develop demonstration programmes to identify technologies with high potential and fund projects to evaluate technology and product performance under real-world conditions through demonstrations and field-trials	Uncertainty about in-situ costs and performance, and lack of end user awareness. Lack of funding or institutional structures to enable technology demonstration and to utilise the learning in technology/ product improvement.
MARKETS	
Promoting demand through creation and strengthening of markets for climate technologies	
Market analysis to help better understand the characteristics of the demand and markets for specific technologies	Lack of clear understanding amongst policy-makers and firms about potential size and nature of markets
Help develop policies to enhance markets for climate technologies (this can involve, for example, feed-in tariffs, renewable portfolio obligations, government procurement programmes, environmental standards)	Climate technologies may cost more than existing options in the absence of climate policies; buyers are risk-averse about new technologies; firms do not invest in technology development, manufacturing facilities, and supply networks until markets exist.
Identifying and overcoming barriers to deployment (for example, lack of consumer awareness tackled through information and labelling programmes,making financing options available for firms that cannot invest in energy-efficient options that have high initial investments but low payback periods)	Lack of awareness, information, and market structures limit uptake of climate technologies, even if they are cost-competitive with existing options.
COMPANY	
Supporting entrepreneurial as well as existing ventures to succeed in the business of climate innovation	
Advance enterprise creation by linking technical researchers with entrepreneurs, venture capitalists, and business people; provide some limited seed funding for new firms	Lack of business skills within research/ technical personnel; lack of seed funding to start new technology firms
Provide business advisory services such as strategic and business development advice to start-ups; information provision about new technologies; market analysis and consumer surveys	Lack of detailed understanding about technologies, markets, consumer needs, business strategy, and business development possibilities
Training programmes to upgrade business management, managerial, operational, and technical capabilities	Limited skills of existing personnel, lack of appropriately-trained workers
Provide support services and infrastructure for start-ups and other small firms	Lack of resources to invest in appropriate infrastructure

Table 7: Potential functions of the CIC	
CIC function	**Gap/ barrier addressed**
Working with governments to streamline policies for effective operation of small businesses	Bureaucratic hurdles and complex policies impede effective functioning of small firms and act as barrier to entrepreneurship
REGULATIONS	
Ensuring that the regulatory framework supports climate innovation	
Help develop regulatory framework that supports the uptake of new climate technologies in existing markets	Regulations may hinder the introduction of new climate technologies that may incur higher costs or have different performance characteristics than existing option (for example, by requiring utilities to choose lowest-cost options)
Help develop technology standards and certification schemes to build consumer confidence in new technologies	Uncertainty on part of consumers about performance of new technologies
Help with modification of regulations that may impede technology development and diffusion	Regulations may serve as a barrier to the development of fledgling or even established local businesses (e.g., high customs duty on parts but not assembled goods)
Improve financial regulatory architecture to promote investments in climate innovation	Financial regulations may limit investment and exit strategies for investors, limited openness to new debt and financing instruments
Improve evaluation and protection of intellectual property	Lack, or ineffective functioning, of IPR rules and institutions impedes both innovators as well as investors
FINANCE	
Facilitating the expansion of financing options for climate innovation by both helping deepen the pool of funds available and enhance access for firms	
Work with governments and private investors to increase pool of funds to support various, especially early, stages of climate innovation	Limited funds available to support technology innovation, especially climate innovation, in many developing countries
Help expand early-stage financing through co-investments, loans or risk guarantees to help viable businesses attract private sector funding	Lack of financing (typically first or second round) for early stage technology/ product development due to classic innovation barriers combined with perceived energy technology market/ policy risks.
Help overcome "valley of death" by working with government to develop programmes to provide financial support for the translation of technologies to viable products through for example early-stage innovation grants to small firms or new business units	Limited funding from private and public sources available for moving technologies to product ready for market but no internal source of funding within firm, especially if start-up, since too early for cash flow from technology
Explore innovative options to develop and tap new avenues of finance	Financing approaches often are not tailored to the needs and context of developing countries
Facilitate easier access to finance for firms through improved interactions between firms and funders, coordinate funding avenues, elimination of bureaucratic hurdles, and enhancing investor confidence	Access to financing is impeded by bureaucratic hurdles, limited avenues of interaction with funders, and limited information about, and confidence in, firms available to funders
COORDINATION AND NETWORKING	
Streamlining the innovation process through a bird's-eye view of various activities in the innovation process	

VARIATION IN DESIGN

It is also clear that the focus and scope of CICs will differ between developing countries according to circumstances, including factors such as population size, level of development and climate vulnerability (see Figure 29 and Table 8).

High-GDP developing countries, such as India or Brazil, which have big economies despite low or medium average per-capita incomes simply because their populations are large, are likely to have sufficient market size and internal capabilities to support a national-level CIC. Given their high GDP, these countries will also have significant aggregate GHG emissions which eventually will have to be managed. And given the size of their populations and area, adaptation will probably be an important issue for these countries too.

Medium-sized countries that do not have a large GDP (in other words, those that are very poor, such as Ethiopia, Bangladesh or the Democratic Republic of the Congo) will require a focus mostly on meeting basic energy needs as well as adaptation; their economies are not yet large enough to warrant a strong focus on mitigation at present.

Smaller countries with a High to Medium rating on the Human Development Index (HDI) such as Singapore, Malaysia or Cuba, may also have the capabilities and resources to support a CIC. However, they may need to exploit not just national but regional markets to achieve economies of scale and make the CIC worthwhile.

Smaller, low-HDI countries such as Malawi, Chad or Burundi, may have neither the markets nor the capabilities to support a CIC without international help, and are unlikely to have aggregate emissions that merit concern. However, they will have adaptation needs, especially since their economies, largely dependent on activities such as agriculture, fishing, and tourism, are likely to be highly vulnerable to climate change. In these countries, a regional CIC with a focus on adaptation may be most appropriate.

In practice, CICs in the different types of countries would conduct many of the same activities, but with distinctly different emphases. CICs in High-GDP or High/Medium HDI countries likely would perform the full range of functions listed in Table 7, while those in Low HDI countries would probably need limited or no focus on R&D, and more on facilitating international technology transfer, possibly even from other developing countries. The emphasis here would be on the effective deployment of imported technologies - with some adaptation to local conditions – since there will not be enough technical expertise to undertake significant climate innovation locally.

Figure 29 offers a broad categorisation of CICs by country population size and level of development. Table 8 gives a practical illustration, using India and Ethiopia as generic examples, of how the emphasis could vary between countries.

Figure 29: CIC focus by country size and level of development

Country attributes	**Large/medium population countries**		**Low population countries**	
	High GDP	Medium/Low GDP	High/medium HDI	Low HDI
Scale of Centre	National	National	Regional	Regional
Scope of Centre	Main technology thrust	Technologies for basic energy needs; mitigation; adaptation	Mitigation; adaptation	Technologies for basic energy needs; adaptation
	Innovation process	Full range (technology research, development/ modification and deployment)	Emphasis on deployment process and strategies	Emphasis on deployment process and strategies
Need for international resources (finance, human)	Selective	High	Selective	High

Source: Ambuj Sagar

Table 8: How CIC emphasis might vary between countries		
TECHNICAL	India	Ethiopia
Technology needs assessment	+	+++
Technology options analysis	+	+++
Facilitating R&D collaborations/ partnerships between actors (firms, universities, govt. labs, international experts)	+++	+
Facilitating technology transfer from international actors	+	+++
Facilitating technology demonstration	++	+++
Assisting with technology standards and certification	+++	+++
BUSINESS		
Consumer/market analysis	++	+++
Business advisory services	+	+++
Start-up support (training/toolkits, infrastructure, strategy development, delivery models)	+	+++
Provision of seed funding	+	+++
Facilitating appropriate financing options	+	+++
Domestic business networking	++	+++
Regional business networking	+	+++
POLICY/ REGULATION		
Policy needs analysis	++	+++
Working with policy-makers to assist in development of policies to support product-development funding	+++	+
Technology demonstration and early-deployment programs	++	++
Market creation through policy mechanisms	++	+++
Awareness and information dissemination programs	++	+++
Human resources development	+	+++
Assisting with development of regulations for technical and environmental performance	++	++
Financial markets for climate technology investment	++	+++
CAPACITY BUILDING		
Entrepreneur training	++	+++
Policy workshops	++	+++
Coordination across CICs	+++	+++
Regional coordination for technology diffusion	+	+++

Note: Number of '+' marks indicate relative importance of activity for CIC. indicates the potential presence of partner organisation. Categories reflect the 'innovation journeys' listed in Figure 7. This is an illustrative assessment of authors' preliminary analysis. Detailed assessments will be needed for individual CICs and will also depend on the specific technologies being advanced by any CIC Source: Ambuj Sagar

BOX 7: WHO CAN BECOME A CIC?

Many existing organisations such as incubators, seed funds and industry associations may currently perform some of the potential functions of a CIC, and some such as Baoding appear to be evolving organically into the role.

However, many have a specific focus that may render them ill-suited to make the transition. They may well have an organisational culture and existing relationships with other players that make such a transformation difficult. It may be hard, for example, for an incubator to work with large industrial players, or to facilitate technical collaborations between firms.

To our mind, a CIC that begins with a clean sheet, and is able to work with all relevant institutions as needed, will probably be most effective. Existing players should not see a CIC as competition but as a new institution that will complement, leverage, and perhaps even strengthen existing organisations and capabilities.

Any existing organisations that do seek to become CICs must assess their institutional capabilities and 'baggage' before starting out, and find ways to manage that legacy while expanding and changing their role.

BOX 8: WHAT ABOUT IPR?

The question of whether intellectual property rights (IPR) pose a significant barrier for climate technology innovation continues to be debated internationally. Climate Innovation Centres, meanwhile, could play an important role by facilitating collaboration and technology transfer on the ground, and using that experience to inform policy discussions.

The existing intellectual property framework may be sufficient to achieve diffusion of climate change innovation in some circumstances. Many governments, research institutions and private laboratories have developed effective technology transfer offices, at least in the developed economies, and increasingly in the emerging economies as well. Although imperfect, the existing framework has allowed players to develop sustainable businesses based on negotiated allocations of IPRs and economic benefits. But a sustainable commercialisation programme will ultimately require CICs to develop the skills to facilitate these relationships in more novel environments.

Where existing frameworks and incentives are inadequate, CICs may also be able to build on new collaboration mechanisms such as patent pooling initiatives, knowledge marketplaces for underutilised patents, and "Creative Commons" type approaches. These mechanisms can provide enhanced access to innovation, on a commercial, contingent or "social good" basis. Again, CICs can play an essential role in structuring collaboration so that, for example, social good providers can be assured that their commercial IPRs remain protected, or that they are able to exploit improvements to their IPRs generated by local users in the course of practical use.

Finally, not all climate-friendly technology is protected by IPR, as noted by Kunihiko Shimada, co-chair of the UNFCCC subgroup working on the issues of technology development and transfer. We expect that CICs will facilitate commercialisation of non-proprietary intellectual property, such as business models and expired IPRs, which may be repurposed or enhanced by client companies.

Because of these varied circumstances, the role CICs play around IPR will be highly flexible and specific to the sector, technology, and country. On the basis of their experience, CICs could also feed back into IPR policy discussions, helping to develop frameworks that promote collaboration and allow developing countries to achieve progress on climate innovation.

TECHNOLOGY FOCUS OF CICS

Countries differ in their need and ability to support a CIC, but within an individual country the chances of successful climate innovation will also vary by technology. Geothermal power, for instance, may be considered entirely appropriate in China, but not very relevant for Ethiopia. So the potential of any technology for a country or region must be assessed in terms of the area's specific endowments. Conducting such technology needs and options analysis may well be the first job of any CIC, and will in turn help focus the work of that CIC and its host country's climate technology policies more broadly.

The method described below, summarised in Table 9, is intended as a ready-reckoner to evaluate broadly the innovation potential for climate technologies in any country. Three sets of factors (relevance, co-benefits, and enablers) are each assigned a numerical value, to give an overall ranking of the fundamental viability of the technology in a given country, the potential additional economic and environmental benefits, and local conditions that may boost or hinder the chances of success. The higher the final scores, the greater the potential for that technology in that country.

The relevance threshold

The first question to ask about any potential climate technology is whether it is capable of delivering climate benefits in a given country - in other words, is it relevant? This depends on a number of subsidiary questions, such as 1) can the technology actually deliver mitigation or adaptation benefits; 2) is it ready to be introduced to the market; 3) is it economic against the incumbent technologies; and 4) does the country have the capacity to adapt and disseminate the new technology under local conditions?

Each of these elements is critical, meaning the absence of any one of them renders the technology not worthy of further evaluation. Obviously, a technology that has low climate benefits falls at the first hurdle; but so does one that has great climate benefits, but is not yet market ready or economically viable.

Since each of these elements is vital, the overall 'relevance rating' is calculated by multiplying their scores together, and then dividing by the maximum possible score, meaning that underperformance in any single category significantly impairs the overall result. Since the final category concerns the country's capacity to absorb the technology, the same technology can receive different scores in different countries.[30]

Co-Benefits

If two technologies have identical relevance ratings, they may still offer different co-benefits such as the potential to contribute to economic growth, employment, air quality, health, and particular benefits to the poorest in society. These provide an additional set of criteria to help guide investments in climate technologies.

Co-benefits are a bonus but cannot substitute for any lack of climate benefits in this assessment. Their impact is additive, and each is 'nice to have', but the absence of any one of them is not a show-stopper. For this reason, the aggregate performance of this set should be derived as an average of the performance on each indicator: the scores are summed and divided by the number of indicators.

Enabling factors:

Enabling factors are those whose presence in a country can improve the chances of success, including market demand, industrial capacity, natural resources (such as high average wind speeds or strong insolation), sources of funding, a capable workforce, and a supportive policy framework. Like co-benefits, the presence of these factors is helpful, but their absence may not be a show-stopper. For this reason enabling factors should also be assessed as an average of the performance on each indicator.

The importance of co-benefits and enabling factors could be weighted to reflect the priorities of the organisation carrying out the assessment. A development agency, for example, may give a higher weight to the co-benefits rating than an industry association or a private funder. Since public policy can affect many of these factors, this approach could also help highlight policies and programmes that would increase the chances of successful climate technology innovation. Such assessments are likely to be a key function of CICs.

Table 9 illustrates how all these factors combine for five different technologies in, for example, Kenya. The indicative results here suggest Kenya's highest priorities should include micro-hydro; mid-level priorities should include water harvesting and storage, and biopesticides and fertilisers; but that much less emphasis should be put on technology innovation in wind farms or HVAC efficiency.

Table 9: Where should Kenya focus its climate technology innovation?

Key indicators	Water harvesting & storage	Micro Hydro	Wind farms MW	Biopesticides/ fertilizer	HVAC efficiency
	Performance score				
Relevance: critical elements	0.44	1.00	0.15	0.44	0.04
Technology Readiness: Potential of the technologies to enter the market in near future					
Economic viability: Ability of technology to compete with existing options					
Climate benefits: Potential of technology to contribute to mitigation or adaptation efforts within country					
Technological capabilities: Technological capabilities in country to adapt technology/ product for local conditions					
Relevance: co-benefits	1.00	0.94	0.56	0.67	0.33
Economic growth: Potential of technology to contribute to economic growth/ competitiveness					
Employment: Potential of technology to enhance employment					
Health benefits: Potential to deliver health benefits					
Local/ regional environmental benefits: Reduction of air or other pollution at local/ regional level					
Benefits to rural populations/ “bottom of pyramid”					
Other developmental benefits					
Feasibility: enabling factors	0.67	0.67	0.63	0.50	0.37
Market Demand: Size of potential market, consumer orientation, competing technologies, etc.					
Entrepreneurial/ Industrial Capabilities: Existence of, or ability to develop, firm capabilities to take technology to market					
Clear path to commercialisation and scale-up: Existence of realistic technology, business, and delivery pathways					
Leverage of Indigenous Resources: Ability to utilise and/ or leverage natural resources & endowments					
Availability of Funding: Near-term fund available for R&D, commercialisation, and expansion					
Sophistication of local innovation ecosystem: How well-developed is the local innovation system, i.e., actors and networks that support innovation?					
Workforce: Current or potential workforce capabilities necessary to commercialise given technology					
Clear, Ready Stakeholders: Presence of stakeholders who could help promote the adoption of a given technology					
Supportive Policy Framework: (Existing or potential) regulations, incentives and policies to promote the given technology					
Possibility of synergy with programmes in other countries/ regions					
Total non-critical factor rating:	0.770	0.752	0.601	0.550	0.352

7 CONCLUSIONS & RECOMENDATIONS

In previous sections we have highlighted the need to foster climate innovation in developing countries; described the concept and the potential activities of the CIC; identified and surveyed the existing institutional capacity that supports technology development and commercialization; and analysed the gaps and barriers in the services provided by existing centres. Here we draw together our conclusions and recommendations on how CICs in several developing countries should be designed and rolled out.

CONCLUSIONS

On the basis of the evidence gathered for this study, we conclude:

1. Technology innovation must be enhanced in developing countries if they are to meet climate challenges and advance sustainable development.
2. The gaps and barriers to climate innovation in the developing world are far greater than in the developed, and CICs are intended to help overcome them through a strategic approach that recognises the technology- and country-specific nature of innovation needs.
3. The core function of the CIC is to foster climate technology innovation in both mitigation and adaptation by helping to develop and deploy technologies that are appropriate to local environmental, economic and social conditions. This means working across all aspects of innovation, and with all the relevant players including large and small firms, universities, R&D organisations, investors, regulators and policy-makers.
4. While there are a large number of organisations worldwide that facilitate innovation, only a small fraction of these focus primarily on climate innovation. Even among these, there are just two organisations globally that resemble a fully-fledged CIC: the Baoding National New and Hi-tech Industrial Development Zone in China, and the Carbon Trust in Britain.
5. There are around 25–70 relevant institutions that could develop into CICs or support the creation of new CICs. However, their geographical distribution is patchy, technical focus is biased towards mitigation rather than adaptation, and there are large gaps in the services they provide compared with the ideal of the CIC.
6. The gaps and barriers to climate innovation will vary between developing countries, as will their technology needs. This will be reflected in the design of CICs. However, common functional areas will include facilitating technology development and demonstration, helping develop markets, providing support-services to firms, enhancing access to finance, assisting in the development of appropriate policy and regulatory frameworks, and coordination, networking, and capacity-building.
7. Given the wide range of conditions across the developing world, some countries and regions may not have the capabilities and resources to create a successful CIC without significant external help. There may be a few countries where the CIC is simply not viable, but there are likely to be many more where the design of the centre simply needs to reflect local conditions in order to ensure the greatest chance of success.

RECOMMENDATIONS

Climate Innovation Centres

Variation in design

CICs are intended as a 'one-stop-shop' to foster climate innovation, but the shop-front will look very different in different countries – such as India and Ethiopia, for instance - depending on their population size, level of economic development and climate vulnerability. The UNIDO-UNEP case study shows that standardisation of centre design will not last long in the face of different conditions in host countries. However, this variation should not be seen simply as an inevitable 'fact of life' imposed by reality, but should be embraced in the design of CICs to achieve the greatest chances of success in widely differing conditions.

Human resources

CICs will also need to tailor their activities to the technical, human and natural resources available in the country or region. Many developing countries do not have access to large numbers of highly-trained technical researchers, and in these circumstances a centre may choose to focus on technologies that are already relatively mature, rather than reinventing the climate technology wheel from scratch. These CICs may focus less on R&D and more on deployment, and may also need to be more regional in scope so as to better exploit the manpower and natural resources of a wider market.

Even where skilled professionals are available, there may be stiff competition for their services. The Baoding case study revealed the challenge of retaining skilled professionals given the large pay differential between centre staff and professionals working in the capital, Beijing. Yet the presence of real-world business experience is a vital component of any Climate Innovation Centre, along with those with technical and policy-making knowledge.

This problem could be addressed by the use of staff seconded from other organisations (such as companies, universities and government) both domestic and foreign, and a commitment by companies that have been assisted by CICs to provide a certain minimum number of hours per month to help support new technologies at the centre, once their own businesses have taken off.

Measuring and monitoring

Monitoring and assessment will be a vital function of the CIC. Centres will need to work much harder than some existing centres to develop and monitor appropriate metrics to evaluate their impact. The UNIDO-UNEP CP case study showed that centres in that network monitored closely the services they provided, such as the number of people trained, but were initially not set up to record the number of process improvements delivered, or the resulting energy savings – the 'real world' impacts.

Just as important as measurement is rigorous analysis of the results, to glean the lessons and improve the performance of the CIC over time. It may help to have this analysis conducted by independent third parties such as academics or consultants. Other useful data could also be gathered through surveys and focus groups of the CIC's beneficiaries and partners.

Technology

Technology assessment and screening

One of the most important early functions of a CIC will be to conduct technology assessments as described in Chapter 6. The need for this function is particularly pressing given the lack of confidence and understanding around climate technologies we found even among incubators with a significant exposure to the sector. Technology assessments of the kind described in chapter 6 would help identify those technologies where a country has natural resources, capacity, and even competitive advantage, and which therefore give it the greatest chance of success. Such assessments will be crucial in guiding not only the focus of the CIC itself, but also the whole gamut of government policy towards climate innovation. Without such assessments developing countries are unlikely to play to their strengths in climate innovation.

This level of technology screening would also provide reassurance for potential investors and lend credibility to incubatees who seek their support. Without this initial selection process, investors and other partners in the innovation process might find choosing worthy candidates from the plethora of potential candidates prohibitively time-consuming.

Technology specialisation

Some of the most established centres featured in our case studies in this report specialise by type of technology: the CGIAR centres have a strong focus on agriculture; Kinrot Ventures in Israel concentrates on seed investing in water technologies; and the National Cleaner Production Centres of UNIDO-UNEP each tend to focus their assessments on just three-to-five priority sectors, rather than trying to cover the whole of manufacturing in a big developing country. Such specialisation may well raise the chances of success, by concentrating resources and expertise on a narrower group of technologies rather than spreading efforts more thinly.

Company

Supporting climate innovation companies through a range of services is clearly a core function of the CIC. Most existing centres – predominantly incubators - in the developing world tend to focus on supporting later stage innovation, with only a handful of centres (such as Baoding and CIETEC, see Chapter 3) experienced in fostering early-stage companies. This may restrict the pipeline of innovation projects, and CICs will need to develop the skills and capacity to support firms at all stages of the innovation and development.

To be truly effective, CICs may need to stretch far 'upstream'. In India, NVI reports the dearth of good quality entrepreneurial start-ups as one of its two major challenges, and works hard to develop relationships with entrepreneurial networks to try to remedy this. Other developing countries may suffer an even greater shortage of business talent, and CICs will have to develop effective policies to encourage a more entrepreneurial culture.

Market

Market analysis and creation will be another crucial function of the CIC, particularly since many climate technologies are so novel they may have no pre-existing market in that country. Climate technology innovation may well produce exciting products for which there is no expressed consumer demand. Understanding such issues and how to create or encourage new markets will be vital, particularly since our survey suggests that existing centres are generally weak on this function. This will often require coordination with governments to put in place policies that can help create niche markets to 'prime the pump'.

Finance

Financing innovative companies

Another key role for the CIC will be to enhance access to funding for climate innovation companies, from both public and private sources. Some of the current institutions that most closely resemble a full-blown CIC not only help companies secure funds from investors and banks, but are also beginning to commit their own capital. Baoding, for instance, borrows against its own assets and then lends on to incubatees, while CIETEC plans to start its own investment fund to provide early-stage capital to promising technologies and start-ups.

Since the difficulty of financing the earlier stages of innovation is a prominent barrier to climate innovation, these kinds of approaches are likely to be a key feature of CIC funding activities. Other innovative funding techniques will also be needed, such as the ESCO model, public procurement, and innovative debt financing methods. Among the LDCs, soft loans and proof-of-concept grants are also likely to feature heavily.

Financial partners

To overcome the gaps and barriers to funding climate innovation, CICs will need to develop partnerships with a range of domestic investors and financial institutions, as demonstrated by our most successful case studies. The Baoding New & High Technology Development Zone in China has partnerships with state and commercial banks interested in offering venture capital and debt finance. NVI in India has a close relationship with the PFAN network of investors in green projects. CIETEC in Brazil has close relations with the public sector grant-giving administration, and with CRIATEC, the venture capital arm of national development bank BNDES. Only with such partnerships will CICs be able to develop and promote the kind of innovative funding solutions discussed above.

Paying for Climate Innovation Centres

A CIC can only succeed in nurturing climate innovation companies if its own future is secure. Relying on one source of finance is a risk if policies change. Not being too dependent on any one source also provides some independence in decision-making. We suggest there is merit in a mixed funding approach, with part of the contribution coming from fees and part from government or international institutions, as illustrated in our case studies.

The CIETEC centre in Sao Paulo, for instance, aims to receive half of its funding from fees charged for the use of its premises, and to incubated companies, with the rest coming from SEBRAE, the Brazilian government's microfinance initiative. NVI draws funds from USAID and the UK Foreign and Commonwealth Office, as well as from conference fees and consultancy work. National Cleaner Production Centres under the UNIDO-UNEP umbrella took a quarter of their income from private sector fees in 2007, with the rest coming from a range of public sector and international sources.

Another model would be for the CIC to receive a percentage of the revenues generated by successful technology firms, so that companies only start to pay once they are generating income, and the CIC secures a private sector income that increases over time.

Policy and regulation

The key distinction between a CIC and traditional incubators is that the CIC works not only to foster individual innovative companies, but also to strengthen and develop the underlying institutions and policy frameworks. So it is clear that policy analysis and advice, and close relations with key government departments, will be vital.

It is perhaps no coincidence that one of the most successful centres we analysed, Baoding, is also one of the most closely networked into government. The China case study clearly illustrates the multiple roles a government can play in promoting innovation, and how close links to the right departments and agencies - both local and national - can help in myriad ways: financing, infrastructure, networking and policy development.

Links and networks

CICs will also need to develop links with a range of partners throughout the innovation system including universities, which can be invaluable in the work of incubating young companies. The CIETEC case study recounted how Sao Paulo University can provide access to incubatee companies, and make professors available to evaluate companies' technologies. Baoding Development Zone benefits from the first renewable energy college in China, developed with Huabei Electricity University.

It can also help centres that are linked to both private sector industry and research bodies. This point is supported by the UNIDO-UNEP case study, which found that incubators hosted by an industry association communicate best with executives, and others hosted in academic bodies communicate more naturally with policy-makers. It is important therefore that CICs should be linked to both private and public sector partners, not just with one or the other. The point is reinforced by the success of NVI in India, which was founded jointly by the World Resources Institute and the Confederation of Indian Industries, or CII.

The international Climate Innovation Centre network

CICs could be developed individually on an ad hoc basis, but we believe much greater value could be provided by building a network of connected centres. This would allow centres to share learning, best practice and facilitate north-south and south-south technology transfer and collaboration. Some centres, such as those in the CGIAR and UNIDO-UNEP networks, already have the means to share best practice across different countries. Such sharing of information and knowledge should help inform and shape the activities of all the centres.

Important progress has been made on the issue of networks within the UNFCCC and other organizations who are exploring possible approaches to innovation networks for climate technologies. However further exploratory work is needed in designing a network specific to CICs including associated governance structures and functions that will maximize collaboration while minimizing administrative barriers that often stifle effective innovation.

Such a networked approach could offer new centres a back catalogue of the types of approaches and organisational forms that have succeeded in other locations, and flag-up the potential obstacles. There may also be novel ideas in a range of areas – financing, policy, and potential delivery models such as the ESCO model being pursued in India.

Knowledge of technologies under development in other countries would give centres the chance to shape their own activities around the likely competition and possible gaps in the market for a particular technology.

Perhaps the biggest benefit from an international network would be access to finance from private sources. Seed and early-stage venture capital is much more plentiful in developed countries than in developing countries, and more readily available in some developed countries than in others. The overwhelming majority of developed country early-stage investors are unlikely to consider potential deals in developing economies due to travelling expense, lack of local knowledge and perceived high risks. In developing countries themselves, local VC and angel communities are often under-developed, and technology developers have to rely on government grants and local banks.

However competition among financiers may be more limited in developing countries, and the availability of development bank finance may reduce the commercial risk, so the opportunities for profitable growth for young companies are potentially just as great, if not greater, than in Europe, North America or Japan.

We suggest that an international network of Climate Innovation Centre could help bring about the creation of seed and early-stage funds focusing specifically on opportunities in developing countries. Proposals linked to CICs would help overcome an information and credibility gap. One approach might be for multilateral organisations to stage a major annual international event, bringing together CICs, incubatees and investors from around the world, including a competition to find the most promising climate innovation start-ups. For the winners, the prize would be access to early-stage venture capital worth potentially millions of dollars, while for the developing world it would be a major stimulus to climate innovation.

APPENDIX

Appendix 1: Key mitigation and adaptation technologies - present and future		
SECTOR	MITIGATION TECHNOLOGIES CURRENTLY COMMERCIALLY AVAILABLE OR DEMONSTRATED	MITIGATION TECHNOLOGIES PROJECTED TO BE COMMERCIALISED BEFORE 2030
Energy supply	Improved energy conversion technologies (e.g., clean coal); nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; carbon capture and storage	CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and wave energy, concentrating solar and solar PV.
Transport	Fuel-efficient internal combustion engines; hybrid or electric vehicles; cleaner diesel vehicles; biofuels; advanced rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning.	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.
Buildings	Efficient lighting and day lighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases.	Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar PV integrated in buildings.
Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO2 gas emissions; and a wide array of process-specific technologies.	Advanced energy efficiency; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture.
Agriculture	emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.	Improvements of crops yields
Forestry/forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use.	Tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential and mapping land use change.
Water management	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimisation.	Biocovers and biofilters to optimise CH4 oxidation.

SECTOR	ADAPTATION TECHNOLOGIES CURRENTLY COMMERCIALLY AVAILABLE OR DEMONSTRATED	ADAPTATION TECHNOLOGIES PROJECTED TO BE COMMERCIALISED BEFORE 2030
Water	Rainwater harvesting; water storage and conservation; water re-use; desalination	NA
Agriculture	Modified crop varieties; improved agricultural practices; water-use and irrigation efficiency	NA
Infrastructure/ settlement (including coastal)	Seawalls and storm surge barriers; improved building design; disaster management systems	NA
Human health	Improved climate-sensitive disease surveillance and control; safe water and improved sanitation	NA
Transport	Design standards and planning for roads, improved rail and other infrastructure to cope with warming and drainage	NA
Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; exploitation of multiple sources of energy to reduce dependence on single sources of energy	NA
Industry	Strengthened/storm prone industrial facilities; water storage, conservation and reuse; diversification to reduce dependence on single feedstock or fuel	Water-less and low water processes; processing capacities for new climate adapted crops; development of new products and services to cope with altered climate and its impacts (e.g. clothing, insulation/cooling products, pharmaceuticals, agrochemicals)

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[4] Note that the term technology – broadly defined as the applications of knowledge to achieve a specific objective – includes both 'hard' technologies (e.g., engineered products and systems) and 'soft' technologies (e.g., management processes).

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[26] CGIAR is now transitioning from a system managed for the most part informally by consensus into a new model that emphasizes binding contractual obligations and clear lines of accountability in order to improve its effectiveness.

[27] http://www.cgiar.org/who/history/index.html

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[30] The normalised "relevance rating" (RR) of a technology, therefore can be represented as:

$(P_{R1} \times P_{R2} \times P_{R3} \times P_{R4})/(P_{MAX})$, where P represents the performance on any indicator and P MAX represents the maximum possible performance. For example, if a technology, say LEDs, were to be assessed, with 1 representing a low score, 2 a medium score, and 3 a high score, then it might score 3 on R1, 1.5 on R2, 3 on R3, and 2.5 on R4 (for that particular country). Thus, the RR of this technology would be 33.75/81 = 0.42

Thus a technology would have to do well on all dimensions in order to receive a high rating; and a very poor performance on any dimension significantly adversely affects the rating, which is appropriate since it indicates that the technology is inappropriate in some key way.

The threat of climate change worsens almost by the day, and developing countries are most at risk. Technology innovation will be vital to the response, but is weakest in developing countries. A new institution, the Climate Innovation Centre, is intended to change all that.

The CIC is conceived as a national or regional hub to deliver a broad suite of services supporting climate technology innovation in developing countries. This 'one-stop-shop' would not only help develop and deploy locally appropriate climate technologies, but also catalyse new industries to create jobs and growth, and deliver additional benefits such as energy security and reduced local pollution. The functions of a CIC would be wide-ranging but designed to meet the specific challenges of their host countries. Centres would be locally designed and run but networked with similar centres around the world.

This report explores how CICs could help developing countries accelerate the deployment of climate technologies, companies and industries; provides an inventory of existing relevant support organizations, ranging from incubators to centres of excellence to multilateral programmes, and analyses them by geography, technology, innovation, and climate focus; identifies the gaps in the existing institutional capacity; explores the early stage financing landscape for climate technologies; and provides detailed advice about the design of CICs and their development as a global network.