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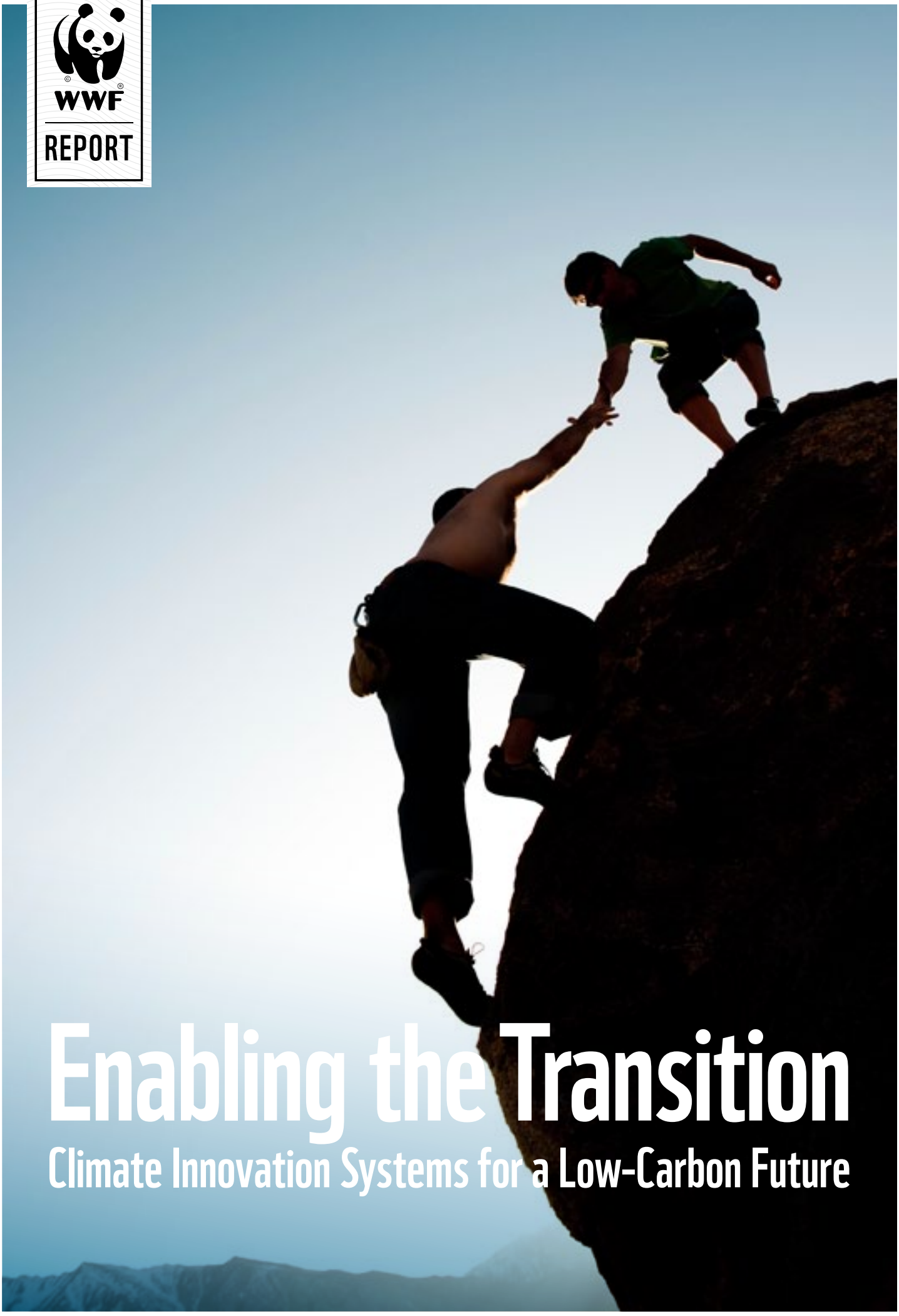

Enabling the Transition

Climate Innovation Systems for a Low-Carbon Future

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WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global Network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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FOREWORD

On a global average, we consume 50% more than the Earth's annual biocapacity. This overshoot is largely due to greenhouse gas emissions from human activities which are far more than ecosystems can absorb. Our carbon footprint has increased by over 30% since WWF:s first Living Planet Report in 1998, and now accounts for over half of humanity's Ecological Footprint.

While awareness of climate change impacts is rising, people and societies all around the world are already struggling with the severe consequences of widespread poverty, declining food security, energy shortages, the financial crisis, and degradation of ecosystem services.[1] Hundreds of millions of people are affected by these pressures, and it is the poorest who are hit the hardest. Continued exploitation at this same level will cause escalating threats to lives and livelihoods around the world.

The speed, scale and complexity of climate change is having a multiplying effect on other environmental stresses, and calls for inclusive actions of equal speed and scale. In light of the negative effects of fossil fuels and future projected energy demands, a transformation of the global energy system towards 100% renewables is both possible and necessary. It's about mitigation and adaptation. It's about business opportunities and poverty alleviation. It's about reducing wasteful consumption and job generation.

This transition requires new solutions – products, systems and services – with radically reduced climate impact. Such climate innovations[2] are numerous, proven, and available. The question is how we can employ them at speed and scale, globally?

Innovation systems are vital enablers for the transition to an equitable low- carbon future, as the base camps for explorers of new solutions, or improving the eco-system in which they pursue their endeavors. However, urgent improvements are needed in the innovation process in order to radically reduce lead times from idea to market penetration. This period of time is usually counted in decades, but emissions need to peak-and decline before 2020.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature. This report contributes to this mission by: (a) consolidating the results and learnings from analyses and projects 2008-2010; (b) bringing the findings to the attention of key stakeholders in order to mobilize necessary actions to reinforce climate innovation systems; (c) establishing the basis for expanding our efforts and acting on the recommendations presented; (d) facilitating dialogue with policy makers, investors and corporate leaders on their role in innovation systems and in the transition to a low-carbon future.

Climate change is a global challenge and must therefore be tackled by people around the globe in the spirit of cooperation, with a perspective that goes beyond protectionism. It is not a contest to be won by any single country or company. Narrow-minded competition may turn us all into losers. But if we manage to enable the transition successfully, together, everyone will be a winner.

1 UNDESA (2009). Global Humanitarian Forum (2009). Millennium Ecosystem Assessment (2005), UNEP (2009 B) & UNDESA (2009).

2 In this report climate innovations refers to cleantech, clean energy technologies, low carbon solutions etc. Visit www.climatesolver.org to find example of climate innovations, each of which has the potential to reduce global CO2 emissions by 20 million tons per year in 10 years – if given the right support to grow.

EXECUTIVE SUMMARY

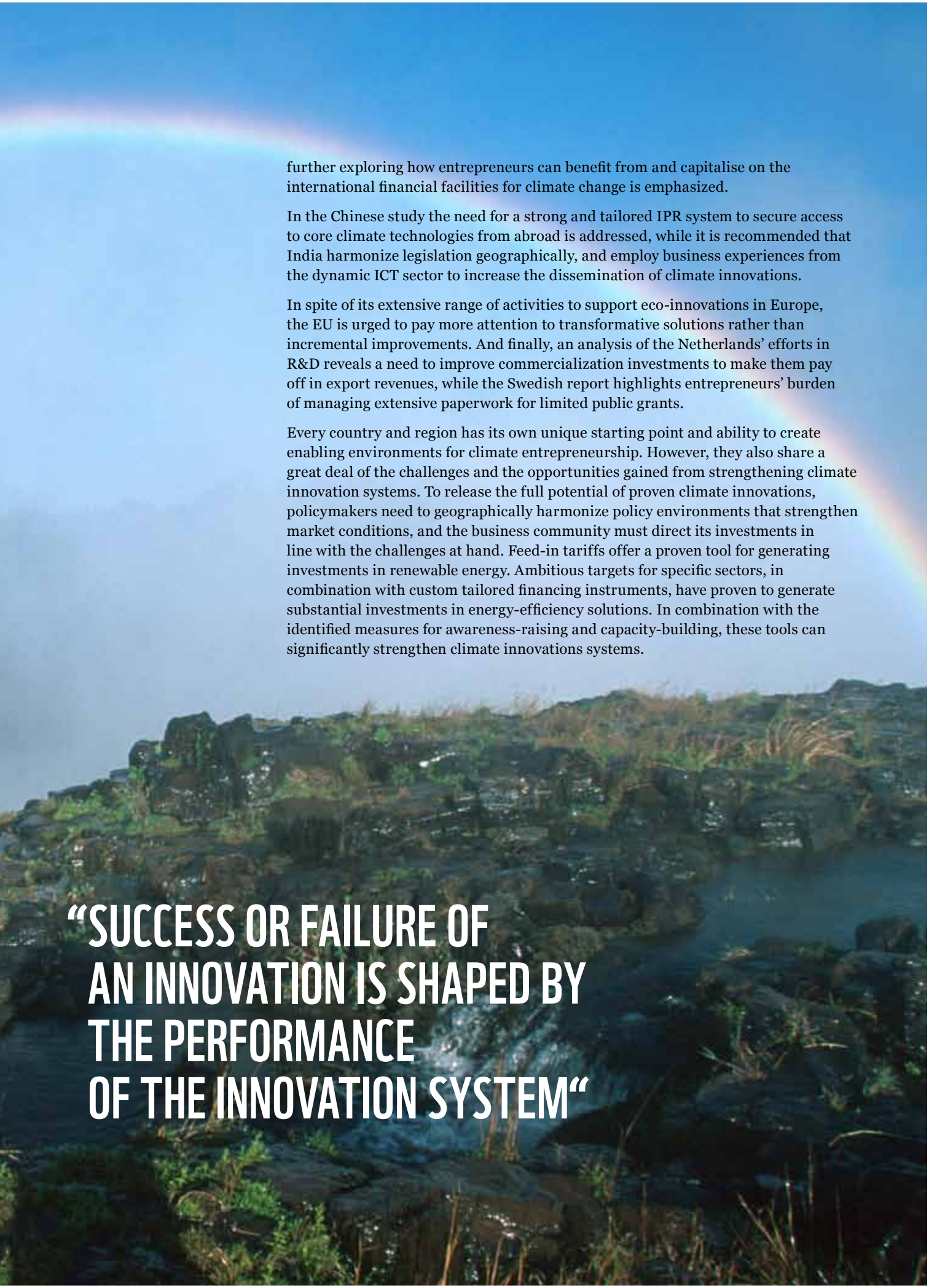
Business-as-usual CO_2 emissions will guarantee a catastrophe with global repercussions for the natural systems upon which we depend. In addition, from a long-term economic perspective, climate change is more serious in terms of its expected negative effects than any single financial crisis. Decisive actions are needed now to stimulate the peak-and-decline transition needed within the next ten years.

Technology isn't the issue, as renewables can replace fossil fuels globally by 2050. Climate innovations are available, it is political will and market frameworks which are lacking. Concerted efforts from leaders in policy and business can bring jobs and prosperity in all parts of the world.

Innovation systems can be described at primarily regional or national level. They typically encompass stakeholders, resources and processes necessary for bringing innovations to market that we depend on for our future. Success or failure of an innovation is shaped by the performance of the innovation system.

There is a need for policies and incentives tailored to the specific dynamics of climate innovations, and harmonized across borders. Policy frameworks must favour low-carbon technologies and stimulate radically increased investments in them. In particular, public funds must be used as a lever to attract commercial investments in climate innovations – without private capital too few climate innovations will reach the global market too late.

In this report, summaries from nine climate innovation system assessments are provided as a reality check. A wide range of issues are identified, such as the weak demand for climate innovations in Uganda due to limited awareness of climate change and available solutions.. The Kenyan study highlights the need for a national platform to exchange ideas and generate collaboration between key stakeholders. Improved collaboration between civil society, knowledge institutions, and the private sector to establish proof-of-concept demonstration and technology-transfer projects is discussed in the report from Ghana. For Tanzania the need for



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further exploring how entrepreneurs can benefit from and capitalise on the international financial facilities for climate change is emphasized.

In the Chinese study the need for a strong and tailored IPR system to secure access to core climate technologies from abroad is addressed, while it is recommended that India harmonize legislation geographically, and employ business experiences from the dynamic ICT sector to increase the dissemination of climate innovations.

In spite of its extensive range of activities to support eco-innovations in Europe, the EU is urged to pay more attention to transformative solutions rather than incremental improvements. And finally, an analysis of the Netherlands' efforts in R&D reveals a need to improve commercialization investments to make them pay off in export revenues, while the Swedish report highlights entrepreneurs' burden of managing extensive paperwork for limited public grants.

Every country and region has its own unique starting point and ability to create enabling environments for climate entrepreneurship. However, they also share a great deal of the challenges and the opportunities gained from strengthening climate innovation systems. To release the full potential of proven climate innovations, policymakers need to geographically harmonize policy environments that strengthen market conditions, and the business community must direct its investments in line with the challenges at hand. Feed-in tariffs offer a proven tool for generating investments in renewable energy. Ambitious targets for specific sectors, in combination with custom tailored financing instruments, have proven to generate substantial investments in energy-efficiency solutions. In combination with the identified measures for awareness-raising and capacity-building, these tools can significantly strengthen climate innovations systems.

"SUCCESS OR FAILURE OF AN INNOVATION IS SHAPED BY THE PERFORMANCE OF THE INNOVATION SYSTEM"

Checklist for high-performing climate innovation systems

- Ensure that basic environmental legal and regulatory systems are in place – including an efficient and widely accepted approach for intellectual property rights.
    - Focus a significant portion of economic stimulus packages and infrastructure investments on development and use of low-carbon technologies and energy efficiency as a method to accelerate both prosperity and global emissions reductions.
- Explore and implement the most efficient policy vehicles (e.g. energy-efficiency standards, feed-in tariffs and tax incentives) as a key government contribution towards accelerated domestic and foreign direct investments in climate innovations.
    - Institutionalize support for climate innovations by ensuring government ownership and accountability through a dedicated ministry or agency with a central role in national planning. Mandate this body to coordinate cross-sector public engagements, sufficient capacity-building and to drive a nationwide technology shift towards climate innovations in housing, transport, industry and agriculture.
- Make sure that standards and targets for energy efficiency and clean energy are set high and favor transformative solutions in public and private procurement, thereby stimulating market demand for climate innovations.
    - Increase transparency and accountability around policy-making on climate innovations, through increased outreach and involvement of civil society organizations and private sector in national dialogue and decision-making.
- Enable stronger support for technology demonstration and market deployment in order to facilitate the survival of climate innovations through the so called 'Valley of Death.'
    - Establish a national platform that facilitates increased awareness of current climate impact and existing solutions, and the collaboration among climate innovation stakeholders. Through this platform, engage in international cooperation to exchange experiences and best practices, and employ climate innovation policies and tools from all over the world.
- Foster and strengthen a collaborative attitude among all stakeholders in the climate innovation system so that more climate technologies are able to serve the global markets.
    - Expand the opportunities for climate entrepreneurs to receive one-stop support from facilitators like business incubators. Reduce administration required for grants, demonstration support and commercialization by encouraging more entrepreneurial policy practices.

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CONTENTS

MEETING THE CLIMATE CHALLENGE THROUGH GLOBAL TRANSFORMATION

Key messages:

- Business as usual CO_2 emissions will guarantee a catastrophe with global repercussions.
- Climate change is more serious for long-term economic growth than any single financial crisis.
- Decisive actions are needed now to start a peak-and-decline transition before year 2020.
- Technology isn't the issue, renewables can replace fossil fuels globally by 2050.
- Climate innovations are available, political will and market frameworks are lacking.
- Concerted efforts from leaders in policy and business can bring jobs and prosperity.

Numerous scientific papers and policy reports published in recent years stress the fact that the planet cannot afford a continued 'business as usual' pathway. The stakes are simply too high; as a civilization we are running out of time if we are to succeed in avoiding runaway climate change. If no new actions are taken to mitigate global warming, the level of greenhouse gas emissions in 2050 is estimated to increase by 70% compared to today's already critical levels.[3] Several well-known governmental- and non-governmental actors – including WWF – have published a numberous CO2 emission scenarios[4].

These scenarios have been analyzed, together with simulations of sustainable emissions pathways, in order to estimate the level of emissions reductions needed by 2050 to avoid dangerous climate change. Although these scenarios differ in methodology and present a variety of required emission targets, they all conclude that continued emissions at today's levels will guarantee movement towards a series of catastrophic events with global ramifications.[5]

To avoid devastating consequences, we must keep eventual global warming below 1.5°C compared to pre-industrial temperatures. For this to be possible, global greenhouse gas emissions must start falling within the next five years, and be reduced by at least 80 per cent globally by 2050 (from 1990 levels)[6]. Reducing emissions to such a great extent and pace requires radical action immediately. A commonly held opinion among actors and institutions is that the point of no return will occur within the next ten years. According to the International Energy Agency (IEA), a delay of global actions within this timeframe will make stabilization of the climate impossible.[7] WWF's climate models show that there is even less time available; requiring comprehensive actions to commence no later than within the next five years – before the end of 2014.[8] Regardless of the exact timing for this point of peak-and-decline, it is clear to all that governments, in cooperation with market actors, will have to show tremendous political will and courage to guide the world to a low-carbon re-industrialization.[9] Such a shift in the world's economic and technological systems needs to be undertaken at a pace never previously experienced in any economic or industry transformation in history.[10] So far, the climate debate has focused on marginal changes to fundamentally unsustainable systems – as opposed to a discussion of how to entirely reconceptualize and construct these systems to meet future demand.[11]

As urgent as it is, social transformation at the level required will take time. Each new addition to housing, transportation, or industrial systems that is not based on or not compatible with new climate innovations will contribute to further locking societies into carbon-intensive infrastructures for decades to come.[12] What is needed today are decisive actions to commence the peak-and-decline transition, towards a low-carbon economy enabled by a massive deployment of appropriate systems and services that produce

3 OECD (2009 A).
4 See for example the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC); The Energy Report by Ecofys/WWF (2011).
5 UNDP (2009).
6 WWF (2011).
7 IEA (2008 B).
8 WWF (2009 A).
9 Harvard Business Review (2009).
10 Ibid.
11 Global Focus (2008).
12 World Bank (2009 B).

low or no greenhouse gas emissions. The longer the wait to introduce these advanced technologies, the higher and more costly the required emissions reductions will be.[13]

The following sections will review available strategies for reducing emissions in an effective and sustainable way, identify key public policy actions and investments needed, as well as discuss how world governments best share the burden and opportunities of mitigating climate change. There are basically three key drivers that determine world CO2 emissions; energy mix, economic growth, and trends in world demography.[14] We will briefly examine each of these drivers.

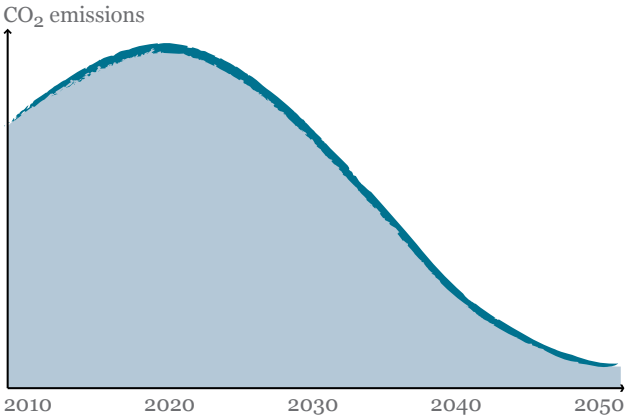


Figure 1: In recent years, several scenario analyses emphasize the need for CO2 emission to peak and start declining before the year 2020.

Enabling the right energy solutions

Energy efficiency

To enable the transition to a low-carbon future it is crucial that we employ the full potential of energy conservation practices. Energy efficiency can be defined as all practices that enable a reduction in the energy used for a service or product.[15] In a business-as-usual scenario the global energy demand will be at least doubled (+100%) in 2050. Energy conservation has the potential to reduce energy demand by -15% by 2050.[16] In fact, energy efficiency constitutes the most time- and cost-effective strategy to reduce CO2 emissions, and it is fundamental for the transition to an energy system with 100% renewables.

The future impact of continued economic growth on CO2 emissions will very much depend on the success or failure of decoupling GDP from carbon emissions. The carbon intensity of world GDP has fallen over the past two-and-a-half decades as energy efficiency has improved. However, statistics show that the positive trend of reducing carbon intensity has stalled since 2000. Recent figures indicate that investments in energy efficiency might be on the rise again.[17] But increasing world population, improved living standards, and consumption patterns pose a severe challenge to this positive trend, as energy demand increases in absolute terms.

To continue the positive trend we must become more efficient on both the energy supply side and the demand side.[18] There is an untapped potential for saving energy in several key sectors - industry, transport, and housing - though barriers currently prevent us from reaping the efficiency benefits.[19] Generally higher up-front costs decrease the cost-competitiveness of energy-efficient technology and products, resulting in unaffordable end-prices.[20]

Governments, in cooperation with market actors, will have to show tremendous political will and courage to guide the world to a low-carbon re-industrialization

To date, only a few industrialized countries have established robust energy-efficiency policies and put relevant measures in place.[21] Yet energy conservation is the most important element in achieving a sustainable, renewable energy future – and in every sector, solutions already exist that can deliver the massive energy savings required. The challenge is rolling them out on a global scale as soon as possible.

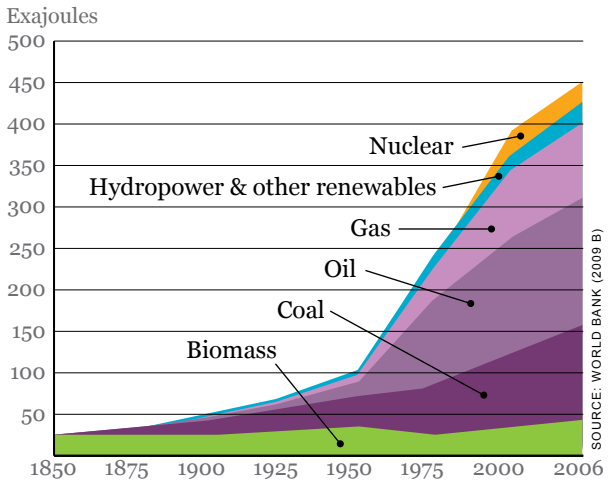
13 UNDESA (2009).
14 World Bank (2009 B).
15 World Energy Council (2008).
16 Ecofys/WWF (2011).
17 UNEP (2010 A).
18 UNDP (2009).
19 World Economic Forum (2009).
20 World Bank (2009 B).
21 UNIDO (2009 B).

The need for a new energy mix

In parallel with world economic growth, demand for energy has been growing since the 1850's, with a steep rise around the 1950's continuing through the present. Without intervention, this trend is expected to continue all through this century as well. Persistent increases in energy use should not necessarily be viewed as something negative. From a development perspective, it indicates that more people are able to improve their living conditions and that the global fight against poverty is achieving results. What determines the level of damaging CO2 emissions causing global warming is the mix of energy sources used to meet global energy demand. Since 1850 the primary energy sources exploited to build cities, warm houses, accelerate transportation and fuel the economy in general have been coal, oil and gas – the three most CO2-intense energy sources in the world. As is shown in figure 2, these fossil fuels have dominated global energy supplies, presently accounting for more than 80 percent of the primary energy mix. By contrast, there is seemingly little interest in low-carbon renewable energy.

The use of nuclear power has increased since the beginning of this century. However, WWF does not consider nuclear power generation a renewable energy source or a viable policy option considering the high risks related to the production process, the unsolved issue of safe containment of nuclear waste, and nuclear weapons proliferation[22].

Figure 2: Historic and present primary energy mix



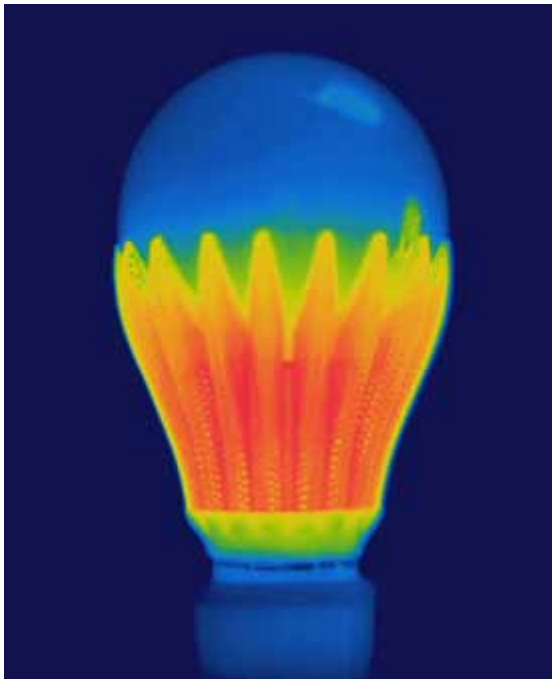
As the world economy and energy demand both continue to grow there is no feasible way to mitigate climate change without drastically decreasing the quantity of CO2 emissions per unit of GDP. There are various approaches to achieve this. In principle, we can:

- Enhance energy efficiency by reducing the energy used for a given service or product;
- Increase the use of clean energy sources at the expense of fossil fuels;
- Decrease the amount of carbon in a unit of fossil fuel through carbon capture and storage (CCS) technology;[23]
- Reduce the level of CO2 in the atmosphere by capturing and storing bioenergy-generated carbon in the ground (BECCS).[24]

While all these approaches will have important roles to play in future emission trajectories, WWF strongly believes that large-scale dissemination of climate innovations is instrumental to enable the transition to a low-carbon future.

This transition needs to start immediately. The current ratio of fossil fuel consumption to cleaner energy use needs to be reversed within the next few decades. Targeted fossil fuel subsidies of $557 billion in 2008 (compared to $43-46 billion to renewable energy and biofuel technologies, projects, and companies in 2009)[25] as well as other public and market regulations that favor carbon energy seriously hamper these efforts. They also enable oil to remain the most competitive energy source. Today renewable energy sources (including solar, wind, and geothermal energy) account for no more than 5 percent of the total energy mix in all the major CO2-emitting countries.[26] In spite of this, opportunities to boost interest and investments in clean energy and in efficiency measures may

22 Read more about WWF's view on nuclear power in "Climate Solutions" (2007).
23 See for example World Bank (2009 A) or McKinsey & Company (2009).
24 See for example Tyndall Centre (2010).
25 IEA (2008 C) and Bloomberg New Energy Finance (2009).
26 World Resources Institute (2009 B).



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New technologies in combination with cleaner energy sources are key for a low carbon future.

emerge as a result of peak oil, which will inevitably result in rising oil production and consumer costs.

There are several reasons why governments and business communities should quickly embark on a low-carbon pathway for energy systems, infrastructure and economies – e.g. protect eco-systems, green job creation, energy security, energy access to alleviate poverty, improved health etc. From this perspective, it is frustrating to find that while renewable energy sources are increasingly acknowledged as having great potential as substitutes for fossil fuels, the use of coal (with the highest carbon content among all energy sources)[27] has grown faster during the last decade than consumption of any other fuel[28]. World governments and the business community need to start leading the way for a rapid transition to a low-carbon economy by enabling renewable energy sources and climate innovations immediately.

Clean energy technologies

Today there are several clean alternatives to climate-damaging fossil fuels. Energy production based on wind, solar and biomass sources is substantially lower or even free from greenhouse gas emissions compared to fossil fuels. While wind and solar power can generate heat and electricity, energy production with biomass has the additional advantage that it can be transformed into liquid to replace fossil-based transport fuels. Imaginative innovations have allowed humans to develop technologies such as solar cells, wind turbines, electric cars, and biofuels, letting us make use of these renewable energy sources. It is widely accepted that technological solutions that directly contribute to reduction of negative climate impact are labeled 'clean energy technologies.' These technologies are crucial to successfully achieving a peak-and-decline of CO_2 emissions and to avoiding dangerous global warming.[29]

Figure 3: Renewable electricity generation (excluding hydropower) worldwide 2000-2008[1]

1 Excluding hydropower.

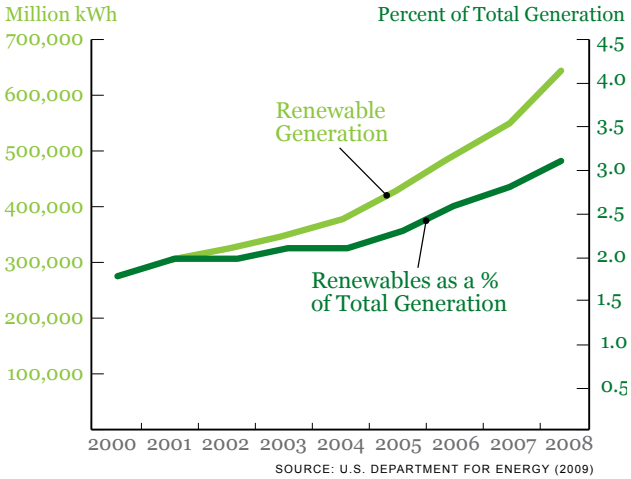
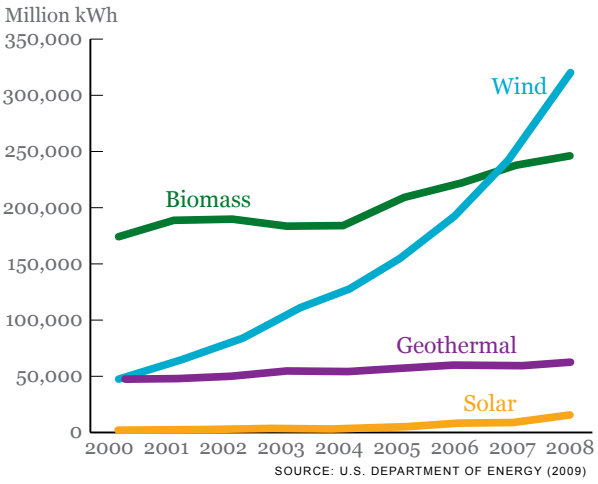


Figure 4: Renewable electricity generation worldwide by technology (2000-2008)



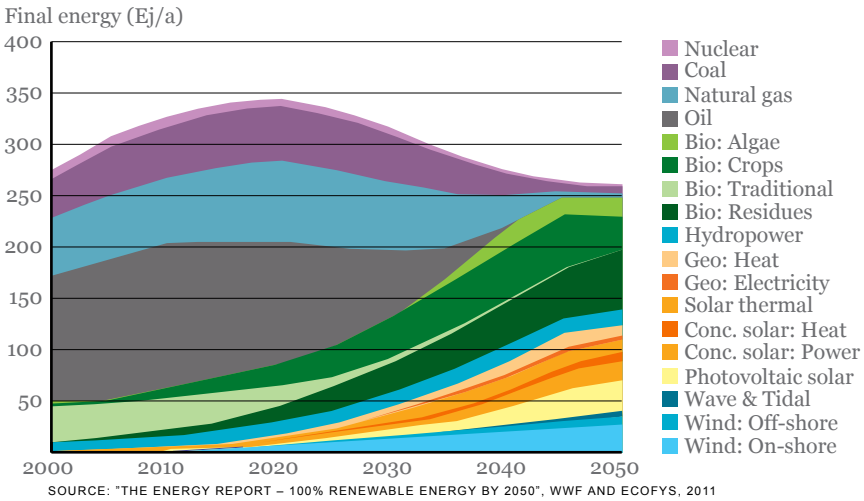
27 World Resources Institute (2009 B).
28 World Bank (2009 B).
29 Roland Berger/WWF Netherlands (2009 A).

Several analyses indicate that renewables could provide almost 100 percent of the global energy demand by 2050.[30] While the next section will review the investments needed to reach such quantities of clean energy generation, one could for now conclude that such a target will necessitate a massive increase from current generation levels. As is shown in figure 3, the renewable electricity production capacity, as well as its share of total electricity generation, has increased steadily during the past decade. In 2010 the share of renewables in electricity generation was around 18%, with 15% of global electricity coming from hydroelectricity and only 3% from new renewables.[31] The trend per energy source as presented in figure 4 reveals that wind and biomass fuels represent the major bulk of clean electricity production, while the potential for solar technology is yet to be realized.

Despite the fact that clean energy is a marginal fuel source in the world energy mix, the average cost of renewables has continued to decrease over the past two decades.[32] From 2005 to 2009, the annual average rate of growth in wind power capacity was 27 percent; solar hot water 21 percent rate; ethanol production 20 percent, and biodiesel production 51 percent.[33] The cost-competitiveness and political interest in these sources need to be further strengthened in order to create a much-needed boost to continued development of the vital low-carbon industry.

The prospects of succeeding in establishing a vast range of different renewable energy sources may seem quite frail, given the gigantic leap required to move away from the traditional energy mix of a few fossil-based fuels. Nevertheless, such a technological transformation is feasible and necessary. The future challenge of supplying energy for 9 billion people, while staying within the boundaries of our planet's resources calls for a variety of solutions – large- and small-scale, centralized and distributed.

Figure 5: Scenario of climate solutions for a sustainable energy mix by 2050



SOURCE: "THE ENERGY REPORT – 100% RENEWABLE ENERGY BY 2050", WWF AND ECOFYS, 2011

Presenting comprehensive modeling and analysis in more elaborate terms in other key publications[34], WWF has made a strong case for clean energy solutions while presenting a feasible scenario for meeting the 2050 emission targets. Figure 5 presents a robust energy mix where traditional use of fossil fuels are quite rapidly phased out and where climate innovations are forcefully diffused and developed for energy conservation and

30 See for example: WWF (2007, 2011) and IEA (2008 B).
31 REN21 (2010).
32 World Bank (2009 B).
33 REN21 (2010).
34 WWF and Ecofys (2011), WWF (2007).

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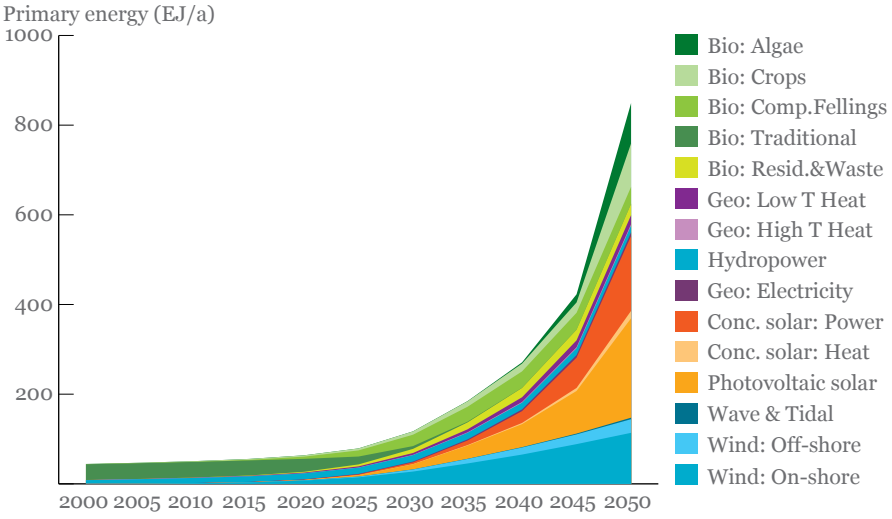
Algae is often seen as an environmental problem but can also be a resource in the quest for sustainability.

renewable energy production. This model illustrates a recently developed energy projection by Ecofys for WWF as a possible solution to the climate and energy security crisis that guarantees continued possibilities of meeting a rising global demand for energy services.

Most of the climate innovations needed are already available today and calculating the development potential of each clean energy source, the total supply of renewables in 2050, could by far exceed world energy demand (figure 6) – what is mainly lacking is political will and enabling market frameworks. An important role for the enabling framework is to create conditions where climate innovations become more economically attractive as well as more sustainable in the coming decades.

Figure 6: Estimated potential of clean energy solutions



SOURCE: "THE ENERGY REPORT – 100% RENEWABLE ENERGY BY 2050", WWF AND ECOFYS, 2011

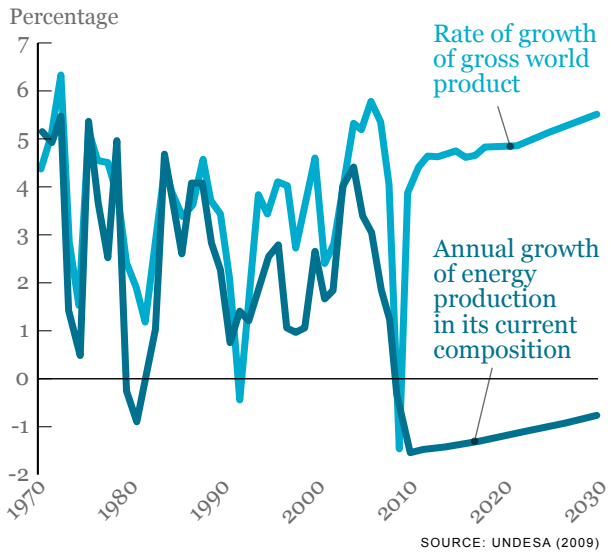
Investments in clean energy technologies

Green stimulus investments

There is a strong link between trends in world economic growth and the total level of energy production. The carbon intensity of economic growth is the most powerful driver of CO_2 emissions. As mentioned above, decoupling GDP from carbon emissions is essential if we are to stay below the 1.5°C target without compromising continued economic growth. In fact, the Copenhagen meeting and the international negotiations leading up to this fruitless conference of December 2009, clearly showed that only a climate solution that ensures continued economic growth stands a chance of becoming politically endorsed globally.

Figure 7 illustrates the strong link between global trends in GDP and energy use, and underlines the need for a complete decoupling between growth and carbon emissions from today onwards.

Figure 7:
The parallel growth of world income and energy use



In the wake of the climate, energy, and financial crises there is high uncertainty about continued growth trends in the coming decades. Up until recently the world experienced one of the longest periods of consecutive growth in history. In late 2007, this positive trend was suddenly interrupted, and today countries around the world struggle with huge national budget deficits as a result of intense efforts to save economies from plunging into the worst economic crisis since the Great Depression of the 1930's.[35] In a very short period the economic crisis triggered huge negative growth rates in development indicators, caused millions of job losses, and resulted in general reluctance to continue engagements in new investment opportunities. The United States lost five million jobs in a period of two years, while the developing world experienced a reduction of around 30 million jobs.[36] A World Bank analysis shows that the crisis caused a halt to poverty reduction, with approximately 55 million people in developing countries failing to rise out of poverty in 2009 alone.[37]

It has proved difficult for the world's leaders to mobilize the financing agreed in the Copenhagen Accord.

As threatening as the current financial crisis is to economic growth, experts stand unanimous in urging governments to realize that the threats posed by climate change are far more serious. Global warming severely challenges the very foundations of our global economy and the developed societies that we live in. While it took only a few weeks for world governments to jointly agree to mobilize one trillion dollars in an attempt to rescue the global economy from collapse, it has proved far more difficult for the same world leaders to mobilize the 100 billion needed annually to invest in climate mitigation and adaptation measures as part of the Copenhagen Accord.[38] In 2009, approximately US$ 3 trillion had been committed by world governments as part of fiscal stimulus packages.[39] By comparison, investments in renewable energy and biofuels technologies, projects, and companies in 2009 were approximately $43-46 billion.[40]

According to IEA:s BLUE Map Scenario for achieving 50% CO_2 emissions reductions by 2050, the global additional investment requirements in renewables and energy efficiency are estimated at US$ 316 trillion, between 2010-2050[41]. This is US$ 46 trillion more than in a Baseline Scenario. However, IEA calculates that the additional investment will yield savings equal to US$ 112 trillion due to energy efficiency and lower fuel prices.

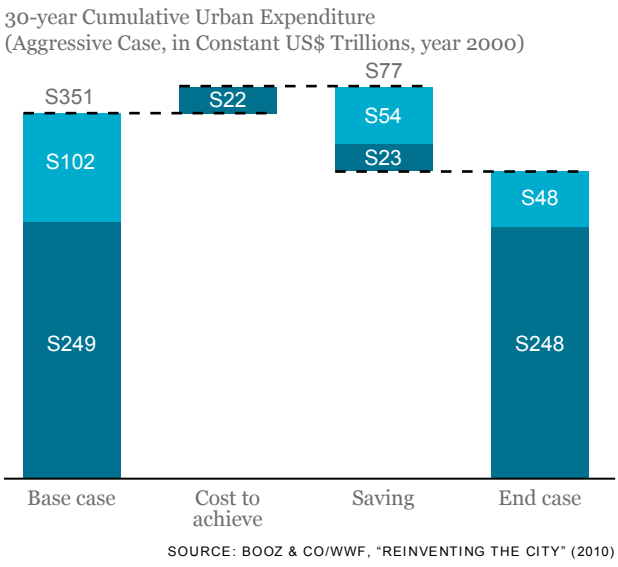
35 World Bank (2009 A).
36 World Bank (2009 B).
37 World Bank (2009 A).
38 Forsberg, Björn (2007).
39 UNEP (2009 B).
40 Bloomberg New Energy Finance (2009).
41 IEA, (2010). See also Stern Review (2006) or WWF (2010 B).

Governments need to ensure that any national stimulus package is based on a green approach, and that spending on urban infrastructure is directed towards climate innovations.

80% of the capital needs to come from private investors, but the market alone will not deliver efficient and clean energy in the time and at the scale required to prevent dangerous climate change. As in any new technology field, government investments are necessary to support R&D efforts and commercialization, and to set policy frameworks that facilitate rapid transition to a low-carbon economy. Policy makers need to find ways to attract capital to make the necessary investments in low-carbon solutions.

Given the great gap between funding requirements and existing low levels of available climate finance, it is crucial that the economic stimulus packages deployed in a number of countries include far-reaching investments in climate-smart technologies and green innovations.[42] Investing in climate innovations and policy contributes to the long-term goals of avoiding runaway climate change and adopting more sustainable lifestyles. Clean energy investments also bring economic gains in the short and medium term. Compared with fossil-based industries, the renewable energy sector constitutes a particularly labor-intense and expanding market, generating job opportunities for millions of people.[43] Examples of win-win investment opportunities that benefit both climate and development goals are increased public funding for climate innovation, expansion of climate-smart railroad systems, and proper insulation of buildings.[44] Clean technologies are increasingly becoming reliable and affordable, and investments in RD&D, the scaling-up, and dissemination of climate innovations are vital to accelerate widespread availability and use. Governments need to ensure that any national stimulus package is based on a green approach in order to stimulate short-term economic gains while at the same time paving the way towards establishing a more climate-resilient economic system.[45] These requirements are valid for governments in both developing and industrialized countries. Governments in countries that lack access to reliable energy services, electrification, or renewable fuels, could push forward investments in climate innovations as key measures to reduce poverty, improve health conditions, and increase standards of living.[46]

Figure 8: Urban infrastructure expenditures and savings with green-tech investments

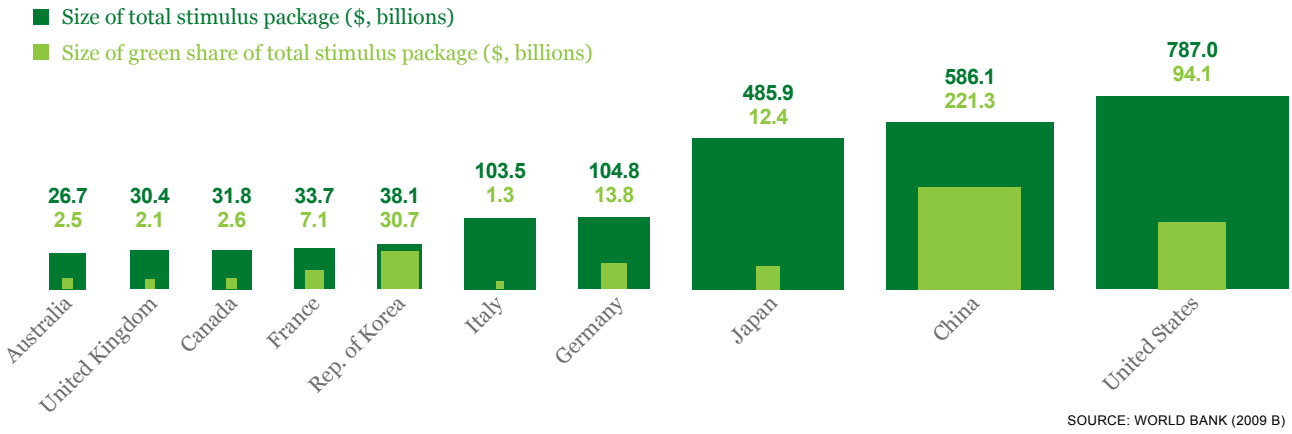


Given the estimated $351 trillion that will be spent on urban infrastructure, housing and transportation over the next three decades, it is essential to simultaneously direct these investments towards climate innovations systems, so that cities can become early adopters and investors in new, promising technologies. Estimates show that upfront investments of $22 trillion in the early construction phase will result in savings of $77 trillion in the usage phase. To a large degree, the keys lie in the status and direction of urban planning, the adoption of climate innovations, and well-targeted investments.[47]

42 UNDP (2009).
43 World Bank (2009 B).
44 Bowen, Alex et. al. (2009).
45 World Bank (2009 B).
46 UNIDO (2009 A).
47 WWF (2010 A).

As shown in figure 9, the clean energy sector is starting to see a flow of fresh public funding. Governments are acknowledging the great potential of energy efficiency and the renewable industry more and more often. Many have begun to include a share of green investments in their financial stimulus packages. Korea, for example, stands out in allocating approximately 80 percent of public investments in green solutions. While in the U.S. and China climate financing amounts to 40 and 15 percent respectively of total stimulus packages.[48] Altogether, total green stimulus investments are far from sufficient, and to date 90 percent of these funds have yet to be released.[49] Furthermore, while having some positive long terms effects, the stimulus package in China is quite far from helping the country achieve its 2020 goal of reducing emissions per unit GDP by 45%.[50] Nevertheless, financing for clean energy and climate mitigation solutions is very welcome, and has the potential to stimulate new innovations and millions of jobs in this expanding sector.

Figure 9: Global green investments in stimulus packages are rising



SOURCE: WORLD BANK (2009 B)

Besides greening fiscal stimulus packages, governments can play a key role in further stimulating clean energy investments through public procurement. In most countries, the government constitutes the largest individual consumer.[51] Underlining the great potential of public procurement, the World Economic Forum notes that with "central, regional and local government accounting for 35-45% of economic activity in all of the world's largest economies, public sector purchasing can be a powerful force. Clean energy use should be mandated in public procurement, which would create guaranteed markets for leading innovators in transport, heat and electricity."[52]

Furthermore, as UNDESA report concludes, in order to really succeed in stimulating and scaling low-carbon technologies, governments need to review current policy interventions and introduce incentives, taxes, and regulations that put a price on CO2, at the same time that they subsidise increased use of climate innovations.[53] Various types of renewables subsidies can greatly enhance the competitiveness of climate-smart solutions - the experiences from such targeted subsidies show considerable success in a number of countries (e.g. Germany and Denmark). Government policies that offer investment opportunities through low-interest loans for entrepreneurs and businesses can help create a market that otherwise might take a very long time to emerge, as well as climb to a scale where significant cost reductions become feasible.[54] A first small step that would generate huge economic and climate benefits would be for governments to remove

48 World Bank (2009 B).
49 UNEP (2010 B).
50 WWF (2010 C).
51 UNDESA (2009).
52 World Economic Forum (2009).
53 Bowen, Alex et. al. (2009).
54 UNEP (2008 A).

existing perverse fossil fuel subsidies, which would lead to annual savings on the scale of US$ 200-500 billion.[55] These funds have tremendous potential if redirected into a more sustainable energy future. Reductions of fossil-fuel subsidies would decrease energy demand while increasing incentives for climate innovations resulting in deep carbon-emission cuts.

Generating green jobs

In the pursuit of making our societies and economic system more climate resilient, there will be need of investments in new solutions (such as retrofitting of houses, expansion of low-carbon infrastructures and smart transportation) for decades to come.[56] Such investments are expected to stimulate a steep future rise in much-needed new employment opportunities offered by the green market sector. Public debate is increasingly acknowledging that research, development, and distribution of low-carbon and high-efficiency energy technologies serve as important drivers for boosting sustainable economic growth. Interest in stimulating green jobs is today high up on many government agendas. Intensified government action to accelerate energy efficiency in energy-intensive sectors such as housing and transport could, with well-developed policy frameworks, generate millions of new jobs in a relatively short time frame.

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On top of a wind turbine blade in expansive Baoding, China.

Green job creation is facilitated through the development of new climate smart technologies and an expanding market for climate businesses. Several studies confirm the positive correlation between innovation, entrepreneurship and job creation.[57] In addition, already existing jobs may be transformed, through retraining or a change in work methods, into green jobs. This happens when established firms and industries that traditionally run operations on inefficient and CO2-intensive energy solutions start greening their work modalities and thereby guard against possible future losses.[58] Governments should consider a range of measures besides direct investments to actively stimulate such creation of green jobs. Developing a clear set of targets and mandates, establishing business incentives as well as scaling up and replicating best practices through genuine public-private partnerships are examples of effective measures at hand.[59]

China clearly stands out as a hotbed of high-expectation entrepreneurship. The indicated number of high-expectation entrepreneurs in China is the highest of any country examined in the world.[60] This means that there are a higher number of entrepreneurs in China who expect to grow and create at least 20 more jobs over the next five year period, compared to anywhere else. Interestingly, there are only 20% as many high-expectation entrepreneurs in India as in China. This is very relevant for the dissemination of climate innovations since a large majority of the low carbon solution providers are small today and their solutions need to grow quickly.

55 For the lower estimate, see UNEP (2009 B) and for the higher, see IEA (2008 C).
56 WWF (2010 A).
57 New York Times (Sept. 11, 2010), WWF (2010 E).
58 UNEP (2008 A).
59 UNDESA (2009).
60 Global Entrepreneurship Monitor (2007)

Some estimates from the U.S industry suggest that $1 billion in government investments in green projects have the potential to create 30,000 jobs in one year. This would be 30% more jobs created than in a traditional carbon-intensive investment scenario.[61] The opportunities are unlimited - the clean energy sector has managed to continue positive growth rates in the midst of a global economic crisis. Today, jobs within the clean energy sector amount to several hundred thousand in several progressive countries. Globally, the number of direct jobs in low-carbon industries is estimated to amount to 3 million, with millions of additional jobs in supplier industries.[62]

Figure 11 presents a breakdown of estimated green jobs in the clean energy sector in 2006, when the total number of people in green employment was estimated to be around 2.3 million. While biofuels have made up almost half of all job opportunities, the wind and solar industries constitute very promising sectors.[63] In fact, the investments in wind energy technology have continued to grow very rapidly, accounting in 2009 for $US 67 billion, while its share of total financial investment in sustainable energy rose to 56 percent.[64]

The estimated employment statistics in figure 11 also clearly illustrate how a few progressive countries have actively invested in policy and finance strategies that have enabled them to establish and expand their clean energy industries and become leaders in climate smart innovations for a sustainable future. Transforming the global climate challenge into opportunities, while sharing the burdens of global warming, is the topic of the next section.

Figure 10: Estimated Employment in the Clean Energy Sector 2006

Renewable Energy Source	World*	Selected Countries	
Wind	300,000	Germany United States Spain China Denmark India	82,100 36,800 35,000 22,200 21,000 10,000
Solar PV	170,000**	China Germany Spin United States	55,000 35,000 26,449 15,700
Solar Thermal	624,000-plus	China Germany Spin United States	600,000 13,300 9,142 1,900
Biomass	1,174,000	Brazil United States China Germany Spain	500,000 312,200 266,000 95,400 10,349
Hydropower	39,000	Europe United States	20,000 19,000
Geothermal	25,000	United States Germany	21,000 4,200
Renewables Combined	2,332,000-plus		

* Countries for which information is available.
** Under the assumption that Japan´s PV industry employs roughly as many people as Germany´s PV industry.

SOURCE: UNEP (2008 A)

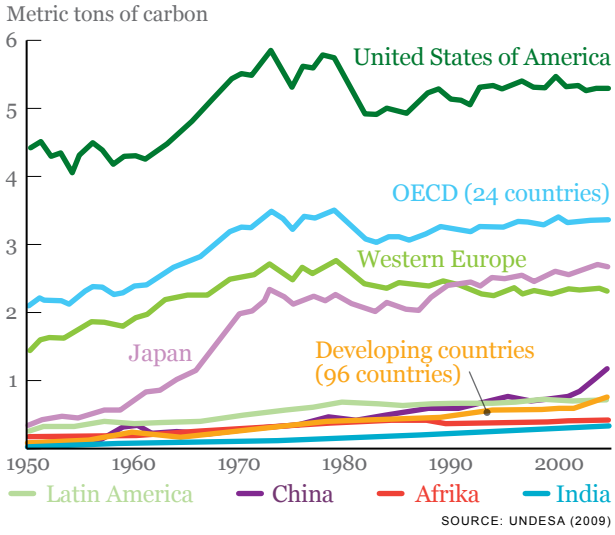
61 World Bank (2009 B).
62 REN21 (2010).
63 UNEP (2008 A).
64 REN21 (2010).

Sharing global burdens and opportunities

International cooperation for a low-carbon future

Avoiding the unprecedented threats posed by runaway climate change will require concerted efforts at international cooperation. After years of difficult climate negotiations, the disappointing outcome from COP15 in Copenhagen in December 2009, painfully reminded us that achieving solid international cooperation is a daunting task. One of the main reasons for the lack of strong global cooperation is the recurring manifestations of a trust gap between today's industrialized and developing countries. This trust gap is caused by a variety of issues – decades of broken promises, lack of political will and leadership, as well as struggles between short- and long-term incentives.

Figure 11: China and India continue to produce low annual per capita emissions, (1950-2005)



All countries have a critical role to play in the much-needed joint efforts to curb global warming. However, the principle of "common but differentiated responsibilities" in the United Nations Framework Convention on Climate Change (UNFCCC) maintains that high-income countries should take the lead in reducing CO2 emissions. The main argument behind this idea is that the developed countries have caused global warming during the past century through high-polluting industrialization and should therefore bear the largest bulk of costs for mitigating climate change. Also, today developed countries continue to produce significantly higher per capita emissions, consuming on average five times more energy per capita than developing countries. The third and final argument for high-income countries to take on a larger share of emission reductions is that developed countries have the advanced financial and technological means to address the mitigation challenges, not least through investments in climate innovations.

All countries have a critical role to play in the much needed joint efforts to curb global warming.

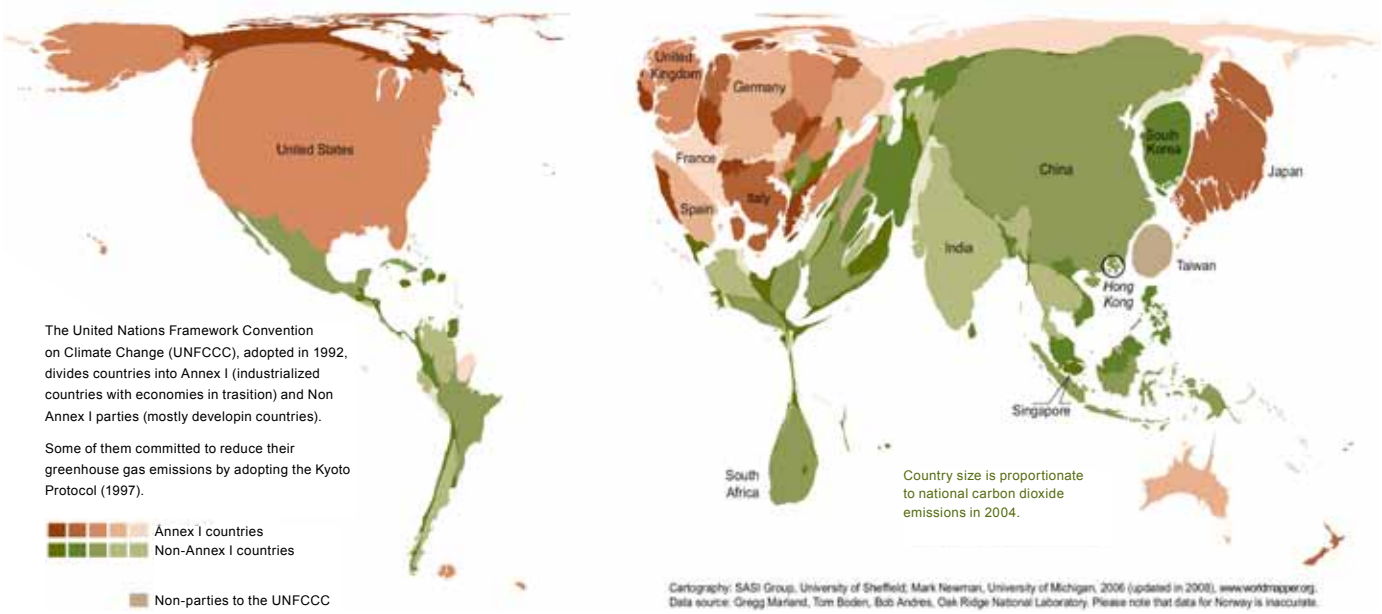
However, even if high-income countries were able to reduce their emissions to zero, it would still not suffice if we are to reach global emission targets by 2050. Industrialized countries cannot do it alone. During the last decades the world has gone through remarkably rapid change, and the traditional division between developed and developing countries does not reflect our current reality. Middle-income countries such as China, India, and Brazil have caught up with industrialized countries and are today responsible for the largest share of total national emissions due to rapidly increasing energy consumption. Estimates show that during the next two decades 90 percent of the projected increases in global energy consumption, coal use, and energy-related carbon emissions are likely to take place in developing countries.[65] However, despite these gloomy emission trends in countries such as China and India it is important to note that middle- and low-income countries generate, and will continue to generate lower per capita emissions when compared to the US and Europe (see figure 12).

Low-income countries are projected to continue to cause low levels of carbon emissions. While rising GDP in these poor countries will increase future energy demand, it is estimated that low-income countries' share of global energy-related emissions will remain low – somewhere near today's 3 percent.

65 IEA (2008 C).

Figure 12: Total CO_2 emissions from fossil-fuel burning, cement production and gas flaring.

As figure 12 illustrates, there are a dozen high-and middle-income countries that account for two-thirds of global CO2 emissions. Their political commitments and financial investments in clean fuels and energy-efficient solutions will be critical to putting the world onto a 1.5°C trajectory.



Energy access a means to combat poverty

"Energy poverty denies people a basic standard of living which should be available for all.[66] 1.4 billion people have no access to reliable electricity.[67] Some 2.7 billion depend on traditional fuels such as wood, charcoal, or manure for cooking and heating – often harvested in ways highly damaging to the environment and used in ways highly damaging to personal health. They pay dearly for dirty energy which results in poor people being locked into a cycle of poverty.

In 2010, the UN issued a report which emphasized that access to sustainable energy is an essential condition to the achievement of the Millennium Development Goals and that by 2030 all people should have access to modern forms of energy.[68] In January 2011 WWF, in collaboration with ECOFYS and OMA, produced the "Energy Report: 100% Renewable Energy by 2050," where eradication of energy poverty is high on the list of recommendations. A sustainable energy future must be a fair one, in which the equal right of every person to benefit from the world's energy resources is recognized. Climate innovations offer the potential to transform the quality of life and improve the economic prospects of billions of people.

Sharing the burden – the only option

While acknowledging the fact that all countries need to play a role in achieving 80 percent global emission reductions by 2050 while bringing millions of people out of poverty, it is clear that constantly seeking comparative advantages in decision-making and investment will be crucial. For example, investments in development and demonstration of climate innovations are far more costly in developing countries than in developed

66 67 Practical Action (2009)
67 IEA (2010).
68 United Nations (2010).

of climate innovations research, demonstration, and development should primarily be carried out in high-income countries.[69] On the other hand, analysis shows that most emission reduction opportunities are found in developing countries. Therefore it has been suggested that at least two-thirds of all climate innovation investments should be carried out in developing countries, where energy-saving measures are estimated to be around 35 percent cheaper.[70]

Curbing climate change is both a shared responsibility and a mutual opportunity. Without global collaboration, the responsibility cannot be met and the opportunity cannot be realized.

To enable a flexible strategy that allows governments to collectively capitalize on the most cost-effective mitigation opportunities, it is essential that governments in high-income countries raise considerable funding for developing-country assistance. It will require massive international transfer of climate innovations to developing countries in order for middle- and low-income countries to leapfrog into climate-resilient development. Such required transfer involves so much more than mere machines and tools.[71] As defined by the World Bank: "Technology transfer comprises the broad processes to support flows of information, know-how, experience, and equipment to governments, enterprises, nonprofits, and research and educational institutions. The absorption of foreign technologies depends on much more than financing physical equipment and technology licenses. It requires building national capacity to identify, understand, use, and replicate useful technology."[72]

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Discussing the anticipated effects of rising sea levels in India.

To date, it has proven difficult to convince governments from high-income countries to commit to such transfers of finance, technology, and know-how – even though it would be in their best interest to do so. Missed opportunities today will end in doubled costs in a future where business as usual is no longer an option for world leaders. In fact, there are no options; the models developed to estimate annual emissions reduction costs until 2050 normally assume a successful international cooperation that allows mitigation to take place wherever or whenever it is the cheapest. In other words, the emission reduction trajectories guiding global decision-making today are already based on the assumption that a large majority of mitigation activities will be carried out in developing countries, no matter where the funding and technology originates.[73]

69 World Bank (2009 B).
70 World Economic Forum (2009).
71 CESifo (2008).
72 World Bank (2009 B).
73 World Bank (2009 B).

CLIMATE INNOVATION SYSTEMS

Key messages:

- Innovation systems are a base camp for explorers looking to find solutions that we need for our future.
- Success or failure of an innovation is shaped by the performance of the innovation system.
- Policy frameworks must favour low-carbon technologies and stimulate radically increased investments in them.
- There is a need for policies and incentives tailored to the specific dynamics of climate innovations.
- Without private capital the world will see very few climate innovations on the global market.

In the words of Lord Nicholas Stern, climate change constitutes the biggest market failure ever in history.[74] The strong messages from the Stern review in 2006 were recognized by world leaders and shaped the global discourse from that point and on. They stressed the fact that our societies had been created on unsustainable structures and norms, and that only far-reaching transformations of social, political and economic systems would help set the course towards safer, climate-resilient living. Thus, it is today widely acknowledged that in order to succeed in curbing global warming we need to come up with smart and innovative ways to solve and manage unprecedented complex challenges. This insight is now starting to bear fruit. A study of national strategies and policy initiatives in ten OECD countries recently showed that governments increasingly perceive climate change mitigation and adaptation as opportunities rather than barriers to continued economic prosperity.[75]

There is a close relationship between innovations, the innovation process through which they are developed, and the innovation system that provides the framework and resources for these activities. Aiming at finding the keys to high-performing *climate innovation systems*, the following sections will examine these three dimensions further, with a particular focus on global dissemination of innovations for the transition to a low-carbon future.

Defining climate innovations

The meaning of *innovation* can be described in many ways. Indeed, the word has become the focus of a whole field of research and is a term used fondly by decision-makers. Typically, innovations refer to new ways of doing something while increasing the value for a customer, producer or user. An innovation might be a significant improvement of an existing product or service or a radical transformation of how a problem is solved or a particular need is fulfilled. According to the OECD Oslo Manual, an innovation is "the implementation of a new or significantly improved product (good or service), or process,

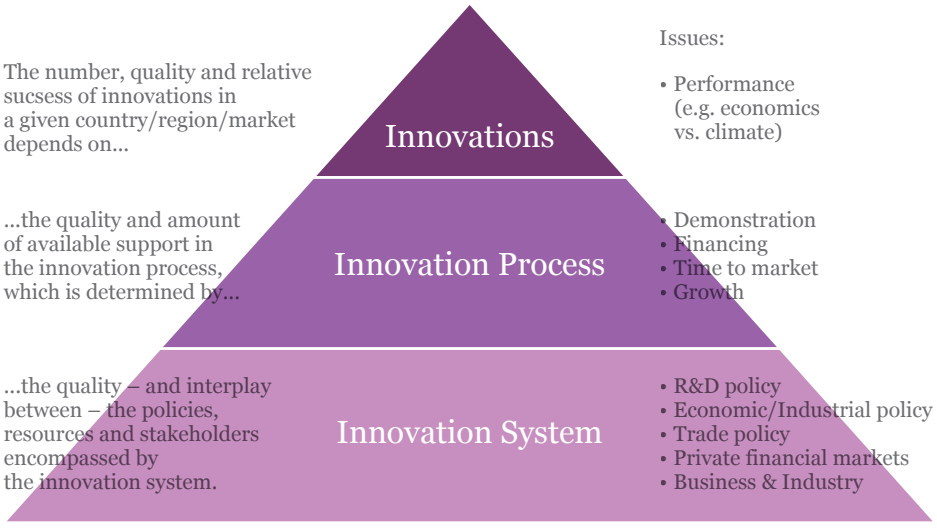


Figure 13: The innovation system is a fundament to innovation processes and innovations.

74 Stern, Nicholas (2006).
75 OECD (2009 B).

© MICHEL GUNTHER / WWF-CANON

The performance of innovation systems are key to employ climate innovations in the fight against climate change.

a new marketing method, or a new organizational method in business practices, workplace organization or external relations."[76] Another option is the definition offered by the Business Panel on future EU innovation policy, which perceives innovations as "the ability of individuals, companies, and entire nations to continuously create their desired future" (2009) A third definition manages perhaps to encapsulate all these aspects of the term in only three words; "ideas successfully implemented."[77]

When innovations are applied in the area of climate change, WWF defines a *climate innovation* as a transformative non-fossil and non-nuclear product, service or system that, given favorable conditions, will generate >20 million tons of annual greenhouse gas reduction in ten years if applied at scale. [78] Climate innovations are often primarily associated with mitigation activities but can just as well be found as adaptation measures in the shape of innovative technologies, collaborations, financing instruments, etc.

76 OECD (1997 B).
77 Prof. Robin Batterham, University of Melbourne and Chair of the IEA Expert Group on Science for Energy, EGSE (2010).
78 Visit www.climatesolver.org to find example of such climate innovations.

Making it through the innovation process

As previously concluded, climate innovations are instrumental for competitiveness, job creation, and a successful transition to a low-carbon future. But the steps needed to turn an idea to a widely-adopted technology are numerous, and only a fraction of all promising concepts make it all the way to the market. This innovation process, i.e. the course of action from initial idea to large-scale market dissemination of a new solution, is commonly illustrated as in figure 14.

The process is divided into a number of stages, including: basic research, testing and development of the idea, business preparation and start-up, as well as market launch and expansion. While each of the stages covered in figure 14 constitute important steps in successfully establishing a new climate innovation, it should be noted that these models reflect a ”textbook version” more than anything else. In real life the extent of time, individual efforts, and investment needs in each of these steps may vary greatly. As will be further analyzed later in this chapter, investment challenges and weak enabling frameworks can easily stall or even put an end to an innovation process, regardless of the stage and how close the process is to large-scale commercialization. . Due to this long and cumbersome innovation process, the time scale for a new technology to penetrate a global market and substitute an existing technology is by default counted in decades rather than years.

Figure 15 illustrates a “real-life version” of the innovation process as perceived by many innovators and entrepreneurs. Contrary to the text-book version, this illustration highlights the great challenge of bringing new solutions to the market. Although global funding seems to be insufficient for R&D on climate innovations, the major obstacle lies in the lack of access to resources that help tested, proven, and commercially available solutions achieve global market penetration. Due to the urgent need for a rapid transition to a low-carbon pathway, WWF puts particular emphasis on this crucial phase in the innovation process. Mobilizing investments and political attention to already existing climate innovations, which are needed to replace conventional solutions is fundamental in the fight against climate change.

What determines the success or failure of a potential innovation is to a large extent the quality, performance, and available resources in the innovation process, which in turn is shaped by the quality of interplay between stakeholders encompassed by the innovation system. We will now delve into the characteristics of an innovation system and the main characteristics of its strengths and weaknesses.

Figure 14: The innovation process - text book version. Typically, the process for developing a product and bringing it to the market is presented as a series of equally long steps. Part of the activities occur before a company is established and before revenue generation, some after.

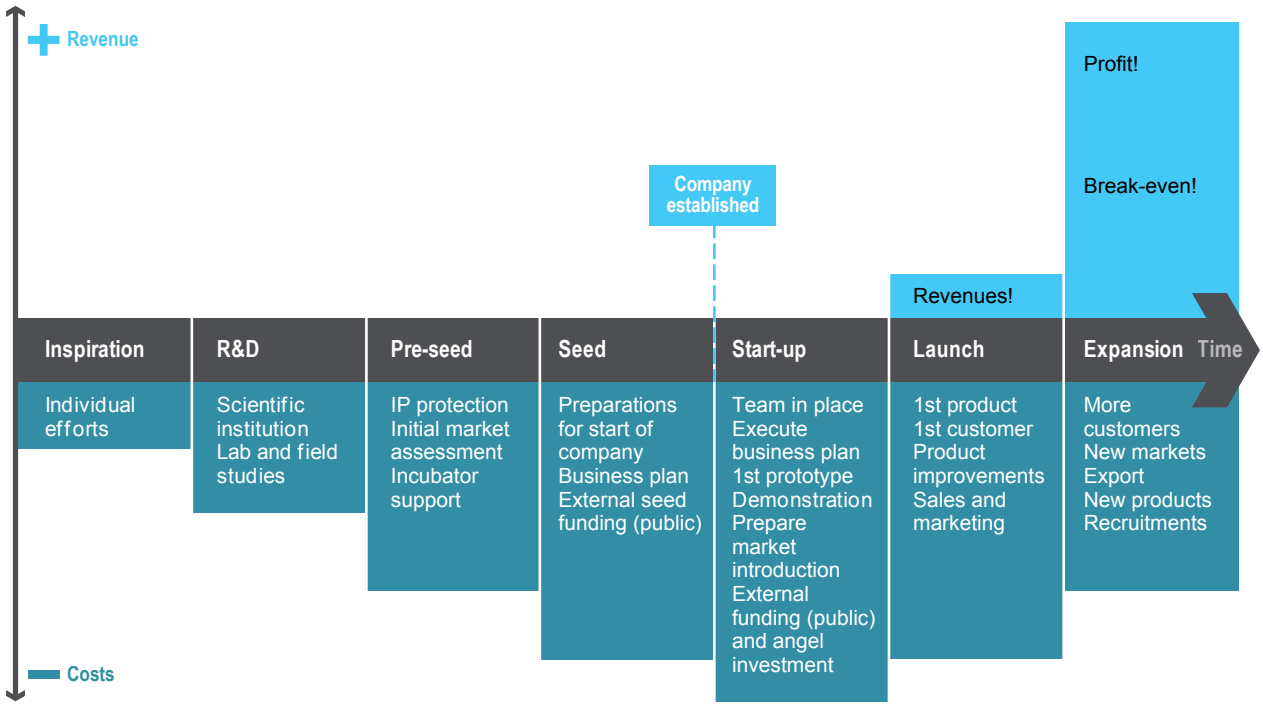
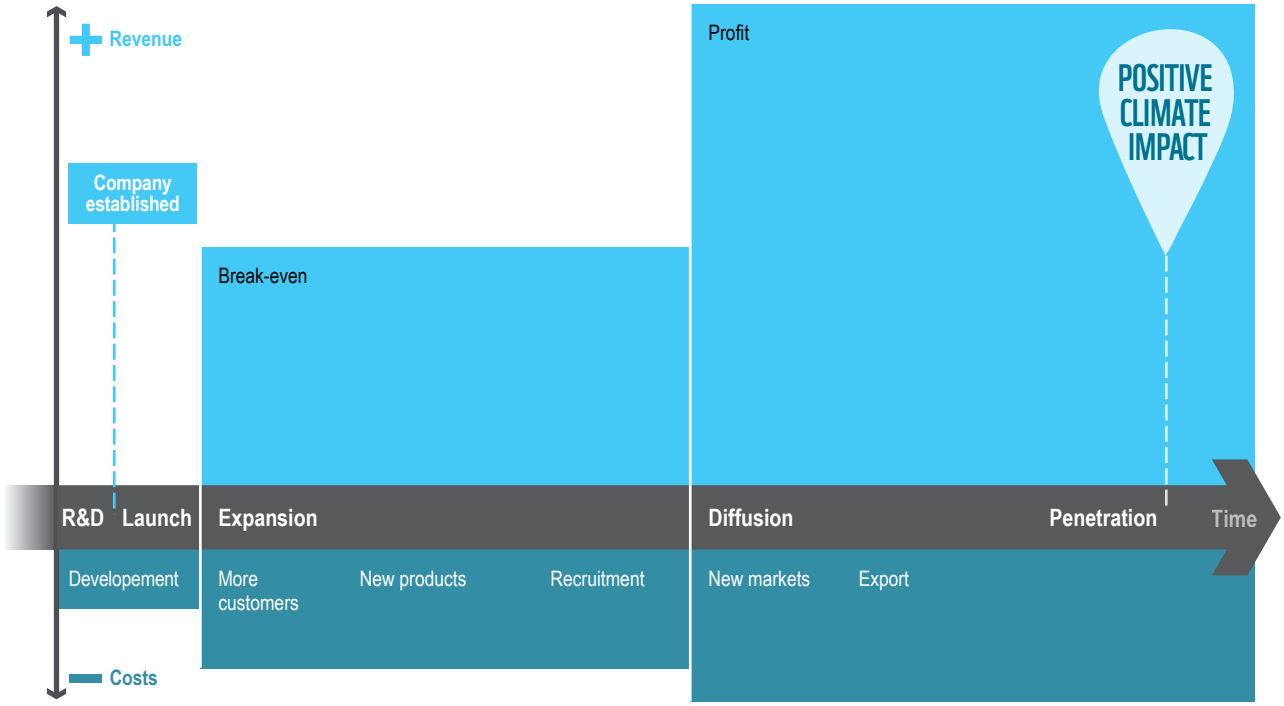


Figure 15: The innovation process – actual version: While the time for the R&D phase certainly may vary, the time for diffusion and global penetration of a new product is measured in decades rather than years. Climate innovations must reach global penetration to have a substantial positive impact on climate change.



The innovation stakeholders

Innovation is the outcome of a complex system that relies on the individual capacity of a multitude of actors, ranging from governments, universities, and research institutes to businesses, consumers, financial institutions, and non-profits. The performance of this diverse set of actors, and how these actors interact, need to be continuously improved, which is as difficult as it is necessary. Before examining the climate innovation system in more detail (as well as the strategies needed to enhance innovations), we will briefly explore the roles and functions of these key actors in accelerating innovations.

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The staff of the Bogoria Bank Community financial services office. Lake Bogoria region, Kenya.

One obvious stakeholder group in the innovation process consists of the extraordinary *inventors* and *entrepreneurs* who create the initial ideas and then apply great effort into materializing them. Without these inspiring and highly-committed people we would be without the great potential of thousands of green solutions and climate innovations, from solar panels to electric cars. Climate entrepreneurs can be independent inventors, or have their base in academia developing innovations from research findings. They can also come from established corporations, forming spin-offs from in-house research and development activities.

However, entrepreneurs do not work in isolation, and cannot succeed without support from other key actors. The *government* plays a very important role in creating the enabling policy environment that promotes necessary investments in innovations, and establishes incentives for technology development and transfer. The use of various types of regulations, financial incentives, institutional reforms and public procurement are all powerful tools, and proactive governments have shown that it is possible to successfully stimulate climate innovations' supply and demand for the benefit of both the economy and our planet.

Knowledge institutions that carry out critical research and gather information about new findings for the use of businesses and entrepreneurs are also significant actors in climate innovation systems. Government commitments to invest in basic research and provide start-up support for low-carbon solutions make new robust climate innovations possible. This collaboration between knowledge institutions and government would include areas that touch the lives of more vulnerable communities in targeting issues like pro-poor, low-carbon energy options, and remote area energy access.

The last but definitely not the least important stakeholder group that is key to a successful innovation process is comprised of the *financial institutions* and public-private partnerships that provide the technology, knowledge, and financial resources needed in order to make it all the way through the innovation chain. These are various types of actors such as large corporations, venture capitalists, banks, industry associations, and technology innovation centres. They all share the objective of identifying and helping entrepreneurs and innovations in the clean technology market flourish, with the promise of high profits for those that do succeed. With a continuously growing clean energy market, more and more venture investors have started to show interest in climate innovations. The number of venture and private equity groups interested or involved in the clean energy sector today is estimated at 1,500.[79] This is indeed an indicator of a positive trend. However, investments in clean energy only account for 10% of global energy infra-

• An invention is a new composition, device, or process.

• Innovation comes from Latin, innovare, "to renew or change."

• An entrepreneur is a person who has possession of a new enterprise, venture or idea and is accountable for the inherent risks and the outcome.

Wikipedia

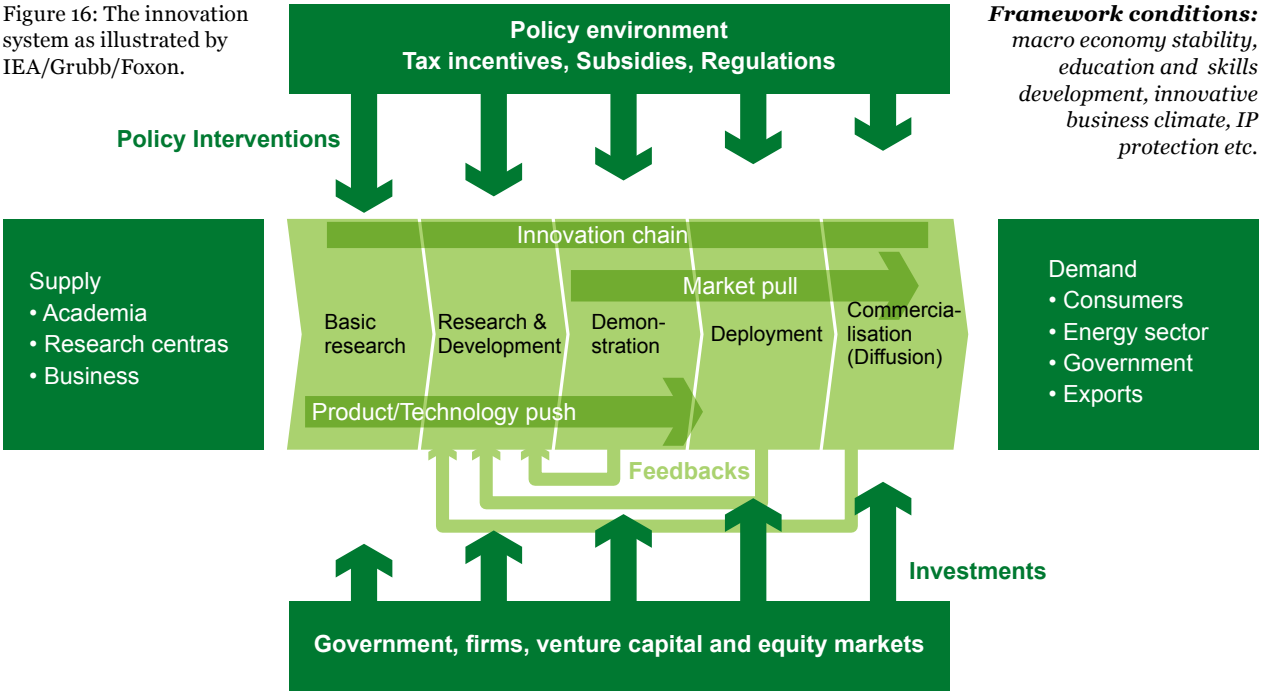
79 World Economic Forum (2009).

structure spending. This fact raises questions about what the remaining 90% is spent on, and how it can be mobilized for the transition to a low-carbon future.

The DNA of an innovation system

All the above-mentioned actors play a unique and crucial role in an *innovation system*, which can be defined as that set of distinct institutions which jointly and individually contribute to the development and diffusion of new products, systems, or services, and which provides the framework within which governments form and implement policies to strengthen innovation processes. As such it is a system of interconnected institutions with the aim to mobilize, store, and transfer the knowledge, skills and resources which are employed in the creation of new products, service and technologies. Many of the components in an innovation system are generic and apply to any kind of innovation, while some are unique factors related to the development and dissemination of a particular sector or technology.

Figure 16: The innovation system as illustrated by IEA/Grubb/Foxon.



Many of the models that seek to visualize an innovation system are based on Dr. Michael Grubb's illustration of such a system – as is the figure 16, with some modifications added by IEA. At the core of the innovation system are the five stages of the innovation chain:[80]

- Basic research;
- Technology- and product-specific research, design and development;
- Market demonstration of technologies to show potential purchasers and users that the technology works in real-world applications, and tests through demonstration of its performance, viability and potential market;
- Deployment through either adoption of the technology by an established firm, or the establishment of a firm based around the technology;
- Market accumulation, in which the use of the technology expands in scale, often through accumulation of niche or protected markets, as well as diffusion on a large scale.

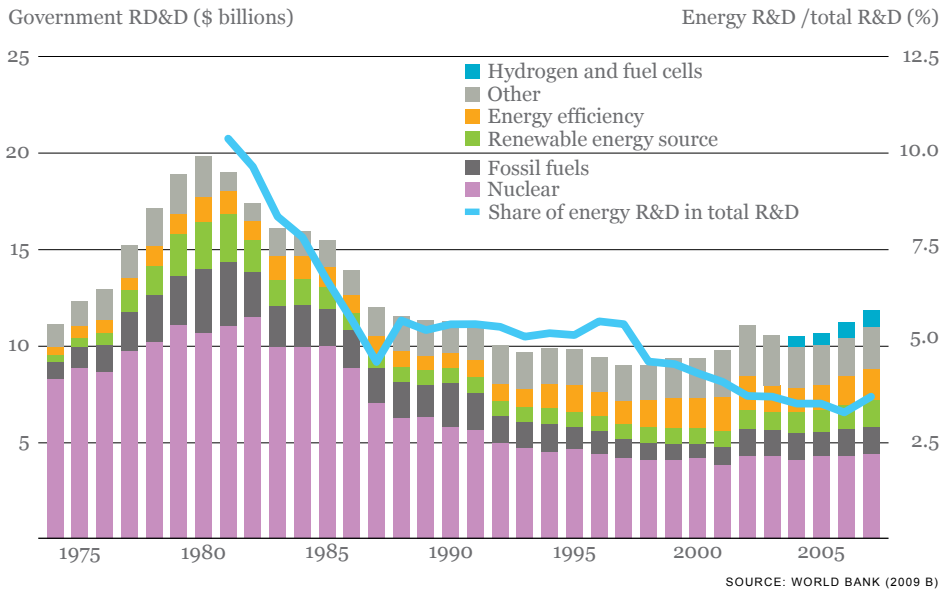
80 IEA (2008 B), Grubb, M. (2004), Foxon, T. (2003)

It is important to note that the innovation process is not as linear as may seem. Rather, the process is very likely to go back and forth between stages at varying pace, as the technology undergoes continuous modification through constant feedback. Furthermore, the first part of the innovation chain encompassing R&D and the last part of the chain, the market stage, are linked and influence each other. The R&D of a particular climate innovation is very much dependent on and shaped by perceived consumer needs and market demands, having what is called a "market-pull" effect. At the same time, it is also true that new attractive technologies have the potential to expand the market and create demand for new products and services. This is commonly called the "technology-push" factor.[81] Both the push and the pull factors need to be properly stimulated through government and market support. While the aim is the same, the government plays different roles and applies one set of tools for stimulating technology-push and other sorts of interventions for market-pull forces.[82]

The role of policy and investments for technology-push

As is illustrated in the innovation system model above, the role of government in shaping the policy environment is significant in each stage of the innovation process. The main tool for the government in supporting technology-push is financial direct investments in R&D carried out by academia and corporations (including introducing tax incentives that stimulate enhanced investments in R&D by industry). The investment needs in basic research as well as specialised R&D are quite intensive, requiring both private and public support. In addition, public financing of R&D has through the years had an important catalytic role in the development of key technologies, and it is clear that governments will need to continue to play such a role in the on-going development of climate innovations.[83]

Figure 17: Government budgets for energy RD&D are decreasing



This should not be perceived as a burdensome task for governments and private investors, however. On the contrary, studies show that investments in R&D – however large they might be – stimulate an outstanding 20-50% return, which is much higher than average returns in many lucrative sectors.[84] The state of California is well-known for

81 UNDESA (2008).
82 Bürer, Mary et. al. (2009).
83 UNDESA (2008).
84 World Bank (2009 B).

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showing exemplary commitment to leading a climate-resilient future. The total public and private investments in R&D and demonstration of climate innovations reached US$1 billion in California in 2007. IEA data stresses that funding for clean energy R&D will need to increase to similar volumes in other countries around the world.[85] The Major Economies Forum on Energy and Climate reinforced this message in 2009, stating that investments need to increase 3-6 times for R&D or even more, particularly for commercialization.[86] Unfortunately, the level of R&D investment flows seems to follow the booms and recessions of the general economy, even though R&D is a key component of refuelling and transforming economies in the long-term.[87]

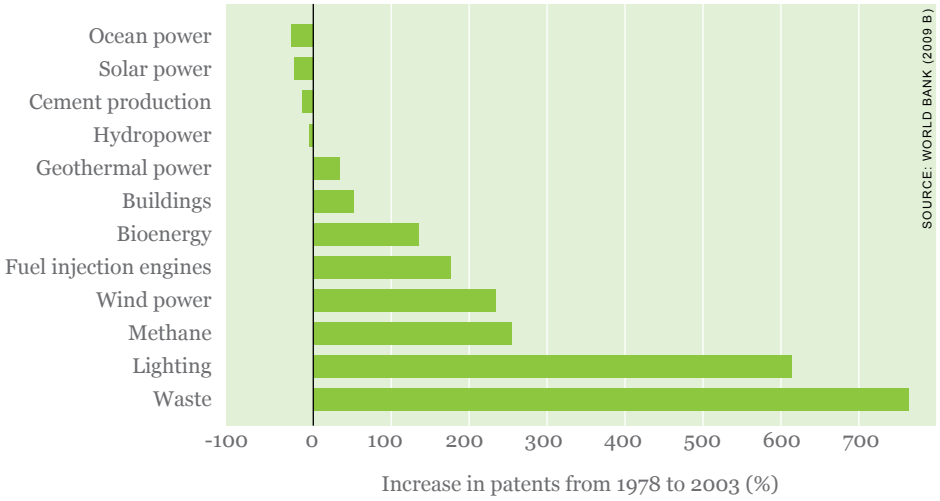
The diminishing interest among governments to finance energy R&D – even less for clean energy R&D – can also be detected in statistics from the past decades, where public investments have seen dramatic decline (see figure 18).[88] Turning this trend around will be a winning strategy among governments, and recent data indicates that public investments in clean energy research and development are gaining speed and volume.[89] Governments should accelerate this positive trend and increasingly focus R&D investment on climate innovation, while phasing out research and development of carbon-intensive technologies incompatible with a peak-and-decline trajectory.

While investments in basic research are done relatively far from any financial returns in the form of market commercialization of a specific technology, access to public funding is of particular importance in the very initial steps of the innovation process. However, only public financing of R&D will not be sufficient for the entire journey through the innovation chain into the market. Private funding is even more important for the commercialization of new solutions, and though such investments are hard to keep track of fully it is estimated that the private sector allocates four to six times more towards energy R&D than total government spending.[90] Additionally, experience shows that the amount of private capital needed for an innovation to become commercially successful on the international market is approximately five times that of public funding. Several expert studies point to the fact that some 80% of the investments in climate innovations need to come from private sources.[91] This indicates that without private investments the world would see very few new solutions on the global market.

85 IEA (2008 B).
86 Major Economies Forum (2009 B).
87 World Bank (2009 B).
88 World Bank (2009 B).
89 IEA (2008 B).
90 IEA (2008 B).
91 For example: UNFCCC (2009) or UNEP/SEFI/Bloomberg (2010).

As a complement to public funding, the private sector is more attracted to financing the development and design of products and systems (rather than financing basic R&D), as corporations and venture investors can capitalise on their exclusive knowledge of market demand and consumer needs.[92]

Figure 18: The pace of patents for new inventions is uneven across clean technologies



Governments can also stimulate investments in research and development by ensuring that the next steps in the innovation chain are clear and reliable. A solid and effective patenting system for intellectual property rights is an important enabling factor that influences the willingness of entrepreneurs and investors to fund R&D of promising ideas and innovations. Issuing patents for newly developed technologies grants innovators a temporary monopoly, allowing them to capitalise on their ideas and reap a return on their investments. The number of patents granted each year is one way of measuring the enabling environment for innovations in the clean energy sector. The picture of patent trends during the last three decades is mixed however, with great variations between different types of technologies. The focus of patents for low-carbon technologies is currently in waste, lighting, methane production, and wind power (see figure 18).

There is also great variation in the number of patents granted at national levels around the world, with the majority of patents issued in only a few developed countries. Several middle and high-income countries still have some significant steps to take before national patent regulation systems are perceived to be sufficiently strong and reliable and the patent application process not seen to be too burdensome. Middle-income countries such as India, China, Brazil, and South Africa have lately made great advances in reinforcement of the individual patent systems, resulting in annual patenting growth rates more than double those of the EU or the United States.[93] The ability to trust that any solution solution that results from R&D investment will be protected from external exploitation is a fundamental expectation from private and public investors. Thus patents are a key factor for ensuring continued and increased public and private funding in the much-needed research, development, and demonstration of clean and effective energy technologies.

Enabling a market-pull for accelerated innovations

Corporations, through development of climate innovations and products, constitute a key link between research institutions and the end market. Meanwhile governments play an important role in funding early R&D, as well as in scaling up the deployment

92 UNDESA (2008).
93 World Bank (2009 B).

of new clean energy technologies in the later stages of the innovation process. On the market-pull side, the government functions primarily in setting an enabling framework, i.e. designing "rules of the game" through three main sets of policy instruments: public procurement, standards and regulations, and tax incentives/subsidies.[94]

As pointed out in chapter 2, the government is a very significant customer through public procurement. By adopting a proactive approach, governments have great opportunities to create and strengthen market demand for clean and efficient energy solutions, especially in market sectors such as housing construction, wastewater management, and transport. Climate-friendly procurement can easily be enhanced by learning from best practices. For example, in Germany and Sweden "green" criteria are included in over half of all tenders.[95] Public procurement should also be used to encourage the development of new and transformative energy solutions. Furthermore, public administrators such as regional governments and cities should actively contribute by participating in the testing and market introduction of these solutions.

Besides taking an active role in the market as consumer, the public sector has the opportunity to shape policy frameworks in such a way that low-carbon technologies and products are favoured over fossil-based technologies. To that end, setting regulations and standards, such as energy-efficiency targets, product standards, and building codes, are some of the most cost-effective measures. This is especially true in the drive towards accelerated energy efficiency, where many governments have adopted national energy saving targets and established building codes that force construction firms to use climate-smart building material and technologies.[96] The requirements should be ambitious and correspond with the transition pace needed to meet the climate challenge.

A third set of policy tools is the use of financial incentives to stimulate demand for climate-smart solutions. This can be done, for example, by subsidising the end-user costs of climate innovations and products while at the same time introducing a tax on fossil fuels and also phasing out fossil-fuel subsidies. These public instruments are of particular importance when it comes to low-carbon technologies since they tend to require particularly high initial investments, which creates disadvantages in competition with established fossil energy. Well-targeted taxes and subsidies are proven instruments in achieving successful market penetration for many emerging innovations, and should be systematically employed in the quest for a low-carbon future. With the objective of supporting market penetration, feed-in tariffs are seen by many investors as a particularly attractive and efficient policy tool. These feed-in laws have been introduced in many countries with convincing results, stimulating investments in climate innovations through ensured price stability and administrative simplicity.[97]

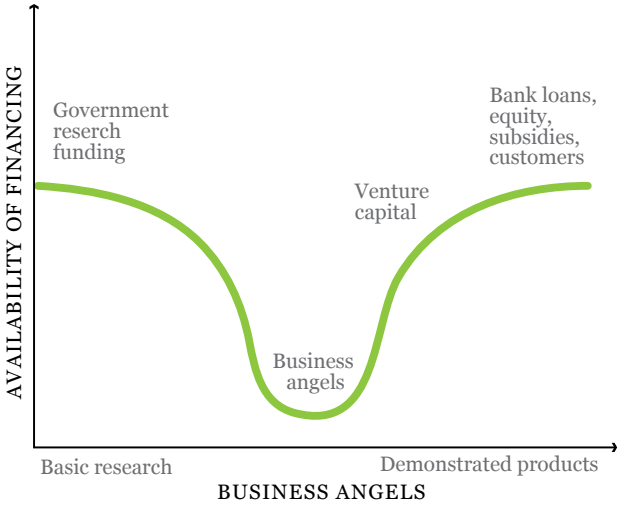
Bridging the Valley of Death

Unfortunately, the combined efforts of public and private actors in stimulating climate innovations through forces of technology-push and market-pull are often not enough to ensure successful commercialization of individual technologies or products.[98] This reluctance creates a funding gap in the innovation chain. As discussed above, both public and private actors tend to invest in the early stages of R&D of clean energy innovations. On the other side of the spectrum, at the market, firms and banks play the most significant role in providing the expansion capital needed. However, it is when moving from concept

94 UNDESA (2008).
95 World Bank (2009 B).
96 World Bank (2009 B).
97 World Bank (2009 B).
98 IEA (2008 B).

to commercial product – i.e. from the often publicly-funded R&D environment towards successful market penetration – that many technologies falter. Making this transition requires substantial investment to establish a company in the market and initiate sales while technical and commercial risks are still high. It's a tough test, and if too many weak spots are revealed, the journey will end abruptly for many endeavours. This is also a passage in the innovation process where funding usually dries up. Many companies are unable to survive this phase, which is why it is commonly referred to as the Valley of Death. Both public and private actors tend to avoid having to finance entrepreneurs in this stage.[99] Figure 19 illustrates the finance gap between early stage R&D and widespread market dissemination.

Figure 19: The Valley of Death between research and the market



SOURCE: WORLD BANK (2009 B)

This financing gap has been found to be particularly deep for the clean energy technology sector due to high capital intensity, and fewer allocated funds, combined with lower competence in this area among actors in the financial markets. In principle, there are a few dedicated stakeholders, such as venture capital investors and business incubators that can facilitate a smoother process through the innovation chain towards commercialization.

When the public funds start to run out and own revenues are not yet sufficient, the climate entrepreneur can open up for investments from *venture capital firms* and *angel investors* (banks and debt financing are rarely available for early stage enterprises). These groups or individuals seek promising technologies and growing companies to invest in, in exchange for shares in the invested business. The aim of course is to stimulate a win-win situation where investors earn a share of the commercial returns while the technology entrepreneur receives the funds needed to get established in the market and escape the Valley of Death.

As mentioned in the discussion above, venture investors have become increasingly interested in the fast-growing sector of clean and efficient-energy innovation. As a result, several new low-carbon technologies have received financial support to make it through the Valley of Death. In 2008 new venture investments in this sector were estimated to total US$ 14 billion - this positive trend managed to be sustained even during the financial turmoil.[100] This is still far from the additionally required investments of US$ 500 billion to achieve only 50% emissions reduction by 2050, not to mention the US$1.4-4.7 trillion per year needed for a transition to 100% renewables in the global energy system.

Access to venture capital needs to be radically improved. Too many climate entrepreneurs are still today faced with funding difficulties. They struggle to attract interest from venture capital funds and angel investors. Accelerating climate innovations means creating an investment framework that results in a low-carbon re-allocation of global assets, attracting investors to the clean energy market despite the occasionally high risks that capital-intensive technologies and significant demonstration costs entail. The commercial and public benefits from facilitating partnerships between climate-innovations entrepreneurs and potential investors are deemed to be immense. The majority of venture capital firms are located in just a few developed countries, far from investment opportunities in several rapidly growing middle-income countries. Increasing global access to venture capital constitutes a great challenge, yet an even greater opportunity.

99 UNDESA (2008).
100 World Economic Forum (2009).

During the innovation process, entrepreneurs committed to developing new clean and efficient energy technologies stand a much better chance of surviving the Valley of Death if offered support in ways beyond funding alone. Receiving guidance on best practices for business and technology development; learning from other professionals; and being able to network with relevant public and market actors are all opportunities that can be of great value for individual entrepreneurs and the innovation process. *Science parks and business incubators* act as facilitators by offering such support while providing several other key services.

Science parks and business incubation centres often build on public-private partnerships, bootstrapping academic research into businesses and technologies. In many countries, these incubators have been established as a result of national or regional government programmes for enhanced innovation and economic development. They offer in-house expertise, tools, and funding to small businesses and entrepreneurs with viable business ideas and plans. The work of these institutions is based on demand-driven activities and they may provide clients with services such as

- Market research, and commercialization strategies
- Links to strategic local, national, and international partners
- Evaluation of investment risks
- Support with public policy compliance
- Access to bank loans, venture capital, and business angels
- Technology demonstration and exposition
- Linkages to local and external R&D centres
- Technology investment and management advice
- Technology forecasting needs
- Patenting processes
- Technology upgrading[101]

The list of services could be made even longer. All around the world (albeit less in developing countries) thousands of small climate innovation companies are being supported by a range of public, private, and public-private facilitators.

Given that there is already a vast number of low-carbon solutions tested, proven, and available, but not yet globally distributed on the market, there is urgent need – and opportunity – for improvements and innovative approaches to address this dilemma. Finding the right means to accelerate deployment and large-scale dissemination of these solutions is a global challenge which will be rewarding for all stakeholders in the innovation systems. Science parks, incubators, and venture investors certainly have a role to play here, as they are well-equipped to develop new supportive instruments for the task. There is also room and the need for other stakeholders to contribute to efforts to bridge the Valley of Death, e.g. government policy making can incentivize the allocation of private capital to early stage investments, large corporations can team with entrepreneurs to bring low-carbon solutions to global markets, and cities may actively employ climate innovations to enable sustainable urbanization, etc.

A discussion around these opportunities is presented in Chapter 5. To inform this discussion, summaries from nine climate innovation system assessments is offered in the next chapter.

101 UNDESA (2008).

REALITY CHECK: ASSESSING THE CONDITIONS IN NINE CLIMATE INNOVATION SYSTEMS

For many years WWF has advocated global action to meet the challenges of climate change. It has become increasingly clear that a vital element in this quest is putting (often existing) technologies and know-how into practice on a global scale. Consequently, WWF has increasingly focused its efforts on raising awareness about the potential offered by climate innovations around the world, and on exploring how to radically improve the conditions for disseminating such solutions at speed and scale. Through the years, many such groundbreaking climate innovations have already had a significant impact on the way we lead our lives. However, there are still numerous more opportunities for accelerating innovative solutions to the complex challenges of global warming.

With the aim to identify best practice and establish a solid foundation for catalyzing improved conditions globally for climate innovations, the national innovation systems in eight countries have been assessed – China, India, Kenya, Tanzania, Uganda, Ghana, the Netherlands and Sweden. In addition the related climate, energy and innovation policies of the European Union have also been reviewed. All studies were commissioned by WWF and completed during 2009-2011.

These particular innovation systems have been chosen with the objective of illustrating a variety of opportunities and challenges in accelerating climate innovations. In this chapter a summary of the findings from each individual case study is presented.[102] The assessments are presented by country, forming the basis for a cross-cutting discussion on how to create high-performing climate innovation systems in Chapter 5: "Global Perspectives on Climate Innovation Systems."

102 The original reports can be accessed in full at www.climatesolver.org.

CHINA

Population: 1,324,655,000 (2007)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 6 538 367
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, China: 4,9194
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2005: 15,9 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: China $ 7,400 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

PHOTO: © MICHEL GUNTHER / WWF-CANON

CHINA

This section on China constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Analysis of Conditions for Development & Deployment of Innovations for a Low-carbon Economy in China", produced by Chinese Renewable Energy Society and Beijing JKD Renewable Energy Development Center in 2010. More elaborate description and analysis of China's national climate innovation system can be found in the full report at www.climatesolver.org.

The devastating effects of climate change on people and communities in China are becoming more tangible every year. With the risk that this negative trend continues and worsens in the future, China needs to achieve a fast and smooth transition towards a low-carbon economy. A key factor determining the level of success in this endeavour is the extent to which China will be able to adopt low-carbon technology innovation as part of the national climate innovations system.

In 2009, China passed the U.S. as the world's largest energy consumer[103], and the economy is in the process of speeding up urbanization and industrialization, both of which are characterized by resource-intensive mining and rapid consumption. Identifying innovative solutions to manage limited energy resources is crucial in order to maintain the sustainability of economic growth. Statistical data[104] shows that since 2000, due to the pull of market demand, the average annual growth of China's output of major products in high energy-consuming industries is more than 10%, and this industry's share of China's total energy consumption is more than 55%. The amount of energy used for each unit of GDP is exponentially higher for China compared to Japan, Europe, and the United States and other developed countries. At present, CO2 emissions from energy consumption in China and the United States accounts for 42% of the total emissions of the world.

A vast range of innovations are available for low-carbon energy generation in China. For the purpose of WWF's report on climate innovation systems, the conditions for wind power, solar energy (PV, thermal power generation), biomass energy (liquid fuel), hydrogen energy (production, transportation and storage), fuel cells, new energy vehicles, and LED were analysed, as they dominate the clean energy market in China today.

The Climate Innovation System in China

The role of the government

In order to promote the development of China's renewable energy, the government has worked out a Medium and Long-Term Development Plan for Renewable Energy in China (1996-2010). This national plan states the following overall goal: "to improve conversion efficiency, reduce production cost and increase its proportion in the energy mix." The Renewable Energy Law, which was adopted in 2001, constitutes the cornerstone of and provides legal protection for the development of new energy industries. It explicitly defines the responsibilities and obligations of the government and society in the development and utilization of renewable energy. Furthermore, the Act establishes a series of systems and measures, including long-term funding targets and development planning, and sets up a special financial fund for renewable energy.

103 IEA (2010 B).
104 Zongyu (2010).

© WWF/RINGO MA

Hong Kong – one of many rapidly growing cities in China.

Through the National Science and Technology Program, the Chinese government channels support towards science and technology R&D. This program, centered on economic development, has made strategic efforts to promote the upgrading of industrial technology and enhancing sustainable technological innovation. The government also works actively with taxation incentives in order to stimulate investments in innovative low-carbon solutions in many different ways.

In 2008, the Ministry of Science and Technology, together with other Ministries, put forward guidance on "Promoting the Setup of Industrial Technology Innovation Strategic Alliance." This welcome alliance will help fulfill the demand for technology innovation of national strategic industries and regional industries, aiming at forming industries and new competitiveness among enterprises.

One of the first pilot test programs within this alliance is trying to work out a credit, responsibility, and interest mechanism for production, study and research, with an aim to jointly develop common key technologies through integration of resources and innovation of industrial technologies. As a leader in industrial technology innovation, it is expected that the alliance will play an irreplaceable role in technology innovation, industrial development, cooperation among the Mainland, Taiwan, and Hong Kong, as well as increasing international communication and intellectual property rights management.

Knowledge institutions

China has made substantial progress in science and technology since its reform and opening to the outside world. The transformation of the tech-research-oriented enterprises as well as the technical organizational restructure of non-profit research

Biogas production in rural China.

© BRENT STIRTON / GETTY IMAGES / WWF-UK

institutions have made great advances. Today it seems that the research-oriented enterprises have become the main bodies of R&D activities in China.

However, many knowledge institutions are seen as having outstanding conditions for doing research, enjoying access to high-quality equipment as well as powerful research forces – a level of capacity individual enterprises can never dream to have. Research institutions are often non-profit organizations funded to a large extent by the government. As a possible consequence, these knowledge institutions tend to focus a lot of their attention on social responsibility, and care more about the environment than profit-making enterprises. The institutions put great effort in developing low-carbon technologies and examining how such technologies might affect social and economic aspects of society - such as energy-consumption patterns and efficient energy utilization, as well as people's general living conditions. As an example, Clean Energy Automotive Engineering Center of Tongji University (CEAEC) is devoted to promoting the industrialization of hydrogen and fuel cell vehicles. The nations' dependence on fossil fuels would be significantly reduced if vehicles in the future could be fuelled by clean energy, thus reducing CO_2 emissions and helping to build a low-carbon society. Another example is the Hydrogen Power Technology Institute of CEAEC, which mainly focuses its attention on the development and utilization of fuel cells and hydrogen technology. The aim of this research is to reduce the cell's production costs and improve its durability, thus promoting the hydrogen energy infrastructure and related key technologies.

The vast number of national knowledge institutions includes national key laboratories, national engineering research centers, national engineering technological research centers, research institutions managed by Chinese Academy of Sciences, and some distinguished research institutions in many colleges and universities. In 1984, the Chinese government put in place a special plan to build many national laboratories. Today there are impressive 156 national key laboratories running all over the country. These research hubs have put many highly-qualified researchers together, and the government has provided the necessary financing for advanced instruments and equipment. With a relatively independent managing capacity, these labs carry out important work in producing, gathering, analyzing, and disseminating research information in the field of clean energy and innovation.

Studies of the R&D sector of renewable energy electricity generation (hydropower excluded) suggests that compared to the whole energy industry in China, the renewable energy sector is involved in technical collaboration with foreign knowledge institutions to a much larger extent. Through these cooperation modalities Chinese knowledge institutions and enterprises are able to access new research fields and markets, and can capitalise on foreign low-carbon energy technologies as well as critical know-how.

Entrepreneurs and the private sector

China has a very large number of enterprises engaged in the renewable energy industry. At present, there are more than 20,000 small hydropower enterprises, with 520,000 employees. There are more than 2,100 solar, wind, and biomass energy enterprises with more than 3 million employees across the country. In addition, over 3,000 semiconductor lighting enterprises employ more than 800,000 people across the country.

Observations from around the world suggest that the enterprises with their own R&D centers also have the strongest capacity to generate and apply new technological innovations. Therefore, it is of high interest to study the various support mechanisms of Chinese business that aim to provide such R&D capacities for small and medium enterprises (SMEs). These institutions are described further in the next section.

Intermediaries and incubators

There's an extensive support service system for technology innovation in China. It includes institutions that could be called intermediaries, such as industry associations, productivity promotion centers, technology development zones, scientific parks and incubators, etc. The main function of these actors is to provide a bridge between the government and enterprises and between technology provider and users, as well as providing a technology and information platform.

Currently, more than 1,000 of China's Productivity Promotion Centers can be found throughout the country. The main function of these centers is to support Chinese businesses in an array of issues, including providing training, consultations on policies and regulations, business diagnosis, investment & financing consultation, as well as intellectual property right protection. Another supporting structure is the existence of Industry Alliances in China. Through the integration of enterprise-college-research and the industry upstream and downstream chain, the aim is to establish a platform for communication and cooperation. On the basis of the enterprises' demand for development and the common interest of all parties, the alliances aim to upgrade the technological creative ability of industries, and form an integrated, technologically innovative, and cooperative organization which can share interests and risks – and can complement the different players' comparative advantages.

Furthermore, China has for several years promoted additional development opportunities for the country's many businesses through technological development zones, science parks, and incubators. Through technological development zones the government is able to promote research and application of high-tech innovative solutions for enterprises, concentrated on specified regional zones. Science parks provide infrastructure and supporting services to Chinese businesses, such as building cooperation with local development institutions as well as universities and research institutions. The science parks also provide critical management support and technology transfer services for small-and-medium-sized enterprises.

The business incubators for small- and medium-sized enterprises in the renewable energy industry provide physical space and infrastructure for these businesses.

The incubators offer a range of support services to reduce risks and entrepreneurial start-up costs, with the ultimate aim to foster successful businesses and entrepreneurs. Taking the Zhangjiang Star Business Incubator as an example, the service system includes the following five categories of support: (1) Providing financial means to grow: Companies that engage in the incubator enjoy supportive policies provided by both central and local governments, such as a large rent subsidies, tax relief, investment funds, etc. (2) Establishment of an "Angel Investment Platform": The platform provides - in advance - prepared equity investments for start-up enterprises that are assessed to have great potential. The platform works to make sure that the enterprises grow along with the incubator. (3) A special fund for new energy start-ups: A special fund that can contribute towards many private ventures and angel investments is dedicated to supporting new energy innovation and entrepreneurship. (4) Improving the investment and financing system: The incubator actively helps enterprises receive various sources of financial support from the government, including venture capital funds and innovation funds, as well as profitable loans. (5) Strategic guidance: With the professional guidance from venture mentors, counselors, and liaison teams, new enterprises receive a helpful hand during their first years of development.

The business incubators play an important role in facilitating low-carbon energy innovation development in China. Hi-tech zones provide effective actions to support the innovation of large- and medium-scale corporations. As an illustration of the crucial role of these national supporting structures, one could turn to the statistics from Baoding hi-tech technology zone. The *Baoding hi-tech new-business service center* has achieved a growth rate of over 50% for three consecutive years.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

In order to further enhance use of low-carbon innovations in China, there is a need to raise public awareness of the opportunities and benefits that come with a low-carbon lifestyle. Efforts to strengthen dissemination should be carried out through, for example, public information campaigns, the media, and school education. However, the difficulty in popularizing low-carbon lifestyles is due to people's living habits, and the high costs of utilizing low-carbon technologies. Therefore, further research on innovative systems for reducing costs of low-carbon energy use is needed. A strategy to increase the use of low-carbon innovations in China may include the development of planning services, management and performance appraisals, and financial instruments to stimulate demand.

Analysing research reports on energy systems in China in the 1990's reveals little mention of renewable energy innovation. This suggests that today's research on low-carbon systems is fairly new and a number of opportunities exist for expanding knowledge and innovation systems in China. One way of seizing this momentum is by establishing a national clean energy laboratory that could focus on enabling breakthroughs in key low-carbon technologies and renewable energy. Such a national hub for high-standard knowledge in this field is necessary to actively cooperate with enterprises and other institutions to popularize new products and encourage private organizations to increase research on innovation systems.

A challenge in the field of research is the perceived scattered approach to knowledge development on clean technology. This makes it difficult to initiate much needed trans-disciplinary and cross-sector R&D projects and programs, which have the

potential to guide China in the path towards a more sustainable low-carbon energy system. Therefore, the government should explore the possibility of establishing a government-funded, low-carbon technology innovation and R & D platform, which can reduce the cost of technological innovation of research institutes and enterprises, and expand the exchange of information at all levels.

Building capacities and increasing resources

Figure 20: Challenges for entrepreneurs in the Chinese innovation system.

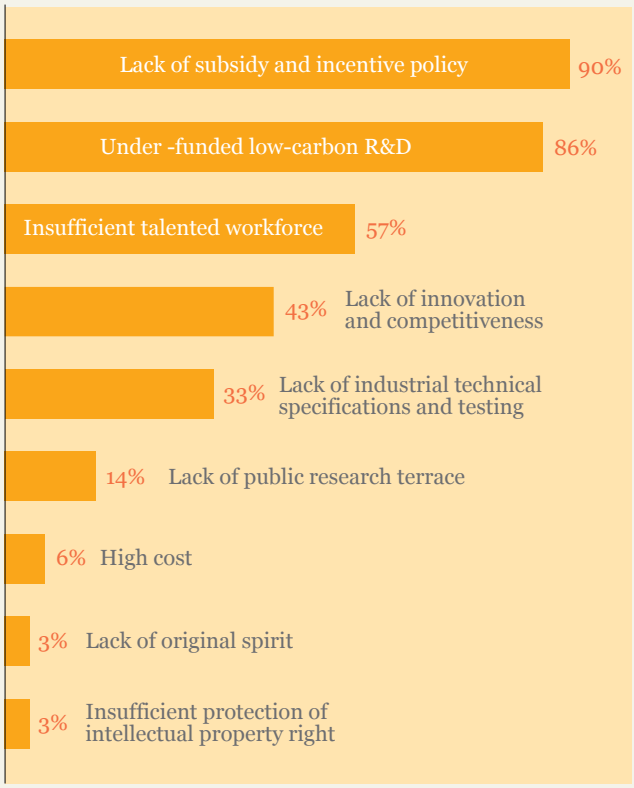


Figure 20 presents existing challenges in the Chinese climate innovation system identified by enterprises interviewed for this study. Turning these challenges into opportunities will determine the success of China's – and the world's! – transition to a low-carbon economy.

Close to 9 out of 10 entrepreneurs interviewed for this WWF research hold the opinion that with current market conditions, investments in low-carbon energy technology do not generate sufficient return in the short term. This results in a heavy financial burden as well as great market risks for individual small- and medium-sized enterprises. Lack of loans and other financing mechanisms, coupled with relatively backward research infrastructures, are the two common problems in the progress of China's low-carbon technology development and innovation. It is clear that there is a great challenge to increase investments in R&D of low-carbon energy technologies in China. Relevant literature in this field[105] shows that in the year 2000, energy R&D investments in China amounted to about 6.34% of total R&D investment, accounting for 0.064% of the country's GDP. Government investments were 10.65% of the total energy R&D investment, accounting for 0.068% of the country's GDP, which was much lower than that of most developed countries in the same period. In terms of absolute amounts invested, China is lagging behind the developed countries even more. In short, China faces a great challenge in stimulating increased investments in energy R&D, as current low levels are the fundamental reason for the lack of energy mainstream technology, along with independent intellectual property rights, and the slow development and high cost of low-carbon energy technologies.

Adding to the challenge mentioned above, 57% of the companies included in this study face the problem of lack of a technologically-talented workforce. There is a need to enhance the number of professional and technical personnel who have innovative capacity and can master core technologies that support technological progress and industrial development. It is therefore important to assist institutions of higher education with the continuous expansion and creation of related disciplines according to market demand, and to create a reserve of high-skilled entrepreneurs and personnel for the low-carbon industry. To that end, there is a similar need to address the lack of adequate business entrepreneurship training mentors, which are deemed to be too few to meet the needs of today's market.

105 A study on Chinese Energy R&D Input, Ma Chi, National Oil Economy, March 2003; Cleantech Group, "10 Predictions for 2010" (2009).

Finally, close to half of the interviewed enterprises (43%) identified the lack of innovation and lack of competitiveness of low-carbon core technology, due to insufficient software and hardware for such research.

Establishing an enabling institutional framework

Despite the positive trend of increasing attention on renewable energy and environment as critical areas of concern in today's Chinese society, the economic inefficiency and high costs have forced the government to revaluate promoting a low-carbon economy. This has resulted in a slow-down of its large-scale industrialization process, and has impaired its international competitiveness. Also, while most institutions for renewable energy research are fall under the management of local governments, institutions for fossil energy are usually attached to the central government. These circumstances all hinder much-needed efforts to promote low-carbon energy innovations in China.

Notwithstanding impressive government efforts to enable development of low-carbon climate innovation systems in China during recent years, there are still challenges in the establishment of industrial technical specifications, standards, and certification systems. Limited access to such frameworks leads to cost-inefficient overlaps and disorderly competition in the market, which causes waste of public resources. So, there is an urgent need to develop quality and safety standards, so as to avoid wasting scarce resources, to protect interests of users, and to safeguard market expansion and development. With the establishment of standardization, serialization, and authentication systems for low-carbon technology and products, the costs could gradually be reduced and the technology could become more available in national and international markets.

Given that the low-carbon industry in China is relatively new and undeveloped it is critical that small- and medium-sized enterprises initiating investments in this market receive support. At the initial stage of business development in the low-carbon industry, enterprises are to a large extent dependent on incentive policies and subsidies, including loans, taxes, selling prices, etc. To meet the needs of such enterprises with high potential, the government should establish and strengthen favorable policies and financing channels for the application and industrialization of new energy technology. Direct support for low-carbon energy technologies is necessary in order to create a level playing field in competition with the continued massive subsidies for the conventional fossil-based energy industry. It is also reflected in research that the intensity of tax incentives is not sufficiently effective in China. This is partly because many rules and regulations are broad, brief, and too principled, without much-needed manoeuvrability. It is important to recognize, however, that many of the rules and policies in this area have just been formulated and adopted, and need to be tested in practice. For this reason it will be necessary to put national frameworks in place that make it possible to regularly track, research, monitor and evaluate government regulations and policies.

Last but not least, many enterprises stress the challenge of long application periods for intellectual property rights. In the low-carbon innovation patent process, it is necessary to: further simplify and shorten the approval time for patent applications; help enterprises convert a patent into productive force in a relatively short period of time; and, at the same time, constantly improve and strengthen patent protection.

Establishing a national platform for coordination and information exchange

The sections above have emphasised the need for increased national efforts to establish a series of industrial alliances and scientific centers to enhance coordinated

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Wind power production site for one of China's 2,100 renewable energy enterprises.

and effective supporting services for low-carbon innovations. These platforms could facilitate useful connections between stakeholders in the innovation system, and ensure access to professional and technical personnel to take part in key processes and services.

The role of incubators in these efforts is of great importance. In order to seize opportunities for increased climate-sensitive investments, the following steps could be taken in the respective fields of renewable energy production:

1. Set up an alliance of solar energy power generation at the Yangtze River Delta, to gather the strengths of relevant corporations, research institutions, universities, etc. The alliance would focus on development and production of photovoltaic cells and generating systems with high efficiency and low cost.
2. Build a new energy alliance along the Bohai Sea in Tientsin that brings together rim corporations, research institutions, and universities mainly to develop and produce thin-film solar cells.
3. Set up a wind power generating alliance along the Southeast coast that gathers climate innovation stakeholders to practice autonomous designs and constructions of wind farms and maritime wind farms.
4. Construct bio-fuels alliance that could mainly take part in the development and production of ethanol, diethyl ether, and synthetic fuel with the association of related corporations, research institutions, and other key stakeholders.
5. Using the same model as proposed above, build up hydrogen energy and fuel cell alliances.

INDIA

Population: 1,150,196,000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 1 612 362
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, India: 1,3844
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2005: 41,6 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: India $ 3,400 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

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INDIA

This section on India constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Indian innovation system – development and diffusion of low-carbon technologies", produced by Centre for Emerging Market Solutions, Indian School of Business, April 2010. More elaborate description and analysis of India's national climate innovation system can be found in the full report at www.climatesolver.org.

As India and other emerging economies develop, energy requirements, per capita consumption and emissions are all expected to increase dramatically. This has raised serious concerns about increased carbon emissions and the effects on global warming. Climate change already takes its toll on many parts of the Indian population. Climate-induced natural hazards such as droughts, floods, and cyclones as well as disrupted rain seasons that destroy vital livelihoods are some of the very tangible effects of climate change in India today.

Despite a global downturn, the Indian economy registered a GDP growth rate of about 6.5% in 2008-2009. The country's greenhouse gas emissions have risen concurrently. Estimates show that while India in per capita terms emits much below the global average, the country is in absolute terms the third largest GHG emitting country in the world. Looking forward, India needs a sustained growth rate of 8-9% over the next twenty years to keep up with population growth and lift a quarter of its population out of poverty. This implies that India will need to increase its primary energy supply by a factor of three to four and to increase electricity generation by a factor of five to six, based on 2003-2004 levels. Energy demand is increasing at a rate of 2.5% annually while over 600 million Indians still have no access to electricity and very limited access to any form of renewable energy. The challenge is to ensure continued economic growth while applying sustainable solutions to environment protection, climate mitigation, and climate adaptation.

India is moving ahead aggressively on low-carbon technologies. The government objective on solar energy calls for 20 GWh of installed solar power generation capacity by 2020. Some progress has already been made in other areas of renewable energy. With 16.2 GWh of installed capacity from mostly wind, but also significant amounts of biomass and mini-hydro power, India ranks 5th worldwide as a producer of renewable energy. In terms of investment, India is ranked 10th among G20 members and constitutes 2% of total G20 investment in renewable energy.[106]

Meeting India's dual challenges of development and sustainability requires an alternative development paradigm. The reconceptualization of development and prosperity needs to be revisited on the basis of ensuring access to basic needs of food, water and energy security in a carbon constrained world through innovations and solutions which are small-scale in nature and addresses the problem of the masses.

106 PEW Charitable Trusts (2010).

The Climate Innovation System in India

The role of the government

India was the first country to have a dedicated Ministry for New and Renewable Energy (MNRE). The Ministry has recently announced India's ambitious Solar Mission mentioned in the section above, and an Energy Efficiency Mission is in the final stages of review.

At the national level, policies are co-ordinated through MNRE in co-operation with several other concerned ministries and departments. At the state level, policies are implemented by dedicated nodal agencies.

The strategy of "low carbon climate resilient development" pathway is well enshrined in India's National Action Plan for Climate Change (NAPCC), which provides a comprehensive framework for addressing challenges of climate change and its impacts, while following a path of ecologically sustainable development. The strategies in the Indian context would require addressing two imperatives – (i) the first is to protect the poor and the vulnerable through inclusive, sustainable development that is sensitive to climate change issues; and (ii) the second is the need to achieve growth objectives through a qualitative change in direction enhancing ecological sustainability and mitigating greenhouse gas emissions. This would require integrating development strategies with adaptation and mitigation strategies.

The government works through a variety of regulatory incentives to promote investments in targeted market areas. Such incentive mechanisms generally follow one of two approaches: a) financial incentives for generating renewable energy (or increasing energy efficiency) and b) requiring state electricity boards to purchase a certain amount of renewable energy. Individual states often have separate additional incentive schemes or vary in their implementation of schemes. Among the financial incentives for energy generation and efficiency improvement are higher tariffs for renewable energy, access to preferential loans through renewable energy development boards, and some grants for collaborative R&D projects with research institutes. Incentives were initially often based on a plant's installed capacity, but have recently taken positive steps towards more strongly emphasizing generated capacity.

In addition to MNRE, the Bureau of Energy Efficiency (BEE) has been particularly pro-active. One of the BEE's most successful programs, the energy star rating, which informs consumers about the energy usage of appliances they buy, was initially implemented on a voluntary basis. Once the BEE could demonstrate consumer demand for a rating scheme (and consumers' willingness to buy higher-rated appliances), it became easier to introduce a mandatory scheme. The approach and the rating scheme were successful enough to warrant an expansion into agricultural and manufacturing equipment, as well as office buildings. BEE appears to rely less on outright subsidies and other financial incentives than it does on other demand-side mechanisms.

Many ministries employ policy guidance and incentive schemes that target low-carbon technologies directly or indirectly. But the process is still on-going, and policy development and implementation vary widely across states. This may create some beneficial competition between states, but it also creates an environment of policy uncertainty as well as barriers for a national rollout of successful technologies by both firms and public institutions.

Knowledge institutions

By the end of the 1980s, India was perceived as having a strong scientific and technological infrastructure among developing countries. However, these knowledge institutions had very limited contact with industry, and were more focused on teaching than on research. Their research contribution has consequently been fairly small. For a long time, graduates found few applications for their skills in industry and emigrated in large numbers. This trend is now reversing, and many emigrants are returning to India, bringing with them new sources of relationships, knowledge, and financing.

There are several technical degree courses that focus on environmental sciences and even renewable energy. Still, so far there are hardly any opportunities to gain degrees in management in these fields. As an example, TERI University offers both technical and management degrees for clean technology and sustainable enterprise. However, the MBA program is geared more towards developing sustainability awareness among corporate managers than towards developing green entrepreneurs (a situation that India, unfortunately, has in common with the rest of the world).

The government of India runs a large network of research institutions, but political and regional development goals have historically often been more important than research productivity in choosing the location of a laboratory. This has led to a fragmentation of already stretched resources, including budgets, equipment, and researchers. The Council of Scientific and Industrial Research (CSIR) has launched an incentives-based program to encourage increased applicability of research, and offers centralized administrative support for patenting and licensing. Despite early successes, the gap between researchers and interested entrepreneurs remains very large. CSIR has also launched the New Millennium Indian Technology Leadership Initiative to work on cutting edge technologies with the expressed goal of collaborating with industry on high-risk projects that might otherwise remain unfunded. To date, among many projects a few energy projects are being pursued, such as fuel cell development and local adaptation of windmill technology.

Entrepreneurs and the private sector

Low-carbon entrepreneurship is still nascent in India, but it is accelerating thanks to increased awareness of both government and investor interest. The low number of companies currently present in the market means there are large-scale opportunities, even for non-technologists. Many current start-ups are focused on adapting existing technologies to Indian markets and/or developing business models suitable for Indian markets. Developing reliable supply and distribution chains is as much or more of a concern as getting the technology right. Currently, many entrepreneurs build their businesses around a technology that they have developed or acquired. More customer-centric business models are likely to result in greater success for firms as well as broader deployment of low-carbon technologies. This includes a focus on “last-mile” issues of reaching customers, collecting payments, and servicing equipment.

There is a growing view that India provides a domestic market for large scale deployment of clean technologies and at the same time has the potential to become a key player globally in providing clean energy solutions that the world needs, especially to the population at the bottom of pyramid.

Entrepreneurs interviewed for the WWF study fell into two camps as far as their perspectives on government and policy-development processes were concerned. One group tried to minimize government contact as much as possible, even to the point of insisting that business models must avoid government subsidies, specialized tariffs,

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Production of jaggery (raw sugar) in Uttar Pradesh, India. The waste material, bagasse, can be used as a source of biomass energy.

or other financial incentives. This group found that the bureaucracy was too difficult to deal with, and that policy-making was too unstable to provide reliable long-term financial predictability. The second group has developed extensive and deep contacts with the government. Some included consulting and research for policy makers in their activities; others relied on relationships for specific negotiations or to give feedback on policies. The closest contacts resulted from the efforts of entrepreneurs to help create a business ecosystem for their particular low-carbon sector.

Sources of financing for the firms in this study were as varied as the entrepreneurs themselves. They ranged from boot-strapping based on existing business, to "friends and family", to business family investors, to venture capitalists. Entrepreneurs in general found it easy to generate interest in low-carbon businesses thanks to the awareness of climate issues. However, they found that converting that interest into capital proved very difficult. Small startups in particular found it very hard to raise capital, and discovered that government funding sources are hard to get and often not worth the effort. They also usually require firms to show revenues or collateral, neither of which most startups have.

Investors pointed out that many entrepreneurs also resist certain forms of funding. Indian entrepreneurs appear to value full control of their companies far more than the American entrepreneurs that venture capitalists are used to. Often, first-time entrepreneurs have skewed expectations regarding the valuation of their company, or they underestimate the responsibilities that come with accepting equity financing from an investor.

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Experiences from the expanding ICT sector may benefit climate innovations in India

Intermediaries and incubators

The Department of Science and Technology's National Science and Technology Entrepreneurship Development Board (NSTEDB) runs a network of 61 technology business incubators. These are all housed in research and education institutions and NSTEDB provides start-up help and funding for the incubators. However, the distance of most Indian academic institutions from applied research and markets is a distinct weakness of these incubators. While none of these incubators is currently focused on low-carbon technologies, around fifteen to thirty clean technology companies are being incubated across the NSTEDB incubator network.

The Technology Development Board and the Department of Science and Technology provide some grants that are available for entrepreneurs wishing to commercialize a technology. However, the conditions for these grants are quite stringent, and the amounts are relatively small. Another intermediary institution, New Ventures India (NVI), was set up with the goal to identify scalable green businesses and to link them with resources, including capital. NVI has a portfolio of 41 companies (2010) in various development stages. They maintain a network of interested investors, provide access to domain knowledge and are setting up a mentoring network. A final example is the Gujarat Cleaner Production Center, which was instituted as an awareness and training center to improve environmental standards in a wide range of manufacturing industries. Part of the center is involved in a World Bank capacity-building project to establish a climate innovation center.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

Universities in India have strengths in engineering & technical training. But with less than 5% of India's R&D spending, universities are clearly more focused on teaching than research. Another caveat for accelerated research is the tendency that even graduates with specialized high-quality training tend to avoid the risks of joining a start-up or a new sector with high perceived risk and prefer therefore to work in the IT sector.

Government research laboratories have significantly higher research budgets than the universities, but still far less than any industrialized economy, which is a particular drawback in a capital-intensive sector. Research in the government labs, like in the universities, remains strongly fragmented and thus difficult to access or accelerate. As a result, research budgets are also diluted. The prevailing culture of pursuing knowledge for knowledge's sake while ignoring application and commercialization of research is slowly changing, but there is still much room for improvement. Agricultural sciences have traditionally had a stronger focus on application and have built networks of farmers to work with. This could potentially be an advantage in terms of, for example, the development of biofuel technologies and the corresponding supply chains.

In a science-driven industry, such as low-carbon technology, there is a tendency to focus on tertiary education. However, basic vocational skills will be equally, if not more, important for the success of low-carbon companies in India. Some of the biggest challenges in the sector revolve around equipment maintenance that can be completed by a technician with rudimentary training.

Building capacities and increasing resources

Early-stage investment is clearly a choke point in India's low-carbon innovation system. The real and perceived technology risks only exacerbate the problem. There is a need to develop creative financing mechanisms and incentives for investors in order to bridge this gap and enable enterprises and entrepreneurs access to start-up investments. One example of such initiatives is the fund that MNRE and CIIE are establishing, which subsidizes returns for private investors. In general, it would be useful to raise seed funds with both government and private investment - there are also a range of other potential mechanisms that could manage and allocate grants to low-carbon technology investments.

In some instances the risks of early-stage investment are so high that private investors will never carry them, e.g., commercialization and prototyping of new technologies. In these cases, the government could step in to reduce or eliminate this risk, or act as a long-term investor itself. The size of such investments should be carefully considered; the current Technology Development Board grants are too small to have the desired impact. A smaller number of large grants would be more effective. Ideally, some dedicated seed funds and preferential bank lending schemes would focus exclusively on low-carbon technologies.

Furthermore, adding to the challenges of India's climate innovation system, activities in specialized low-carbon technologies are few and fragmented. This combination reduces the likelihood of student-run start-ups emerging out of university labs. The lack of specialized training, combined with the young age of the low-carbon sector in India means that few senior technologists are positioned to create start-ups; and few recent (specialized) graduates are interested.

Indian firms traditionally spend very little on formal R&D. This includes many of the entrepreneurs in this study who run fairly low-tech businesses and focus on adaptation of technology and on developing adequate business models. This may also be related to the lack of networks in the sector that would bring together strong teams (business + technology, experience + young entrepreneurs) to run more sophisticated start-ups.

Establishing an enabling institutional framework

India's low-carbon innovation system suffers from many of the same problems as India's innovation system in general. However, problems are often exacerbated by the fact that this is a science-driven industry with high (perceived) technology risks due to a strongly policy-driven industry as well as the long-time horizons and the comparatively low prestige of the low-carbon sector.

Renewable energy standards and other legislation must be properly implemented and enforced if markets are to work. Involvement of very many ministries and agencies in development of policies and regulations, sometimes with conflicting interests, drastically reduces the efficiency and sustainability of the national climate innovation system. These circumstances are confirmed by entrepreneurs and other key stakeholder groups, which stress that MNRE is implementing many different relevant policies, but without a unifying vision. The current dramatic variations in state policies will eventually become a burden to the deployment of low-carbon technologies. A progression to more uniform policies is recommended. The single most important policy issue affecting entrepreneurs remains paperwork reduction. True single-window clearance would improve access to and the effectiveness of many existing schemes. Ideally, a single window would cover both state and federal paperwork.

The weak co-ordination between the state and national government (especially since nodal agencies are often understaffed and underfunded) coupled with the enormous range of different state policies, is a huge challenge in India today. This leads to high regulatory uncertainty, and presents an obstacle to firms who might otherwise scale their operations faster and across all states.

Taking into consideration that the government's development of policies in the area of low-carbon energy technologies is fairly recent, it should also be stressed that the focus areas of low-carbon policies within MNRE are not necessarily targeting the most important issues. For example, grid upgrading, forests, energy efficiency and fossil fuel subsidies all lie outside the purview of MNRE.

Analysis of the enabling environment for low-carbon entrepreneurs shows that despite the multitude of different schemes and incentives, many entrepreneurs feel that qualifying for government benefits is impossible or not worth the effort. General scepticism also leads many to doubt the permanence of the schemes, and they will therefore avoid including them in their business plans. The effectiveness and consistency of the schemes is also in doubt. National uncertainties are exacerbated by global uncertainties about carbon markets. Despite much proclaimed interest, financing for low-carbon technologies is hampered by perceptions of both investors and investees. Venture capitalists and angel investors remain focused on the IT industry and on low-risk, mid to late-stage financing. Entrepreneurs often misunderstand the terms and consequences of a typical equity investment.

Establishing a national platform for coordination and information exchange

At government level, policies and interests in the low-carbon sector often conflict with one another or simply do not work well together. It would be useful to establish

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Climate innovations can reduce India's dependency on fossil fuels and bring a low carbon resilient development.

a strong body or agency that maintains an overview over all low-carbon issues and is located in a power center, such that it has the competence to steer related policies. Such a center-state national platform would also provide strengthened and more systematic co-ordination and streamlining.

In the private sector there is a need of improved policy research and a formal industry consultancy mechanism that could ensure that policy development considers market and financial implications more strongly and more realistically. In the field of R&D, there is a need to provide better access to existing knowledge, research and technologies by all climate innovation stakeholders. It is proposed that an open-source online platform be established, which may include or complement a panel of experts in the low-carbon sector. The platform may be developed in line with the UNFCCC efforts to create Climate Technology Network Centres (CTCN) which will link different existing and new centers of technology development, deployment, and diffusion in various countries of the world.

KENYA

Population: 38,300,000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 11 236
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2.
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, Kenya: 0,2976
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita.
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2005: 19,7 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Kenya $ 1,600 (2010 est.)
Source https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

PHOTO: © FRITZ PÖLKING / WWF

KENYA

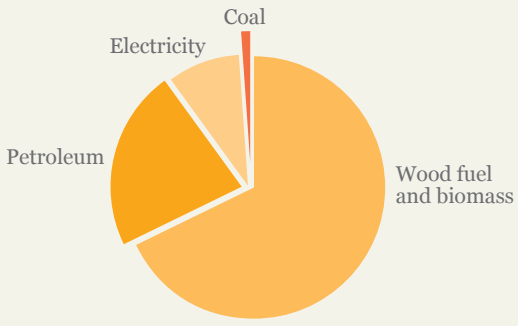
This section on Kenya constitutes to a large extent an extract and analysis of the WWF commissioned national review titled "Climate innovation and entrepreneurship in Kenya", produced by KGroup Consultants and Innogate Aps in 2010. More elaborate description and analysis of Kenya's national climate innovation system can be found in the full report at www.climatesolver.org.

The effects of climate change on the poor and vulnerable population groups in Kenya today are already devastating to millions of lives and livelihoods. Prime Minister Rt. Hon. Raila Odinga has acknowledged that, as a consequence, Kenya's economic development may be impaired because of the negative effects of climate change. This indicates that Kenya has to develop strategies of adapting and curbing climate change urgently to avoid a further drop in the economy. However, in order to succeed with such a considerable endeavour the government and people of Kenya are in great need of capacity building and increased resources in key areas of climate mitigation and adaptation.

For example, according to Kenya's Climate Change Technology Needs and Needs Assessment in the UNFCCC report of November 2005, the country's technological needs are massive. International support and transfer of knowledge, innovations, and technologies are all imperative in order for Kenya to achieve industrial transformation targets by 2020 and eradicate poverty by 6.6% as required by the National Poverty Eradication Plan.

A large number of the climate change mitigation solutions existing in Kenya today are drawn from the private sector. These are entrepreneurs, students and non- governmental organizations that have developed or adopted innovative and cost-effective technologies, which benefit local communities through job creation, environmental protection and energy-efficiency. Kenya is currently grappling with an energy crisis, due to its overdependence on hydro facilities, rapid depletion of forest cover, and lack of investment incentives from the government on clean energy. As a consequence, a power rationing programme has been implemented by Kenya Power and Lightning Company (KPLC), stating the number of hours and days electricity will be provided to those connected to the national grid. This has had adverse effects on businesses countrywide, highlighting the need for clean energy innovations and low-carbon technologies.

Figure 21: Current energy consumption in Kenya divided by energy sources.



ADAPTED FROM: GOVERNMENT OF KENYA (2007)

The Kenya Vision 2030, states that, "Kenya is likely to use more energy in the commercial sector by 2030. Wood fuel and other biomass account for 68% of the total primary energy consumption, which explains the gradual degradation of forest cover in Kenya. Figure 21 illustrates current energy consumption in Kenya divided by energy sources.[107]

107 Government of Kenya (2007).

The Climate Innovation System in Kenya

The role of the Government

Through support to various local and national initiatives, the Government of Kenya is making an effort to reduce greenhouse gas emissions and transform the energy industry by focusing more on cleaner technology solutions. As examples of such efforts the government is currently targeting support to up-scaling geothermal and wind power generation as well as reducing costs of solar and wind energy technologies. However, several weaknesses within these government initiatives can be identified, and there is little collaboration between the government and key stakeholders – such as knowledge institutions and the private sector – in combating climate change.

In Kenya the Ministry of Environment is concentrating on the rehabilitation of the environment, particularly the restoration of the nation's largest forest cover - the Mau Complex - through support to a number of tree-planting projects. The Ministry of Energy works towards promoting equitable access to quality energy services at minimal cost while protecting the environment. At policy level, the Ministry of Energy developed a policy on renewable energy in 2004 titled "Framework for Renewable Energy and Other Forms."

At implementation level, the ministry supports a number of initiatives on clean technology and climate-related innovations. Among these, is the running of an energy centre at Jamhuri Park in Nairobi, providing technical and advisory services as well as training individuals on biogas technologies for management of biomass waste. The government is furthermore funding solar electrification projects in schools in Northeastern Kenya, and in collaboration with the NGO Practical Action, supporting efforts to improve the quality of ceramic cook stoves to create low-carbon cooking tools.

Entrepreneurs and the private sector

There are quite a number of climate innovators and entrepreneurs in Kenya who are trying to capitalise on existing energy-efficient technologies. While many of these entrepreneurs find themselves unable to advance because of insufficient funds or incentives from the government, there are a number of successful examples of local and national initiatives. The following three examples present an illustration of entrepreneurship in climate innovation in Kenya today:

- Martha Wambui is a small-scale farmer, with five dairy cattle, who grows both cash and food crops on a five-acre piece of land. She is involved in biogas production, which was started by Martha's father, who had travelled to India on business and came across the gas production. He travelled back to Kenya and constructed a digester in his home and made many others for individuals and schools in Kenya. Martha took over the business when her father passed away and together with her brother she has now constructed 60 biogas systems, mainly within Central Province in Kenya.
- Kenya Bio- Solid Energy Limited (KENBIO) was started by Lynn Miller, the Managing Director at KENBIO, to promote green charcoal and waste as alternative energy sources. KENBIO has interactions with Columbia University in the US and Scripts University in Latin America, both of which are researching and analysing green charcoal as an alternative energy source.
- Jeremiah Murimi and Pascal Katana are fourth-year students studying Electrical Engineering at the University of Nairobi. They have invented a cell-phone charger that uses energy generated from riding a bicycle. Jeremiah and Pascal have

been able to protect the Smart Charger concept at the Kenya Industrial Property Institute (KIPI), for Ksh. 3000, from their own savings. Jeremiah and Pascal's Electrical Engineering class interacts with students from Massachusetts Institute of Technology (MIT) on innovative ideas.

Although there are a number of individuals and established entrepreneurs in Kenya with innovations with potential to succeed, the high initial costs of establishing new climate technologies on the market is perceived as a major prohibitive factor. If supported by the government, private sector institutions, and NGOs, Kenya would be able to capitalise on a much larger group of entrepreneurs and climate innovations.

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Climate change is causing severe effects, such as drought, in Kenya.

Knowledge Institutions

Knowledge institutions in Kenya are aware of climate change and are working toward integrating climate aspects into education and research. Universities have academic programs addressing sustainable environments and climate change mitigation measures. Students are also encouraged to carry out research on sustainable development projects that address local situations.

The University of Nairobi (UoN) is the pioneer institution of higher education in Kenya. Among its programs, the Department of Architecture has academic programs on sustainable architecture, including Building Science and Sustainable Design. At the department, research and education on energy-efficiency and climate responsive architecture is emphasised and promoted. The Jomo Kenyatta University of Agriculture and Technology (JKUAT) offer an academic program that focuses on environment conservation, construction of biogas plants for electricity generation, as well as energy waste management. While the government generally offers very little financial support for research, these programs have been sponsored by the Ministry of Energy.

Non-governmental Organizations

NGO Practical Action is a good example of a local organisation in Kenya driving the climate change agenda forward both in policy and in practice. Practical Action focuses on innovation of various environmentally-friendly technologies, working to influence policies for wider support and scaling up of technologies, such as micro-hydro. A micro-hydro project developed by Practical Action and the Kenyan Ministry of Energy was piloted in a village north of Nairobi with support from the United Nations Development Programme (UNDP). The project convinced the Kenyan government to include micro-hydro dams as a factor in its renewable energy policy.

The Green Belt Movement is a nationally-based NGO that since 1977 has consistently pursued tree planting country wide - to date planting 45 million trees in Kenya. GBM works with more than 4,000 communities in Kenya to advocate for sustainable management of forests for future generations. The GBM is also in the final stages of becoming registered as a CDM project.

Apart from the above mentioned NGOs there are numerous non-governmental and international actors engaged in climate change issues in Kenya. These include: UNEP, WWF, IUCN, Bill Clinton Foundation, as well as several National Funds for environment and climate change set up by international donors. Among the most common projects are tree-planting initiatives, environment conservation projects, and baseline studies and research on the impact of climate change on Kenya.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

One of the key challenges for knowledge institutions to contribute to climate innovation entrepreneurship is the very limited access to funding for Research and Development (R&D). Research funds given by the government are inadequate to develop innovative solutions through prototypes. Therefore, a large number of these home-grown ideas with high potential face the risk of being shelved in institution libraries. Very few students and academics get sponsored by actors in the private sector, and there is a lack of reward mechanisms and incentives for commercial collaboration. Most importantly, engagement in partnerships with entrepreneurs is usually not rewarded with academic merits - if, say a university researcher develops a climate innovation, the intellectual property rights will remain with the university.

Since there is a weak linkage between knowledge institutions and the private sector and government, the latter stakeholder groups do not benefit from the research findings produced at universities and knowledge institutions all around Kenya. Increased investments in R&D and dissemination of existing knowledge seem to be of extreme necessity in Kenya, if the national innovation system is to be strengthened. Furthermore, the government needs to increase its collaboration with knowledge institutions for policy formulation and decision-making purposes, in order to capitalize on the latest research findings on climate change in Kenya.

Building capacities and increasing resources

As already indicated in the sections above, the lack of finance for entrepreneurs and knowledge institutions constitutes a major challenge in strengthening clean energy technologies in Kenya. There is a general lack of funding to carry out more research on climate innovations. The government offers few funds for research and development of prototypes for climate innovations. Therefore, JKUAT has adopted measures to send funding proposals to international donor bodies as well as foreign

universities. Apart from scarce funding sources, there is also an apparent shortage of equipment and specialised staff at research institutions.

NGOs and CSOs often suffer from similar circumstances, lacking adequate funds to enable them to significantly move beyond test projects to scaling up. As a result, their efforts to accelerate both climate innovation and entrepreneurship risk becoming isolated one-off events without any possibility of replication and outreach. Another challenge identified among NGOs in Kenya is that the programmes carried out by NGOs and CSOs are often fragmented and scattered in many parts of the country, weakening possibilities of potential strong partnerships.

Establishing an enabling institutional framework

Government policy-making processes tend to be slow, with key ministries lacking capacity to formulate policy guidance and regulations for low-carbon technology, renewable energy, and climate innovations. Furthermore, government ministries and departments do not coordinate sufficiently. Climate innovation and entrepreneurship cut across a number of ministries and departments, including private sector development, agriculture, research, and environment and policy development. It is thus critical that there is an increase in government coordination and efficiency in the coming years.

As in many other developing countries, the government has yet to set up a national framework for incentives to encourage development and deployment of climate innovations - technology transfer initiatives, subsidies, and tax schemes. Limited and even lack of technology transfer amongst local institutions is a major hindrance to the country's economic development in relation to climate change. It is therefore advised that steps should be taken with the aim of establishing a national fund to facilitate technology transfer within and outside Kenya's borders. Whether such a fund could be linked to the UNFCCC Green Fund under establishment is a question that should be explored

Due to the lack of collaboration between government and research institutions, as explained above, the government has not been able to establish appropriate nation-wide standards in renewable energy use or development of low-carbon technologies. Likewise, researchers have not been focussing on policy-making procedures and the applicability of research findings to Kenyan societies.

Markets for climate innovation products and services are perceived by many stakeholder groups as underdeveloped in Kenya. As a consequence, many Kenyans are today unaware of local climate innovations or the solutions developed to tackle small and large effects of climate change on daily life. As mentioned, structures that enable access to funding in initial stages of up-scaling climate technologies and innovations are important. This is the same for the system for Intellectual Property Rights (IPR), which is not embraced by many and is seen as too expensive and laborious.

Establishing a national platform for coordination and information exchange

Collaboration among the triple-helix actors is generally too weak to ensure wide-spread and sustained impact in Kenya. However, there are commendable efforts from each of the key stakeholder groups in the climate innovation system as they individually strive towards curbing climate change and improving livelihoods. Information asymmetry is another apparent challenge among the triple-helix actors, since information on climate innovations is not shared amongst the stakeholders for fear of hijacking ideas.

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Improved cook stoves reduce the need for wood fuel by 40 percent in Kenyan homes. Nairobi, Kenya

Kenya does not have any national organization that brings government officials, climate entrepreneurs, and knowledge institutions together to share skills and knowledge on climate technologies. There is a need for a national platform to exchange ideas and generate collaboration on industrial development in general, and on climate innovation entrepreneurship in particular. Another form of national coordination mechanism that is deemed to be useful for the future is the set-up of a research development unit that would aim to promote and coordinate knowledge expansion in Kenya.

Finally, it is important to note that although the government can and should have an important role to play in bolstering investments in climate change innovations, entrepreneurs and other actors should not rely too much on government funding in order to move forward with their ideas and activities. For example, there would seem to be an opportunity for developing a national platform for larger companies to meet small innovative entrepreneurs – with a view in particular to sharing experiences and enabling private joint ventures.

TANZANIA

Population: 40, 600, 000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 6 043
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, Tanzania: 0,1464
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2000: 88,5 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Tanzania $ 1,500 (2010 est.)
Source https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

PHOTO: © STEVE MORELLO / WWF-CANON

TANZANIA

This section on Tanzania constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Climate innovation and entrepreneurship in Tanzania", produced by West Indian Ocean Marine Science Association (WIOMSA) in August 2009. More elaborate description and analysis of Tanzania's national climate innovation system can be found in the full report at www.climatesolver.org.

The Tanzania study reveals that there are a number of innovative activities in Tanzania directly addressing climate change. There are clear indications of collaborative work involving Government, Entrepreneurs, NGOs and Academia. Furthermore, there is general awareness especially in the private sector of the potentials and opportunities that climate change poses for innovation and entrepreneurship in Tanzania. However, there is a lack of clear approaches on how to exploit these potentials and opportunities.

The climate innovation system in Tanzania

The role of the Government

While climate change is an area of concern for Tanzania and constitutes a challenge often referred to in many government-led initiatives and fora, there is to date little evidence of comprehensive action to address climate change at policy or project level. No climate change policy exists and neither is climate change particularly mainstreamed into other policy areas. Nevertheless, the government of Tanzania has been well aware of the environmental problems that the country is faced with for many years, and many policies and regulations have been put in place to address environmental conservation. Issues like coastal erosion, forest degradation, destructive fishing, etc. are well covered at policy level, and are very relevant for adaptation and mitigation of climate change. Furthermore, analysis shows that there are government institutions that have taken initiatives to promote issues such as renewable energy, but these are not run systematically. Such positive efforts were identified by the Rural Energy Agency in the Ministry of Energy in mainland Tanzania and Department of Cash Crops, Fruits, and Forestry in Zanzibar.

The government has initiated the development of a National REDD Strategy in response to the global REDD initiative. There are various programs and projects that are currently being implemented as REDD quick-start initiatives. As a concept introduced in climate change policy negotiations, REDD is a crosscutting issue. It involves various sectors and a broad range of stakeholders in order to bring significant attention to the effects of deforestation and the importance of carbon storage as an ecosystem service vital for mitigating climate change.

Non-governmental Organizations

Several local Non-governmental Organizations (NGOs) are actively engaged in programmes promoting climate change mitigation through climate entrepreneurship. These programmes target a number of relevant areas such as the establishment of biogas plants, the manufacture and utilisation of economy stoves, solar energy installations, and tree planting. Furthermore, strong support from international donors including Sida, DANIDA and GTZ , the NGO community, as well as from several government agencies, make it possible to carry out climate

innovation activities through sensitisation of key stakeholders, and training of trainers in renewable energy entrepreneurship.

Knowledge Institutions

There seems to be very limited initiatives and research on climate change in general and climate innovations in particular within knowledge and R&D institutions in Tanzania. The College of Engineering and Technology, under the University of Dar Es Salaam, is however running a program on innovation systems and clusters where two cluster initiatives are preparing to address issues of climate innovation and entrepreneurship. Within the same University, the Institute of Resource Assessment is supporting the government's work in implementing the REDD program.

Another example of an initiative promoting the use of climate innovations is the work carried out by the Centre for Agricultural Mechanisation and Rural Technology (CARMATEC), which is a semi-state organization under the Ministry of Industries, Trade and Marketing. The Centre is engaged in the design, development, and establishment of biogas plants, solar cookers and solar heating systems, which all constitute important technologies for reducing greenhouse gas emissions as well as for adapting to more sustainable use of natural resources.

Entrepreneurs and the private sector

An analysis of the various climate initiatives among the key stakeholder groups in Tanzania reveals that most activities on climate innovation and entrepreneurship are conducted by the private sector, often in collaboration with local and international NGOs. There are a number of business groups and individuals promoting and benefitting from the use of climate innovations, mostly within the energy sector. Such activities include investments in all types of renewable energy sources - bio-energy, solar, wind, and water power.

Institutions promoting climate innovations in the private sector are the Tanzania Private Sector Foundation (TPSF) and the Tanzania Chamber of Commerce Industry and Agriculture. These institutions are mainstreaming climate innovation and entrepreneurship into their institutional programmes to promote and support climate innovation and entrepreneurship in Tanzania. Such support is channelled as grants, technical assistance, and training in various aspects of climate change and innovative solutions.

PHOTO: © WWF-CANON / JASON RUBENS

Awareness raising and knowledge sharing is important to strengthen the innovation system.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

Public awareness of climate change in Tanzania is quite high. Wide dissemination of climate information as well as personal observations of changes in climatic conditions affecting lives and livelihoods are believed to be among the reasons for such high general awareness. However, this positive trend among the public has not succeeded in raising awareness for the great potential of innovation opportunities and entrepreneurship for climate change mitigation and adaptation. Knowledge institutions can play an important role in developing and transferring research and innovation to entrepreneurs for commercial application. However they are faced with a number of challenges. One such challenge is their limited outreach to communities and markets, which hinders commercial application of existing innovations and new research findings.

In order to strengthen the important role of knowledge institutions in Tanzania and promote increased sharing of information among key stakeholder groups, there is a demand for the establishment of climate innovation knowledge centres ("one-stop centres"). Such centres could play a vital role in the compilation, analysis, and dissemination of knowledge and best practices on climate change and innovations.

Building capacities and increasing resources

Limited access to funding sources, technology, and know-how are deemed to be the most significant obstacles for enhancing climate innovations in Tanzania. Lack of finance is a situation faced by all key stakeholder groups - the private sector, entrepreneurs and research institutions - involved in the climate innovation system, National and local NGOs who are active in the field of climate and entrepreneurship in Tanzania also find themselves dependent on attracting international funding. Though there is no easy solution to this challenge, there is a clear need for government and private sector engagements to establish instruments for targeted funding support to entrepreneurs and other stakeholders in the national climate innovation system. For example, District and Regional Business Councils should promote investments at local levels, while at the national level private sector organizations, NGOs, and support institutions should assist entrepreneurs by providing them with market information and by promoting linkages to potential markets. Considering the possible international support, more needs to be done in order to explore how entrepreneurs in Tanzania can benefit from and capitalize on international financial facilities for climate change mitigation and adaptation.

As mentioned above, it is not only financial constraints that hamper the development of climate innovations in Tanzania. Low access to both technology and explicit skills in key areas are also of great concern. In order to enhance technology transfer from abroad, collaboration between local enterprises and foreign firms and organizations involved in climate innovation should be promoted. Entrepreneurs need to improve their business skills and recognise opportunities that emerge in the effort to manage climate change. Institutions involved in entrepreneur development should become more proactive in disseminating information about best practices in climate innovations while enhancing the competitiveness of enterprises engaged in businesses relating to climate change.

PHOTO: © WWF-CANON / MICHEL TERRETTAZ

Small-scale off-grid energy technologies are part of the solution to address energy poverty.

Establishing an enabling institutional framework

The government obviously has an important role to play in terms of providing policies and incentives to facilitate climate innovation and entrepreneurship. However, neither climate innovation nor entrepreneurship seem to be a particular policy priority in Tanzania, and the few initiatives that are in place suffer from weak implementation and enforcement structures.

The Government of Tanzania would benefit from first harmonizing existing policies to ensure appropriate integration of climate change measures, including entrepreneurship, in the most relevant sectors. Furthermore, many national stakeholder groups are requesting that the government establish consolidated standards, legislation, and a policy on climate change mitigation and adaptation. Finally, while analysis shows that there is currently little dialogue between government and other key stakeholders within the national climate innovation system, such stakeholders should be consulted and engaged in the development of such policy and legislation.

PHOTO: © EDWARD PARKER / WWF-CANON

Preparing biochar in a village near Udzungwa Mountains National Park, Tanzania

Coupled with targeted efforts to enhance the currently poor business enabling and regulatory environment, the government would with the above-mentioned policy efforts be able to stimulate organizations, businesses, and entrepreneurs to invest more in effective climate innovations.

Establishing a national platform for coordination and information exchange

Studies show that a number of institutions and actors from all key stakeholder groups are engaged in the area of renewable energy and climate-change related work. Unfortunately though there is a perceived distance between many of these actors and no apparent national mechanism that promotes cooperation and coordination. Although most ministries, departments and agencies at government level have sections dealing with environmental issues, there is very little coordination and interaction between these institutions.

Harmonization of policies on climate change, climate innovation, and entrepreneurship needs an environment that promotes the inclusion of the government, private sector, and civil society in the policy revision/formulation processes. Such involvement of key actors would be a significant step towards policy frameworks that provide a favourable environment for climate innovation and entrepreneurship.

The key institutions and components comprising the national climate innovations system exist in Tanzania, but they do not reap the benefit of operating as a coherent system with formalised institutional collaboration frameworks. For this reason there is a need to develop a platform that enables better linkages and collaboration among key actors with a particular view to ensure that non-governmental stakeholders can engage in policy development, regulations and the establishment of incentives.

UGANDA

Population: 29,59 3,000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 3 205 Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2 http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, Uganda: 0,1046
Source: Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita (CDIAC).
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2005: 51,5 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Uganda $ 1,200 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

PHOTO: © WWF-CANON/RICK WEYERHAEUSER

UGANDA

This section on Uganda constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Climate Innovation and entrepreneurship research," produced by Makerere University, Innovation Systems Cluster Program-Uganda in 2011. More elaborate description and analysis of Uganda's national climate innovation system can be found in the full report at www.climatesolver.org.

The increasing degradation of natural resources coupled with increasing climate variability and climate change is beginning to have serious negative impacts on the social and economic development in Uganda and the livelihoods of millions of its people. This situation is also threatening the success of the Millennium Development Goals. The effects of climate change are experienced in the form of floods, increasing temperatures, drought, reduced food production, water scarcity, and a drop in water levels in major water bodies used to produce hydroelectricity (Uganda's major source of electricity). Given this and the predicted future climate situation in Uganda, it is vital that the implementation of sustainable climate innovations for adaptation and mitigation is increased. To achieve this, it is important to encourage entrepreneurship.

An array of innovations, both local and foreign, has been developed, and entrepreneurs have been compelled to invest in climate change businesses, which sell climate innovations to the public. However, most of the people who are meant to use these innovations have not yet understood climate change and the relevance of these solutions, which of course has a large effect on the demand for such solutions. There is a serious need for support by the government for effective dissemination of information, for appropriate policies as well as for financial support to innovations and businesses.

The Climate Innovation System in Uganda

The role of the Government

In 2007 a Renewable Energy Policy for Uganda was established along with the government's Policy Vision for Renewable Energy which is "to make modern renewable energy a substantial part of the national energy consumption." The overall policy goal is "to increase the use of modern renewable energy, from the current 4% to 61% of the total energy consumption by the year 2017," To realize these policy objectives, various strategies have been elaborated and translated into policy actions in the form of specific programs within the areas of energy generation, energy services, biofuels, and energy efficiency.

The Ministry of Agriculture has developed some drought and flood tolerant crops that are currently used by famers. More crops are being developed through its research arm National Agricultural Research Organization (NARO). Through NARO the ministry has also developed different water harvesting, storage, and

PHOTO: © WWF-CANON / SIMON RAWLES

Tree planting programs are part of Uganda's response to climate change.

irrigation technology innovations. NARO disseminates the research information through National Agriculture Advisory Services (NAADS) to the famers. However, dissemination of this information is neither wide nor efficient enough., There is, therefore, a need to improve and strengthen the dissemination channels of the available research to improve farmers' awareness of available information.

Entrepreneurs and the private sector

Entrepreneurship in climate innovations is still new in Uganda. Although the need is obvious, the demand for these products is still low and the materials/products are still expensive. Companies selling climate innovations need a lot of support to be able to stay in business and to increase their market share. They need technical support, both in the form of training and machinery, financial support to engage in more research and to improve performance, business skills to position their businesses better, as well as support in the form of community awareness of climate change and its effects. A study where climate entrepreneurs were asked about the type of support they had received to boost their businesses, shows that the level of support to climate entrepreneurs is still low. Out of the targeted businesses 57% responded that they hadn't received any support at all.

One example of existing governmental support is the Ministry of Energy's work promoting and working with businesses that are Promoters of Efficient Technologies for Sustainable Development (PETSD). An example of products promoted is a new models of efficient stoves used for commercial purposes.

However the government would need to increase its support, reduce taxes on climate products like irrigation systems, energy-saving products, efficient technologies and solar products. If these products continue to be highly priced due to high taxes,

their future potential is at risk, given the low income levels of a majority of people of Uganda. The government offers some support, e.g. subsidies on solar loans, and they support famers in acquiring irrigation systems. This has helped some famers, but only a few can benefit at the same time due to financial constraints. Lowering taxes on these products would lead to great improvements in the climate innovation business.

Most of the businesses that are manufacturing in Uganda do their work manually. This is obviously something that affects efficiency in production, and the quality of the products. Because of manual production the demand is sometimes higher than the supply. With increased automation and relevant machinery, production and business could be substantially improved.

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Drought and flood resistant crops are important for Uganda in adapting to climate change.

The entrepreneurs express a great need for development partners and government to fund research in order for them to improve their products and to develop new innovations. Supporting the research of climate entrepreneurs is important, and the fact that they work on the ground, means that they are well suited to identify research needs, and gather feedback from consumers. Their research is therefore focused on the real needs of the community, resulting in the development of innovations that are relevant to current needs.

The biggest challenge all the entrepreneurs face is that a majority of the population has not yet understood the concept of climate change. It follows then that people don't see why they would need climate innovations. Climate entrepreneurs believe that until people have a better understanding of climate change - how it affects their livelihood, how some traditional methods contribute to increased climate change effects - people will not find climate innovations relevant.

A good marketing strategy for these businesses in Uganda has proven to be demonstrations allowing people to see the practicality of a particular innovation. However, this type of marketing is resource intensive and requires support in order to be carried out effectively. It could for example be done with the help of civil society organizations regularly meeting with the community

Knowledge Institutions

Just one-fourth of the approached higher institutions of learning in Uganda were engaged in any kind of climate change research. Some of this research has generated innovations for climate change adaptation and mitigation. The universities engaged in climate research were all government Universities. The private universities approached had no climate-focused research. This shows that although climate change has become a major threat, academia in Uganda has not given it the required

attention to ensure that its effects are reduced or prevented. Consequently there is a need to get academia more involved in climate change research and innovations.

Of the climate innovations developed at the institutional level there are many in the areas of energy, water harvestings, seeds, and pest control, among others. However, the challenge is that most of this research has not yet been developed into business. Out of these climate innovations few (5%) are actually disseminated to business. This is due in part to the limited collaboration that exists between businesses and knowledge institutions. The focus on climate innovations is still small and there is a real need to promote them and to encourage businesses to engage in climate innovation with the support of knowledge institutions.

There are however some examples of knowledge institutions cooperating with business. The Centre for Energy and Energy Conservation (CREEC) has established a link with businesses by training people how to make and use the innovations. However, this collaboration needs to be strengthened and supported to ensure that the approved innovations are being translated into business. Another example is the Innovations Systems and Cluster Program-Uganda, an outreach project with the aim to increase competitiveness of businesses using the triple helix concept that allows business, academia, and government to collaborate to improve the competitiveness of businesses. Businesses doing similar work form clusters and work together, with a secretariat to guide them and provide linkages as well as training to enable better performance. Out of the 30 clusters in the program, three are involved in climate businesses

Non-governmental Organizations

Civil society organizations in Uganda play an important role in disseminating information to the community and identifying innovations which they train the community to use. Today the collaboration of businesses with civil society organizations is poor, yet these organizations are the ones that have contact with the community. All businesses interviewed stated that there is still a knowledge gap among the people, as they have not yet understood climate change, these innovations, how they work or how they benefit the people and the community. Facing this challenge, businesses cannot afford to work alone to promote the innovations. They need to develop a strong collaboration with civil society organizations to create awareness about available climate innovations.

The National Association of Professional Environmentalists (NAPE) and its partners have launched an awareness campaign about climate change. NAPE identifies innovations, promotes them and trains people in how to use them.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

Uganda has a great number of climate innovations, both local and foreign. There are also many at the research phase in knowledge institutions. These innovations are related to mitigation and adaptation to climate change for example, drought-resistant seed and crop varieties, water harvesting, irrigation and energy systems, tree planting, climate change monitoring, energy efficiency, and energy-saving technologies. However there is a need for better dissemination of the findings, and for transforming innovations into business. The link between business and knowledge institutions thus needs to be strengthened. Due to the technical nature of business this link is very important and development partners can facilitate this process.

A big challenge is awareness raising, to make people understand the causes and effects of climate change and hence the relevance of climate innovations. In order to reach individual customers, businesses in Uganda mainly rely on support organizations. Development partners, civil society organizations and businesses can work together to create awareness about climate change and the innovations available to mitigate climate change or adapt to it.

Building capacities and increasing resources

Support to climate change entrepreneurs - i.e. technological support, marketing, financial support for research - is still very limited in Uganda, yet the entrepreneurial focus is still young. The entrepreneurs are struggling to break through to the market. The marketing models are still not well established, and most of them are relying more on development partners, government, and civil society clientele. The entrepreneurs need to develop sustainable marketing models to appeal to the general public and thus create a demand from individual customers rather than being dependent on support organizations.

Climate entrepreneurs need to be supported in form of machinery, technical training to improve skill and quality of products, financial support for research, and business skills, including development of marketing and business models leading to financial viability.

Establishing an enabling institutional framework

Although Uganda has developed some supporting policy frameworks, for example the Renewable Energy Policy, these frameworks are not yet fully implemented. Therefore they do not adequately address the issues of climate innovations, support, and dissemination of climate innovations at entrepreneurship level. There is yet no overall climate change policy in place, thus no policy framework through which the National Adaptation Plans are being implemented, something that negatively affects entrepreneurs.

The authors of “Climate Innovation and entrepreneurship research” recommend the Ugandan government to reduce the taxes charged on climate products and raw materials. The government has launched a scheme where it partners with financial institutions to provide solar loans based on a 30% government subsidy.. The scheme is appreciated as it has increased the use of solar energy, but not everyone who wants to use solar is interested in taking loans. Therefore it is recommended that taxes be lowered which would reduce prices and make it more affordable to acquire solar panels.

The Renewable Energy Policy has no specific focus on promoting entrepreneurs in renewable energy. However, the Ministry of Energy and Mineral Development is trying to support businesses in renewable energy through a private-sector foundation to write business plans, feasibility studies, and fundraising activities. This has provided useful support to energy entrepreneurs. It is recommended that the Climate Change Policy that is being developed by the Ministry of Water and Environment and the Climate Change Unit, focus on climate entrepreneurs and how they will be supported in the implementation of the climate change adaptation plans, as well as other climate change interventions.

Establishing a national platform for coordination and information exchange

In Uganda, the issue of climate change in general has not been given the due focus it deserves. Its effects are devastating , but compared to other issues like HIV/AIDS climate change has not been well prioritized. All stakeholders including government development partners, civil society organizations, academia,

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A wide range of innovations are being developed and tested in Uganda, such as solar cookers.

the private sector, and individuals need to give climate change the focus and attention it deserves.

The collaboration between businesses and government in Uganda needs to improve. The ministry which has most collaboration with business is the Ministry of Energy and Mineral Development. This collaboration would need to be strengthened and include technical support and research. The biggest collaboration for businesses is with development partners. For example, GIZ (formally GTZ) works with businesses to promote renewable energy, mainly through contracting them to offer services. UNIDO through the Uganda Cleaner Production Centre is supporting companies to adopt energy saving and efficient technologies to reduce emissions and deforestation. However, there is need for development partners to support businesses in acquiring machinery to increase efficiency and production, engage in the necessary research, and increase awareness for their products in order to increase market demand.

Some climate innovations - like energy-saving technologies - have been promoted by civil society organizations, but very few of these organizations are working in this way with businesses. The collaboration between businesses and civil society organizations is still very weak. Yet if strengthened, it could facilitate the sale and implementation of climate innovations.

GHANA

Population: 22,901,000 (2008)
Source: Demographic Yearbook 2008, Table 5 Estimates of mid-year population: 1999-2008. http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 396
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2. http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, Ghana: 0,4289
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita. http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2006: 30 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Ghana $ 1,600 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

HARTMUT JUNGIUS / WWF-CANON

GHANA

This section on Ghana constitutes to a large extent an extract and analysis of the WWF commissioned national review titled "Report on assessment of climate innovation and entrepreneurship in Ghana", produced by Science and Technology Policy Research Institute (CSIR-STEPRI) July 2009. More elaborate description and analysis of Ghana's national climate innovation system can be found in the full report at www.climatesolver.org.

As with many African countries, Ghana is particularly vulnerable to climate change, due to its lack of capacity to undertake adaptive measures to address environmental problems, and the socio-economic costs of climate change - health problems associated with malaria are a prime example. Available statistics indicate that malaria is one of the biggest causes of death in the country.

Climate-induced disruption of agricultural systems, flooding of coastal areas, and sea erosion are all tangible effects of climate change in Ghana, a country which ranks high amongst African countries most exposed to risks from multiple weather-related hazards. Ghana is vulnerable to floods and droughts, particularly in the Northern Savannah belt. Epidemics, pests, infestations and wildfires occur across the country. There are risks of landslides, storms, and storm surges. Coastal erosion has become more pronounced, especially along the Eastern coastline. The catastrophic floods in the North in 2007 affected more than 325,000 people, with close to 100,000 requiring assistance in some form or another to restore their livelihoods.[108]

When it comes to energy production, the large Akosombo dam has since its construction in 1965 produced the bulk of the total electricity generated; until the 1990s, Akosombo produced about 80% of national electricity supply. However, erratic and reduced levels of precipitation have in recent years started to seriously threaten the production capacity of the dam. Currently it produces about 65% of the electricity supply, which is still very significant. This is one factor among many demonstrating Ghana's need to review the nation's options for strengthening future resilience with a reliable and clean energy mix.

The Climate Innovation System in Ghana

The role of the Government

The Environmental Protection Agency (EPA) constitutes the designated national authority on climate change in Ghana. EPA, situated under the Ministry of Environment, Science, and Technology, has as one of its core objectives to "ensure environmentally sound and efficient use of both renewable and non-renewable resources in the process of national development" (2009) Furthermore, under the same Ministry, a National Climate Change Committee was established in 2009 whose objective to "develop strategies to deal with the current challenges of climate change and also develop a comprehensive National Action Plan to adapt to climate variability and change for the sustained livelihood of Ghanaians."[109] Apart from these central government actors there are several other actors including Ministries, Departments, Agencies, and Commissions that lead various programmes, projects, and activities relating to climate change, climate innovation, and entrepreneurship.

In 2003, Ghana produced its technology needs assessment (TNA) as required by the UNFCCC. Through a consultative process, a set of criteria was adopted for selecting

108 World Bank (2010).
109 Article from Ghana News Agency, 24 June 2009: http://www.ghananewsagency.org/.

Several climate and environmental challenges can be addressed with climate innovations in Ghana, e.g. waste treatment and coastal erosion.

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relevant technologies within the energy and waste sectors. The TNA identified several recommendations pertaining to the use of technology in the energy and waste sector to address climate change problems. Some of these recommendations include:

- To develop policy guidelines that will address issues like subsidies, ownership, tariffs, awareness, standardization, quality control, institutional set-up, and promoting private sector involvement in the transfer of technologies.
- Build indigenous capacities to develop technologies locally.
- Develop policy, regulations, and enforcement capacities for increased public and private participation in energy-efficiency programmes, taking into consideration the programmes already implemented by the Energy Foundation.
- Review Technology Transfer Regulations needed to allow the incorporation of issues consistent with the criteria for encouraging the introduction of these technologies, in particular the reduction of GHG emissions.

Examples of climate mitigation measures that institutions under the Government of Ghana are undertaking primarily include the promotion of energy-efficiency practices and technologies in industry and public buildings. To facilitate the promotion of renewable energy, the government is taking steps to provide an enabling platform for renewable energy resources to be exploited in the country. In this direction, the government is considering a renewable energy law, which is envisaged to provide regulations on pricing and tariffs, mandatory purchase, and the provision of incentives (tax exemptions and subsidies for instance) that will facilitate the deployment of renewable energy technologies in Ghana.

To help the population adapt to climate change and build resilience against climate-induced natural disasters, the government's National Development Planning Commission (NDPC), in collaboration with the EPA, is working to mainstream environment and climate change concerns into national development planning and budget. Such work is also underway at local levels via an on-going initiative,

supported by the World Bank, in which ten District Assemblies have been assisted to mainstream climate-change adaptation and disaster-risk management into their district plans.

Ghana is in the process of preparing a National Climate Change Policy Framework (NCCPF) which is intended to integrate action on climate change into policies for national development objectives. Furthermore, as a means to ensure the systematic integration of climate change into national development processes for sustainable development, the Ministry of Environment, Science, and Technology is developing a Low Carbon Growth Plan with the vision to integrate all aspects of the economy related to technologies that produce energy and materials with little GHG emissions. As part of the implementation of the Low Carbon development Plan, the establishment of a Climate Innovation Centre is being planned.

Entrepreneurs and the private sector

The understanding of climate entrepreneurs' role in Ghana appears to be vague. However, there seem to be several entrepreneur-driven initiatives that use innovations in relation to climate change. Such activities are mostly in the area of converting healthcare waste, biodegradable waste, and sewage into energy, as well as driving the uptake of biogas technology in the country. There are also examples of entrepreneurs engaged in designing and constructing rainwater harvesting technologies, and entrepreneurs assisting industries in improving energy efficiency through heat and mass transfer. Analysis shows that most climate entrepreneurs are at market introduction stage in their development, mainly focusing on various waste-to-energy solutions and collaborating with companies outside Ghana to implement systems for energy efficiency in industries.

Knowledge Institutions

Climate change research in national knowledge institutions is recent in Ghana. Nevertheless, teaching and research institutions are working to establish the science, collecting the Ghanaian evidence of climate change, and working with local communities to understand climate risks and to identify adaptive measures in areas of high vulnerability.

At the University of Ghana, the Regional Institute for Population Studies, with other collaborators, is working with farmers in a livelihood-mapping exercise, as well as risk-mapping flooding in vulnerable communities. These research activities build the capacity of rural communities to enumerate and interpret information on climate change, vulnerability, and adaptation. Studies are also under way by some knowledge institutions to understand the seasonal variability of rainfall and trends of temperature in Ghana.

The Energy Centre of the Kwame Nkrumah University of Science and Technology (KNUST) is also providing training in renewable energy through hands-on short courses and post-graduate programmes by distance learning. Some fellows of the Centre are supervising post-graduate students who are bundling public universities together to develop CDM projects based on biogas technology. To increase understanding of the national climate innovation system, the University of Ghana is identifying and analysing the linkages that can be established among knowledge institutions in Ghana, as well as the linkages between knowledge institutions and industry.

Knowledge institutions are providing information on climate change to policy makers and have assisted in policy formulation, with some knowledge institutions engaged in providing consultancy services to industry and individuals. The Institute

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There's a large forestry industry in Ghana which could benefit greatly from climate innovations.

of Industrial Research of the Council for Scientific and Industrial Research has conducted studies on wind and solar energy.

Non-governmental Organizations

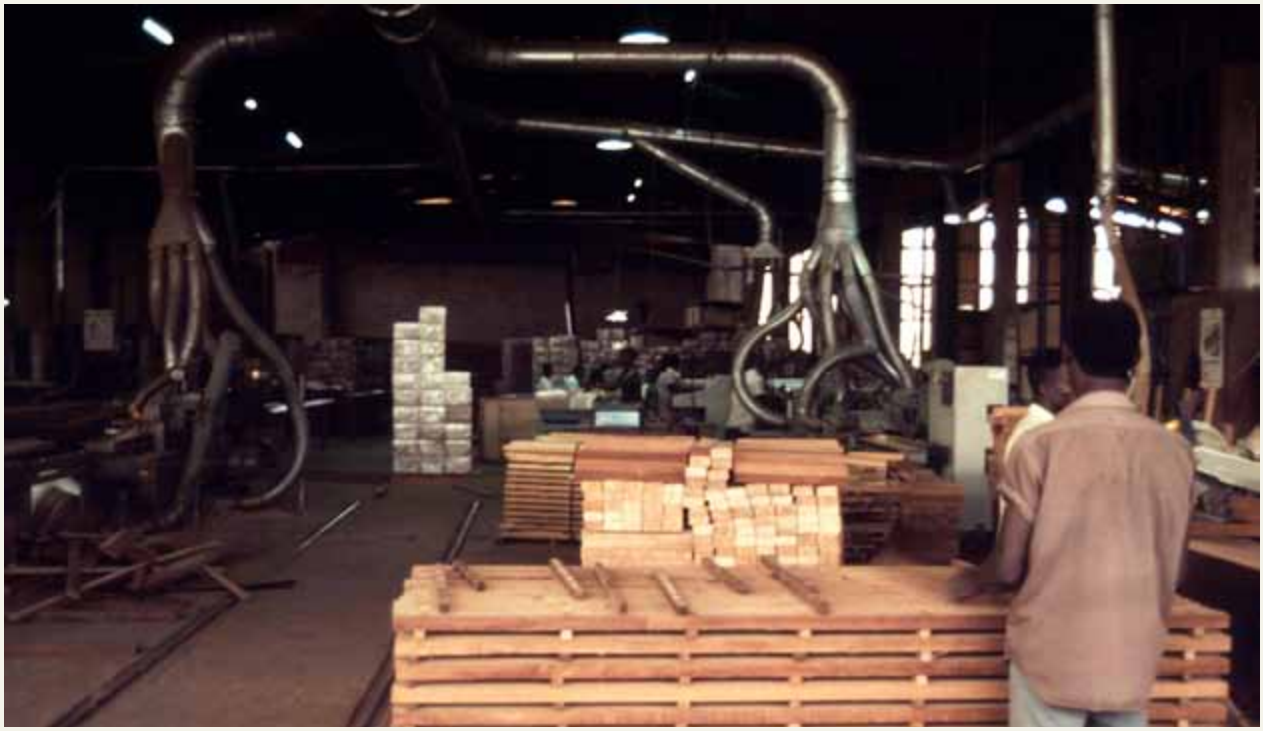
Several NGOs in Ghana are engaged in facilitating the development and growth of climate innovations and entrepreneurship. NGOs have specifically invested resources in clean energy (solar lanterns and other photovoltaic systems), production of energy-efficient cooking stoves, and training of seedling growers and tree nurseries. As an actor in the national climate innovation system, the NGO community is facilitating interaction between the private sector and the government on environmental issues, and is engaged in advocacy for energy efficiency in large public institutions and industries. NGOs in Ghana support research in the area of climate change, and are also engaging children and youth in work on environment and climate change.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

Generally low awareness of climate change issues and of climate innovations in Ghana is a major challenge for enhancing the national climate innovation system. While this challenge requires targeted information campaigns by all key stakeholders, it is recognised that there are difficulties in packaging the information on climate change to reduce its abstract nature and make it tangible for the public.

Analysis shows that knowledge and information on climate change and climate innovations in Ghana is limited to key individuals rather than being anchored at institutional level. Due to this lack of established information systems, it is often



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Training, knowledge sharing and access to funding is required for capacity building in Ghana's innovation system.

difficult to access information on climate change. Establishing frameworks that increase dissemination of climate change information and innovations to knowledge institutions, entrepreneurs, the government, and to the broader public is an urgent need.

Efforts to disseminate knowledge and strengthen capacities by training people in climate mitigation and adaptation practices are moving very slowly in Ghana. Therefore, the government and knowledge institutions have an important role to play in facilitating training and information campaigns to targeted stakeholders, in order to systematically increase national capacities within the area of climate innovations.

Building capacities and increasing resources

For knowledge institutions to increase their important contribution to the climate innovations system in Ghana, there is a need to improve access to resources. While funding constitutes an important factor, limited access to the Internet is a major obstacle for networking and information exchange. Access to the Internet is crucial for obtaining information from scientific databases, linking up with other knowledge centres, and communicating effectively with foreign collaborators. Other identified obstacles for knowledge institutions are the lack of adequate equipment for conducting research, difficulties in obtaining tax exemptions to import such equipment, and poor working conditions (remuneration and facilities) of researchers in public knowledge institutions.

Inadequate sources of funding are often identified as a challenge by many of the stakeholders within the national climate innovation system in Ghana. In the private sector, expanding enterprises in the environment and climate sectors require increased access to funding. However, the level of understanding in existing financial institutions which could provide such funding is too low or fragmented. This mirrors the situation for many knowledge institutions, which face major difficulties in identifying external funding sources to produce prototypes of their innovations. At the same time, government agencies responsible for environment and climate change

have difficulties obtaining adequate funds in order to implement mitigation and adaptation programmes on climate change and to invest in green development.

Establishing an enabling institutional framework

There are several steps that could be taken by the government to promote the establishment of an effective climate innovations system in Ghana. The passing of enabling legislation and allocation of budgetary support for capacity-building programmes are two important steps. What is needed is firm political will to drive the national agenda on climate policy and practice forward. However, the shortage of policy frameworks for climate change and climate innovation is evident. Also, even though some regulations exist, responsible government institutions lack the capacity to ensure policy compliance in society.

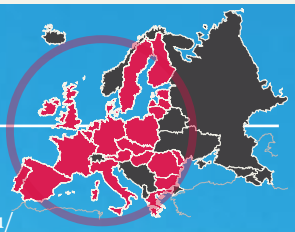
The government of Ghana thus has an important role to play in creating a fruitful environment for enabling climate innovations. The government is advised to strive towards a catalytic function in the development, application, and dissemination of technologies and good practices on climate mitigation and adaptation. Responsible government agencies need to formulate key policies on climate change and take legislative measures that encourage and enable entrepreneurs to make investments into climate innovation solutions. At project level, it is important to seek opportunities for linking with and capitalising on the Clean Development Mechanism (CDM). A possible future scenario is that national plans for adaptation, mitigation and energy access will be a basis for possible external funding from the UNFCCC.

Establishing a national platform for coordination and information exchange

Since the negative consequences of climate change affect and are exacerbated by a number of different sectors in society, the actions to mitigate and adapt to climate change need to be multi-dimensional. The responsibility of tackling the challenge of climate change at government level cannot be placed with one or even a few isolated ministries/institutions. These interdisciplinary challenges require input from a multitude of stakeholders. The absence of an effective body coordinating climate change activities at government level brings major difficulties, since there is no 'rallying' point with respect to climate change and climate innovation. There is a need of a multi-stakeholder national platform that can enable national coordination and transfer of knowledge, best practices, and technological solutions between key stakeholders such as government institutions, researchers, entrepreneurs, and civil society.

The current national frameworks do not adequately support climate innovation and entrepreneurship in Ghana. There is a need for closer collaborations to be established among the actors to enhance knowledge production and technology transfer. As an important partner to the government in advancing the climate innovations agenda, the NGO community supports the formulation of policy and legislation. In view of their strong linkages to communities at the grassroot level, NGOs should be encouraged to increase collaboration with knowledge institutions and the private sector to establish proof-of-concept demonstration in vulnerable communities, as well as undertake technology transfer projects. This will, in many respects, serve to create awareness about the challenges of climate change as well as the possibility for climate innovations in Ghana. The establishment of a national platform that enables different actors to capitalise on each other's strengths and comparative advantages has the potential to create incentives for generating climate innovations and encouraging climate entrepreneurs to emerge and grow.

EUROPEAN UNION



Population EU 27
(Per January 1, 2008): 497,683,000
Source: Eurostat: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en

Carbon dioxide emissions (CO_2), thousand metric tons of CO_2 (CDIAC) EU-27 Egen summering från data i nedanstående källa: 3 986 194
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2 http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita (CDIAC) EU-27 Egen uträkning från data i nedanstående källa: 8,6705
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: No country level data are available.
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: EU $ 32,900 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

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EUROPEAN UNION

Overview of the EU policy landscape for clean tech innovations

This section on EU constitutes an extract and analysis of the WWF-commissioned review titled "Innovations for a Low-carbon Economy – An Overview and Assessment of the EU Policy Landscape", produced by the Institute for European Environmental Policy (IEEP) in September 2010. More elaborate description and analysis of EU's policy on clean technology innovation can be found in the original report at www.climatesolver.org.

In an attempt to map and analyse EU policy on clean technology innovation, this section gives an overview of the most important EU policies and programs for the development and deployment of low-carbon innovations, with an emphasis on measures for commercialization and large scale deployment. As only a few key policies and programs are mentioned in this summary, a more comprehensive presentation of all relevant policies can be found in the original report.

Strategy Europe 2020

It is appropriate to start with the strategy "Europe 2020: A European strategy for smart, sustainable and inclusive growth" for three reasons; firstly because it gives the shape of things to come, secondly it has a significant focus on innovation, and finally because it integrates EU climate policy goals at the highest level. Europe 2020 was put forward by the Commission in March 2010 and later finalized and endorsed by the European Council in June 2010.

Europe 2020 is intended to guide action both at the Union and at the Member State level to 2020.The Strategy contains seven flagship initiatives to catalyze progress and long-term growth, where three of those are of particular interest for this study:

1. "Innovation Union" to improve framework conditions and access to finance for research and innovation, so as to ensure that innovative ideas can be turned into products and services that create growth and jobs.
2. "Resource efficient Europe" to help decouple economic growth from the use of resources, support the shift towards a low-carbon economy, increase the use of renewable energy sources, modernize our transport sector and promote energy efficiency.
3. "An industrial policy for the globalization era" to improve the business environment, notably for SMEs, and to support the development of a strong and sustainable industrial base able to compete globally.

Innovation Union

The stated aim of the Innovation Union flagship initiative is to re-focus R&D and innovation policy on challenges such as climate change, energy and resource efficiency, health and demographic change. As such, every link in the innovation chain should be strengthened "from 'blue sky' research to commercialization." The Commission will work to "improve the framework conditions to innovation." The actions cited include the creation of the single EU Patent and a specialized Patent Court; modernizing the framework of copyright and trademarks; improving access of SMEs to Intellectual Property Protection; speeding up the setting of interoperable standards; improving access to capital; making full use of demand-side policies such as through public procurement and smart regulation. Secondly, in 2011 the

Commission will test the concept of 'European Innovation Partnerships' between the EU, national and regional levels to speed up the development and deployment and development of the technologies needed to meet the challenges identified above. Finally, the Commission will work to strengthen and further develop the role of EU instruments to support innovation, facilitate access to funding, particularly for SMEs and to bring in innovative incentive mechanisms linked to the carbon market.

PHOTO: © WWF-CANON / ANDREW KERR

European industry as well as agriculture can become even more resource efficient and competitive with the help of climate innovations.

The October 2010 Communication, 'Europe 2020 Flagship Initiative Innovation Union', provided more detail on the Commission's plans for innovation over the next decade. The Communication sets out five things that EU innovation policy must do: tackle unfavorable framework conditions; avoid fragmentation of effort; focus on innovations that address the major societal challenges identified in Europe 2020; pursue a broad concept of innovation; and involve all actors and all regions in the innovation cycle. The emphasis on closing financing gaps, demand-side measures and public procurements is promising and raises the expectations on EU's actions in the years to come.

Resource Efficient Europe

The stated aims of the flagship Resource Efficient Europe is to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources, and to decouple Europe's economic growth from resource and energy use, as well as to reduce CO2 emissions, enhance competitiveness, and promote greater energy security.

It is worth noting the way in which Resource Efficient Europe bundles together a resource efficient and sustainable economy with a competitive economy. Several initiatives in relation to the energy sector are brought together, but most of them add little new to improve the conditions for the deployments of climate innovation. These different dimensions of the new economy must be achieved through "exploiting Europe's leadership in the race to develop new processes and technologies, including green technologies, accelerating the roll-out of smart grids, using ICTs, exploiting EU-scale networks and reinforcing the competitiveness of [EU] businesses, particularly in manufacturing and within [...] SMEs, as well as assisting consumers to value resource efficiency." Europe will become resource efficient and decouple growth from resource and energy use through the development and deployment of new processes and technologies, and at the same time, these must serve as a motor of growth by virtue of the market shares they command at home and abroad.

A Resource Efficient Europe promises to "enhance a framework for the use of market-based instruments," and gives as examples: emission trading, revision of energy taxation, the state-aid framework, and encouraging the wider use of green public procurement. No more detail is given. Clearly this could mean a lot of different things, and what would be new is uncertain, too. Nevertheless, from an overall strategic point of view, it is obvious that the flagship Resource Efficient Europe will, if it is successful, help create a demand pull for EU based low-carbon innovations

within the EU, and to promote their commercialization abroad. Otherwise it will have failed on its own terms. That said, at present, the initiatives outlined under the flagship initiative Resource Efficiency Europe are unlikely to add up in a way that will achieve its stated aims.

An industrial policy for the globalization era

The Commission will draw up an industrial policy intended to "maintain and develop a strong, competitive, and diversified industrial base in Europe, as well as supporting the transition of manufacturing sectors to greater energy and resource efficiency." The Commission will also promote technologies and production methods that reduce

PHOTO: © EDWARD PARKER / WWF-CANON

Innovations play an important role in EU:s strategy for 2020.

natural resource use, and increase investment in the EU's existing natural assets. Finally, the Commission will review regulations to support the transition of service and manufacturing sectors to greater resource efficiency, and improve European standard-setting to leverage European and international standards for the long-term competitiveness of European industry. Europe 2020 states that this will include promoting the commercialization and take-up of key enabling technologies. The October 2010 Communication refers to "...a dynamic growth path strengthening EU competitiveness, providing growth and jobs, and enabling the transition to a low-carbon and resource-efficient economy." The Commission suggests that "appropriate framework conditions and further public-private collaboration are needed to ensure the timely deployment and commercialization of these innovations across energy-intensive sectors."

Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan

The 2008 Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan was presented as a strategy to "further sustainable consumption and production and promote [...] sustainable industrial policy." The SCP/SIP contains a specific concern with the demand side of innovation policy and the most developed part of the SCP/SIP is guidance on "smarter consumption and better products."

The Communication noted that while the regulatory framework for production processes is well established at the EU level (including the IPPC and EU-ETS) there is a need to give further impetus to resource-efficient and eco-innovative production processes, to reduce dependency on raw materials and encourage optimal resource use and recycling. Action was outlined in relation to: 'boosting resource efficiency', 'supporting eco-innovation', 'enhancing the environmental potential of industry', and 'promoting sectoral approaches in international climate negotiations.' In addition to the main lines of activity described above, the Communication also contained a set of actions to promote global markets for sustainable products.

The European Strategic Energy Technology Plan

The 2007 SET-plan was developed in the context of the 20/20/20 targets as well as a more long-term vision of 60-80% for 2050 adopted by the European Council March 2007 to "strengthen energy research, in particular to accelerate the competitiveness of sustainable energies, notably renewables, and low-carbon technologies and the further development of energy-efficiency technologies." The SET-plan is grounded in a concern about public and private underinvestment in energy technology research in the Union since the oil price shocks in the 1970s and 1980s and the implications that this might have for the three objectives of Energy Policy for Europe: increasing the security of supply; ensuring the competitiveness of European economies and the availability of affordable energy; promoting environmental sustainability and combating climate change.

The SET-plan put in motion the creation of seven Industrial Initiatives (EIIs) with the aim of strengthening industrial energy research and innovation by mobilizing the necessary critical mass of activities and actors. Six EII's were envisioned to be launched in 2008: wind, solar, bio-energy, carbon capture and storage, electricity grids, and nuclear fission. The first four were eventually launched in June 2010 on wind, solar, electricity grids, and carbon capture and storage. The SET-plan notes that "where appropriate, a combination of 'technology push' and 'market pull' instruments may be used." But it appears that on balance, the EII's, like the SET-plan overall is mainly oriented towards the research and developments end of innovation policy. Thus, while the EII's contain technology roadmaps to 2020, which will include actions to develop the technologies and improve their competitiveness, limited attention is paid to the creation of markets.

The Plan states that existing European Technology Platforms should assist in the preparation phase of the European Industrial Initiatives. However, while there is scope for these platforms to develop deployment strategies, the emphasis appears to be very much on the R&D side. Nevertheless, in a recent evaluation a group of experts convened by the Commission had as one of their conclusions that "the demand side for implementing a potential solution should be tackled by concrete proposed actions" in the context of revised program for these platforms.

Challenges and Recommended strategies

The Commission published a communication reviewing EU innovation policy in September 2009. This is quite interesting for the general criticisms it makes of Community-level innovation policy, and also for the way it pulls out a number of low-carbon, innovation-relevant initiatives as examples of EU innovation policy. The purpose of the review was to identify remaining gaps and propose policy orientations to fill them.

New rules on car emissions is positioned as a way of triggering substantial innovations in the European automotive industry, resulting in cleaner, affordable European cars, and helping to keep the industry globally competitive. The Emission Trading Scheme (ETS) Directive is also mentioned as an initiative that will "foster innovation in renewable energy production and encourage the construction of more environmentally friendly power plants, including new carbon capture and storage (CCS) technologies." The importance of the SET-Plan in achieving the "20-20-20" objectives by 2020 by accelerating the development of low-carbon technologies is referenced, as is the 2008 Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy.

In particular, the review addresses the removal of 'critical bottlenecks in the framework conditions for entrepreneurs,' and 'enhancing the governance of the EU innovation system.' In terms of bottlenecks it observes that "the EU innovation system continues to suffer from shortcomings that negatively influence the market rewards and incentives for private investment in innovation, which as a consequence remains lower than that of our main competitors." This is suggested to be remedied by: completing the single market; improving the legal framework for the protection of intellectual property; addressing the fragmentation of the venture capital market, and stimulating the low level of equity funding; synchronising the standardisation process better with research results and market needs; strengthening the knowledge triangle between business, education and research needs; and increasing the capacity of the EU educational systems to contribute to an "innovative and agile knowledge society."

The Commission suggests further that progress towards improving the international competitiveness and performance of the European venture capital sector has been slow, and that there are structural deficiencies in the European early-stage finance market. This includes the absence of private investors, fragmentation of the market, and low returns. While these observations are not directly addressing the provision of financing for low-carbon innovation, they sketch out a vital part of the context which affects innovation in general, and low-carbon innovation in particular.

Finally, the Commission observes that there is a need to improve the governance of innovation and that in particular there is no lack of innovation support programs in the EU in terms of numbers. The problem is identified as one of lack of critical mass and coherence. The Commission highlights that innovation support involves seven different Commission services, various agencies, and 20 committees with representatives from Member States. It also cites a recent consultation on innovation policy to the effect that users of the available funding find it complex to access.

Based on the review of existing EU policies and programs in the previous section, as well as the results of the EU review, a number of observations can be made with respect to the various features of the outlined policy landscape.

First of all, as an expression of the direction of travel for the EU over the next ten years, economic growth is paramount to the Europe 2020 strategy, and innovation

is attributed a strategic role in achieving it. Within this, low-carbon innovation specifically is also given an important role, both as part of the intention to decouple growth and resource consumption, and as a source of growth in its own right, safeguarding and capitalizing on what is perceived to be the EU's first-mover status in this area. Innovation Union, Resource Efficient Europe, and Industrial Policy for the Globalisation Era are the Europe 2020 flagships of greatest significance in the present context.

Climate change, energy and resource efficiency is one of the areas around which the Commission is proposing to re-focus R&D and innovation policy. The scope is, in principle, the whole innovation chain. EU-level action will centre on improving the framework conditions, including improving access to capital, and making full use of demand-side policy such as public procurement and smart regulation. This is encouraging, as access to capital in the early stages of commercialization is a key enabler for the transition to a low-carbon future. Moreover, 'smart regulation' in the context of the Innovation Union flagship should be decisively employed for the creation of markets for low-carbon innovations.

Of potential note is also the reference to strengthening and developing the role of EU (funding) instruments in support of innovation. There is clearly a link to be made here with the debate about 'climate proofing' the budget in general, and the work now underway to define the post-2013 multiannual framework in particular.

A number of initiatives are outlined in relation to the flagship Resource Efficient Europe, but it is often difficult to determine what is additional to existing plans. The recent Roadmap for a competitive low carbon economy by 2050 and the Energy Efficiency Plan 2011 are important. The Roadmap for exemplifying a cost efficient pathway to 80% domestic emissions by 2020, and the Energy Efficiency Plan by promising a set of potentially significant measures that could help pull forward investment in energy efficiency. The Roadmap is however but a vision, and contains some assumptions about energy supply choices that will be controversial, while the Plan is somewhat vague and leaves much to be more closely defined later in 2011.

It is worth noting that the debate about energy efficiency, which has been going on since the late 1970s, is to a large extent about the deployment of low-carbon innovations, whether these be of a technological or a behavioural nature. Therefore it is not really surprising that the limitations of this debate, in so far as it has by and large focussed on efficiency as opposed to absolute reductions, are also relevant to the debate about the deployment of low-carbon innovations. Like the SCP/SIP Action Plan, the Energy Efficiency Action Plan (EEAP) has the potential to deliver substantial deployment of low-carbon innovation on a product-by-product basis. A general condition for this will be that minimum performance requirements are sufficiently stringent, are updated at appropriate intervals, and are accompanied by appropriate supporting measures such as, for example, transparent benchmarking and technology procurement. However, it should be noted that the focus on products does nothing to halt the trend towards more energy-consuming products, with greater functionality, resulting in increasing use, and therefore increasing energy consumption. This challenge lies at the heart of the problem but has not really been taken up in a direct way in the flagship Resource Efficient Europe.

The flagship Industrial Policy for the Globalisation Era does seem to recognise that the transition to a low-carbon economy would require transition management, at least implicitly. It is recognised that while the challenges of globalisation and adjusting products and processes to a low-carbon economy will create business opportunities for some, other sectors may have to re-invent themselves.

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The overall ambition in the Europe 2020 flagships may not be sufficient to decouple Europe's growth from resource and energy use.

It is clear from the flagships that there are a number of potentially significant policy initiatives in the pipeline. Nevertheless, there is considerable cause for concern that the overall level of ambition will not be sufficient to truly succeed in de-coupling Europe's growth from resource and energy use, thus placing at risk our capacity to secure sufficient reductions in emissions. And so it runs the risk of failing on its own terms.

The SET-plan is, as the name suggests, very much focussed on a set of specific technologies, and little or no attention is given to services, or the need to reconceptualise business strategies in a broader sectoral perspective. A distinction is made between technologies in terms of whether they are relevant for the 2020 or the 2050 targets. While the Plan does make reference to the deployment end of the innovation chain, and indeed to the challenge of bridging the Valley of Death between supply and demand, in practice the balance of the Plan seems to be very much on research and development and thus the supply side of the innovation chain. The most market 'pull' oriented section of the SET-plan is in the context of international co-operation.

Within the EU 2006 innovation strategy, the Lead Market Initiative expressly seeks to address the demand side of the innovation chain, and the sectors it addresses contains some that are explicitly of interest here. However, it is also clear that Lead Market Initiative has some way to go before it may bear fruit, and also, in relation to the clean technology sector, it is not clear yet what the Lead Market Initiative brings in addition to what is already there.

SMEs are responsible for half of the EU turnover, and represent almost 99% of the total number of companies in EU. The Competitiveness and Innovation framework Programme (CIP) was meant to become the main legal basis grouping all Community actions in the field of (eco-)innovation and competitiveness. CIP encourages usage of renewable energies, information and communications technologies (ICT), and promotes energy efficiency. Moreover, CIP stimulates SMEs' innovation activities, and provides better access to finance and business support services by offering grants and a large portfolio of venture capital via the European Investment Bank (EIB) and European Investment Fund (EIF). In order to meet the Lisbon Strategy's objective of making Europe the most competitive and dynamic knowledge-based economy, EU policies should pay special attention to innovative SMEs that can provide low -carbon solutions to other companies, and thereby contribute to their competitiveness.

Conclusions

A number of observations can be made about the overall picture of the EU policy landscape for the deployment of low-carbon innovations. While further analysis of this extensive and evolving arena is required, it may be useful to consider the following three key questions:

Does the ensemble of policies add up to a coherent whole?

The overall picture which is emerging from the analysis is one of an interpenetrating web of strategies, action plans, programmes and more specific measures, rather than a coherent framework. The recent review of Community innovation policy makes a similar point deploring the "lack of critical mass and coherence" in innovation support programmes: "innovation support involves seven different Commission services, various agencies and 20 committees with representatives from Member States." It is clear that the development and deployment of innovations for a low-carbon future is at the very least at the confluence of the work of DG Climate Action, DG Enterprise and Industry, DG Research, DG Regional Policy, DG Energy, DG Environment, and DG Competition. The Innovation Union Flagship could help to improve on this situation.

Are there some elements missing?

This question has multiple dimensions. It is clear that EU innovation policy is overwhelmingly concerned with technology, and plays relatively little attention to non-technological innovations. This also applies to low-carbon innovations. Furthermore, it is also clear that apart from the Lead Market Initiative, the overwhelming emphasis is on supply-side, with much less attention to the formation of markets, or demand-side policy. More emphasis appears to be put on the development of innovations, including low-carbon innovations, than on the deployment of innovations. Again, the Innovation Union flagship suggests that this can improve in the coming years. Here, the critical issue of access to capital is addressed, but more attention could be paid to the private sector side of the financing coin.

As we have seen in the section above, a number of elements are missing from the EU policy landscape for the deployment of low-carbon innovation, although there is an issue about where we draw the boundary around the low-carbon innovation policy landscape. However, even if we adopt an inclusive definition, the array of policies currently assembled will not get us to where we need to get to by 2050 (i.e. >80% reduction).[110] There are some generic weaknesses in relation to innovation policy in Europe, and some specific ones in relation to low-carbon innovation, and there seems to be limited focus so far on policies specifically focussed on deployment. There is cause for concern that the overall level of ambition in the Europe 2020 flagships will not be sufficient to truly succeed in de-coupling Europe's growth from resource and energy use, thus placing at risk our capacity to secure sufficient reductions in emissions.

What is the working theory of innovation, low-carbon innovation, and the transition to a low carbon economy which emerges from the various policy documents?

The perspective appears to have evolved over time, and is influenced by which DG is in charge of a given policy initiative. A more linear view of innovation seems to be giving way to a more dynamic systems perspective. In particular, the 'innovation system' perspective appears to be influential. What is clear is that the boundary of ambition is usually drawn at making the energy system more efficient, and so fails to integrate more comprehensive restructuring approaches proposed by many experts and analysts. The perspective informing the Commission's approach to innovation should be enriched to take account of the more structural issues raised. There is a need for a more ambitious and more fundamentally transformative approach to innovation in the Community if we are to reach our climate change objectives to 2050.

110 Brussels European Council Presidency Conclusions 29/30 October 2009, p.3.

THE NETHERLANDS

Population: 16,446,000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 173 244
Source: (CDIAC) Carbon dioxide emissions (CO_2),
thousand metric tons of CO_2 http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, The Netherlands: 10,5253
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: No country level data are available.
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Netherlands $ 40,500 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

PHOTO: © CHRIS MARTIN BAHR / WWF-CANON

NETHERLANDS

This section on the Netherlands constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Clean Economy, Living Planet - Building the Dutch clean energy technology industry", produced by Roland Berger Strategy Consultants, November 2009. More elaborate description and analysis of the Netherlands' national climate innovation system can be found in the original report at www.climatesolver.org.

The Netherlands is very vulnerable to increasing climate change. With many low-lying coastal and river areas at risk of sea level rise and severe flooding, it is critical that the country generates high levels of knowledge and takes active measures towards mitigating and adapting to climate change. A lot of activities have been initiated to protect people at risk from the effects of climate change and the Netherlands is generally perceived as one of the European countries most active in promoting domestic climate adaptation measures. In spite of this positive trend, the Netherlands does not seem to approach the climate change challenge in a holistic and comprehensive way. Dutch CO2 emissions per capita are among the highest in the world (seventh place). The Netherlands emits three times the global average. Furthermore, when WWF-NL in 2009 presented the first ranking ever of countries' total annual sales of clean energy technology, the Netherlands seriously lagged behind the most proactive countries, coming out in an unflattering 17th place.

Clean energy technologies are urgently needed in the Netherlands in order to genuinely cut CO2 emissions, limit global warming, and protect crucial ecosystems. Although the Netherlands does promote clean energy solutions, there is a long way to go to strengthen this industry and make it as strong as those in Denmark, Brazil and Germany, which hold the top rankings in clean energy technology sales globally. It might take many years until the Netherlands has reached such an ambitious target, but it is important to note that the country has the knowledge (third place in basic science), wealth (sixth economy in GDP per capita) and capacity (more than 260 companies active in clean energy technology) to take a leading role in the world market for clean energy technology. The following sections will summarize the current status of this industry in the Netherlands and analyze the strengths and weaknesses of the country's climate innovation system.

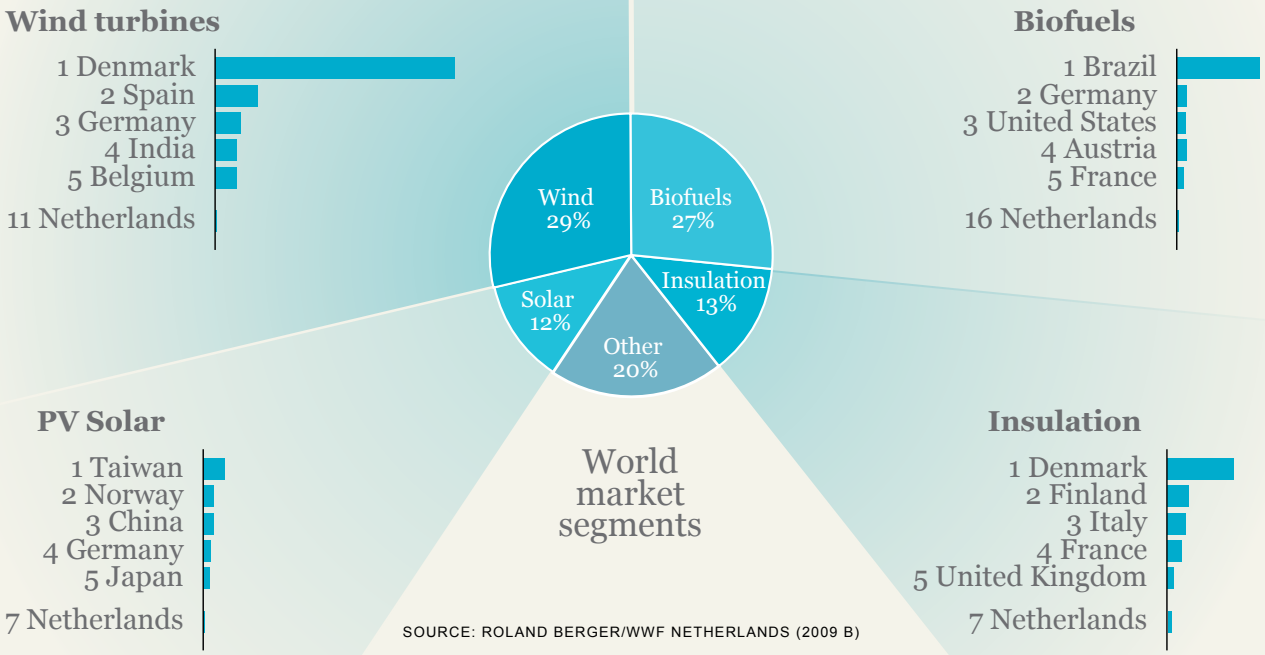
Climate Innovations in the Netherlands

Wind energy and biofuels are the most important markets in clean energy technology worldwide (with 29% and 27% of total sales respectively). The rapid expansion of wind power capacity in Europe, the US, and in recent years, China, has created a 27 GW (capacity) market in 2008. The relatively low cost of wind and biomass favors their use over solar, which holds 12% of the overall low-carbon energy market. The largest market segment for energy efficiency is insulation, with 13% of total clean

energy technology sales in 2008. Figure 22 shows the position of the Netherlands in each of the four largest clean energy technology segments.

As the chart reveals, the Netherlands has no leading position in any of the major segments. The national clean technology market consists of a few start-up companies in wind energy which are mainly focusing on developing prototypes for offshore wind turbines. The few suppliers to this industry are smaller still. A new initiative (FLOW, Far and Large Offshore Wind) may give these existing companies, like Darwind and 2-B Energy, a much-needed boost. Offshore wind has the potential to grow into a substantial industry in coming years, and the Netherlands could still emerge as a major player in the future.

Figure 22: Dutch market position in major clean energy technology segments 2008 – weighted by GDP [%]



SOURCE: ROLAND BERGER/WWF NETHERLANDS (2009 B)

In biomass, the Netherlands still plays a modest role – despite the Port of Rotterdam, a major point of entry for biomass into Europe, and a strong petrochemical cluster that could pioneer biobased chemicals and materials. Although biomass co-firing in power plants is relatively common, the equipment can also be used to burn coal and is mostly supplied by foreign manufacturers. In comparison with the extensive national capacity for fossil fuel refineries, in-country biodiesel production is quite limited. Plans to increase capacity fivefold are yet to be realized. Although the biobased economy is now becoming a policy priority, (first generation) biofuels have not found favor with government and considering that the Netherlands is a gas country, biogas installations are few. Although it is an open, trading nation with a long tradition of science, (civil) engineering, and wind mills, it seems that the Netherlands neither profits from nor contributes to global emission reduction efforts as much as it should.

The Netherlands is home to more than 260 companies active in a broad range of clean energy technology. However it is rather difficult to collect valuable information about these firms since clean energy technology is not recognized as a category in public statistics, and there is no public register for clean energy technology companies.

Through a quick analysis of the 266 identified companies in this arena, it becomes clear that they are active in a broad range of technologies. The largest focus is energy efficiency, mainly through heating, cooling and ventilation (19%), insulation (6%), and lighting (3%). About a quarter are biobased (biomass, biofuels, biogas, algae, biorefinery) and 20% target technologies in the renewable sector of wind and solar.

The knowledge and the seeds for a Dutch clean energy technology industry are clearly there. Many excellent and promising companies could form the basis for a strong domestic industry. However, compared to international competitors, Dutch companies are still small. The small size and embryonic nature of most Dutch companies is a significant reason for the relatively weak sales position of the Netherlands. Building a strong Dutch clean energy technology industry will need increased government and private sector support towards development, demonstration, and scale-up of clean energy innovations and companies.

In contrast to the relatively weak commercial status of renewables in the Netherlands, analysis shows that the nation has an excellent knowledge base. Historically, the Netherlands has a strong tradition of R&D in areas related to clean energy technology, and only five countries in the WWF-NL ranking spent more on renewable energy R&D in 2006 (latest available figures). Statistics show that Dutch R&D expenditures unfortunately saw a steady decline during the last decade, while Denmark, situated in first place, raised its R&D investments almost six fold since 2002. Until the early 2000s, however, the Netherlands was the second or third largest spender on clean energy technology related R&D. It has consistently managed to turn these investments into world-class academic knowledge. Citation scores for scientific disciplines related to clean energy technology place the Netherlands squarely in the global top three.

Unfortunately what has not happened during the same time period is transforming this excellent knowledge base into true innovations delivered on a commercial scale. Yet the Netherlands ranks only 17th in overall GDP weighted clean energy technology sales. Another example is the relatively modest number of 2.7 patents per million

The Netherlands is not able to harvest as much as it should from its knowledge base in cleantech.

PHOTO: © WWF / ROB WEBSTER

inhabitants, especially when compared with Denmark's whopping 20.3. The high-quality knowledge base constitutes a critical building block for supporting a national shift towards accelerated domestic policy and practice for clean energy solutions.

Challenges and Recommended strategies

When comparing the status of the Dutch national climate innovation system with four of the most successful countries in clean energy technology – Denmark, Brazil, Germany, and Spain – WWF-NL identified three distinct areas for success that need to be addressed:

1. Subsidies do not contribute sufficiently to a stronger economic position

The Dutch government invests relatively high amounts in research and development, but this does not result in higher international sales. The most important reason for this is that individual technologies are not supported consistently over the product life cycle. For example: solar energy receives a considerable amount of R&D support, but a lot less support in the demonstration and market development phase.

Many clean energy technology innovations struggle to progress from one stage to the next in the innovation chain, especially where this involves the transfer of knowledge from one actor to the other – typically from academia to industry. Technologies proven in the lab must be made to work under real-life conditions, though testing in demonstration projects is too expensive for research groups or start-ups and too risky for industry: what works in the lab often will not work on a demonstration scale without extensive (and costly) rework and engineering, if at all. The amount as well as the consistency of current government funding is insufficient to encourage either party to collaborate in demonstration projects. Consequently, the difficulties encountered by entrepreneurs in the Valley of Death constitute a prominent obstacle for furthering the national climate innovation system in the Netherlands.

Another reason is that innovation in knowledge centers is not well connected to commercial companies. Furthermore, clean energy technology hardly play a role in public private partnerships (PPPs). Today, there are more than 60 public-private partnerships in the Netherlands that are specifically designed to bridge the gap between academia and industry R&D on themes that include: high-tech systems and materials, chemicals and energy, health and water, climate and the environment. Yet of the total EUR 2.3 billion invested, the combined budget of the five public private partnerships related to renewable energy amounts to less than EUR 100 million, or less than 5% of the total. Energy efficiency only plays a role in one roadmap (process intensification) in one PPP. No PPPs focus on large-scale demonstration or implementation projects in either renewable energy or energy efficiency.

The Netherlands risks falling even further behind as other countries are implementing economic stimulus packages that include significant "green funds," Only EUR 2 billion of the Dutch stimulus package has been earmarked for sustainability, and that includes earlier subsidies already in the works. Other governments, investing a hundred billion US$ or even more in green solutions as part of the stimulus packages, seem to have better understood that they should not "let a good crisis go to waste."

2. There is not enough capital, especially in the seed phase

In the Netherlands there is a shortage of capital for clean energy technology. In 2008, in-country investments in clean technology decreased substantially by 34%. Meanwhile, in the rest of Europe they increased by 55%. In the seed phase especially,

the Netherlands is far below the European average. Furthermore, Dutch banks invest much more in fossil energy than in clean energy (<6%).

Only 1.6% of European PE investments in clean energy technology are in the seed stage, against a 4.4% average for all sectors. In the Netherlands, however, these seed-stage investments are almost nonexistent (0.3% of the total, less than EUR 1 million) and flat. By comparison, start-up and later-stage venture funds grew by more than 1400% each (to EUR 47 and 92 million, respectively) and expansion funding fell by 87% to EUR 34 million. According to venture capitalists in the Benelux, there is insufficient private equity in the Netherlands to finance both smaller and high risk start-up companies and to fund the expansion phase of larger clean energy technology firms.

The government is also pulling back. Public investments fell from EUR 21 million in 2007 to EUR 12 million in 2008, and the budget for the seed stage has decreased by an average 19% each year from 2004.

3. The Dutch home market for clean energy technology is underdeveloped

A strong home market is indispensible. It allows companies to experiment, gain experience and quickly traverse the learning curve – both giving them a competitive lead and providing them with reference and showcase projects. For smaller countries, this means benefitting from a first mover advantage. A well-developed home market is a precondition for the development of clean energy technology companies. It enables the experience and reference projects that businesses need to compete internationally. There is a clear correlation between a high share of wind energy in total electricity demand and international sales from wind energy products.

The Netherlands is lagging behind in developing a home market for clean energy technology applications. Where in Denmark renewable energy sources account for more than 17% of primary energy supply, in the Netherlands renewable energy supplies less than 4% of primary energy. That supply has grown by 10% annually since 2005, but from a very small base. In energy efficiency, too, other countries have far more developed home markets. The Netherlands improved its energy efficiency by only 0.6 % per year between 1990-1996.

There is not much support for a home market. A country like Germany employs a wide range of renewable energy policy instruments: quota obligations, feed-in tariffs, tax exemptions, direct taxation, direct subsidies, R&D subsidies (e.g. for PPPs), thermal regulations, dispatch priority and subsidized loans. The Netherlands only uses feed-in tariffs, tax exemptions, and direct and PPP subsidies – and on a smaller scale.

Thus the Netherlands falls short on all three key success factors (public funding, private investments, and home market maturity). However, the relatively young age of the clean energy technology industry means that it is by no means too late to improve Dutch performance.

Conclusions

The Netherlands has the potential and the ingredients for a strong domestic clean energy technology industry. The companies are present, the technology base is strong, and as one of the richest countries, the financial resources are available. Clean energy technology is needed to limit climate change and save crucial ecosystems. It is also a growing industry with attractive business opportunities, and

PHOTO: © WWF-CANON / MICHEL GUNTHER

Private investments need to increase to make Dutch cleantech grow internationally.

the Netherlands has the potential to play a larger role. This analysis indicates what can be done to emulate the example of leading countries and to build a strong Dutch clean energy technology industry.

As a national target, the Netherlands should aspire to a global top-10 position in 2015 and pursue the 15% annual growth needed to achieve it.

The Netherlands should not be content either with its mediocre ranking, or with total sales figures in comparison to other countries' GDP-weighted CET industry size. Given its potential, in both knowledge and companies, and its long tradition of responsibility and environmental engagement, the Netherlands should be more ambitious. In a business-as-usual scenario, sales growth for Dutch clean energy technology will be limited to the average annual growth of 7.5% that is forecast for the global market as a whole. Dutch industry would add EUR 600 million to its sales between now and 2015, to reach a total of EUR 1.5 billion. In this scenario, the Netherlands would retain its 17th place – at best.

For a global top-10 position, sales must increase by almost threefold. To pass Israel and claim tenth place in the (GDP-weighted) country rankings, the Dutch clean energy technology industry must exceed EUR 2.5 billion by 2015. A global top-10 position in turn will reduce global/Dutch? CO_2 emissions by 130 Mton in 2015 and add 8,000 jobs and EUR 1.6 billion in sales to the Dutch economy.

The Netherlands is not starting from scratch. There are many promising companies in the Netherlands today that could help realize the 15% per annum additional growth needed for a top-10 position. To enable these companies and the Dutch clean energy industry to grow, the Netherlands needs to secure sufficient and consistent government support over the innovation cycle, stimulate high investment in sectors with a strong domestic fit, and facilitate strong home markets for Clean Energy Technology applications.

SWEDEN

Population: 9,220,000 (2008)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 49 248
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, Sweden: 5.3769
Source: (CDIAC) Carbon dioxide emissions (CO_2),
metric tons of CO_2 per capita http://unstats.un.org/
unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage:
No country level data are available.
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: Sweden $ 39,000 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/
rankorder/2004rank.html


PHOTO: © WILD WONDERS OF EUROPE / CAIRNS / NATUREPL.COM

SWEDEN

Identifying Climate Solvers for innovative clean-tech solutions in Sweden

This section on the Swedish conditions for climate innovations is a summary of the report "12 Climate Entrepreneurs – Revolutionary Innovations for a Carbon-Free Future", produced by Global FOCUS, 2008). More elaborate description and analysis of Sweden's national climate innovation system can be found in the original report at www.climatesolver.org.

The purpose of the Swedish assessment, commissioned by WWF-Sweden in 2008, was to help accelerate the transition from a fossil-fuel based economy to a low-carbon society. The report highlights winners in this transition, the climate entrepreneurs who make the low-carbon future possible, and suggests how the Swedish innovation system can improve its support for these entrepreneurs. The objectives for this report were:

- To showcase a selection of Sweden-based climate entrepreneurs and the global potential for CO2 emissions reductions offered by their low-carbon innovations.
- To present ideas and recommendations for faster development, diffusion, and deployment of climate technology globally based on the entrepreneurs' and other relevant stakeholders' experience.

The companies presented in the Swedish report were selected by a panel of technology, innovation, and market experts from China, India, and Sweden. Twelve companies were selected based on their climate innovations' potential to reduce greenhouse gas emissions on a global scale. The twelve companies were divided into five different sectors: Energy Production, Energy Efficiency, Construction, Transportation, and System Innovations. The collective potential greenhouse gas emission reductions (given a set of assumptions on market penetration and share) are 600 million tons of carbon dioxide annually. This is equal to the total combined annual emissions of Australia, Argentina, and Belgium.

Building on the successful introduction of Climate Solver, the concept has become an annual event awarding new non-fossil, non-nuclear technologies that can offer >20 million tons of CO2 emissions reductions per year within ten years. Since 2008, 24 Climate Solver companies from Sweden have been awarded, with a total CO2 reduction potential of 1.5 Gigatonnes. To illustrate the global potential for climate innovations, Climate Solver companies from several key markets will be acknowledged within the coming years.

Challenges and Recommended strategies

In a 2010 follow-up survey with Climate Solver entrepreneurs, a range of barriers and opportunities for commercialization and up-scaling were identified. Together with the original report, findings and experiences of these firms are summarised below, and followed by proposals for how policy makers and the business community can move ahead toward a competitive low-carbon future.

In order to expand into new markets and countries a firm needs to establish local presence. However, it is noted that identifying a local partner to work with is not always easy, and without such a local partnership the firm is on its own in dealing

with cultural differences and putting a lot of effort into finding a common language with customers and other actors in the new market.

It was recognised that in some more proactive countries, SMEs in the cleantech market work in consortium when entering the global markets. Such strategies are perceived to be fruitful and bring many benefits to all involved by sharing costs, risks, resource mobilisation, marketing, etc. Swedish cleantech SMEs do not usually cooperate to such a large extent, possibly due to high competitiveness.

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The future for Swedish industry can benefit greatly from climate innovations.

Other challenges identified when moving into new markets are primarily the large differences among countries (even within EU) in regulations for business establishment and for environmental standards and legislation. Cultural differences are also perceived to be significant obstacles in establishing a small clean-tech business in a new market.

A challenge in attracting investors is that many require involvement of other investors, which in the end can result in the need to find three or four investors at the same time. Many capitalists are also perceived to undervalue the innovation and the business. Another barrier for investments is that investors are deemed to demand excessively high returns and take too large a share of business ownership. Furthermore, the many steps and long processes involved when working with technologies for the public sector is a major obstacle in attracting investors.

Several of the interviewed entrepreneurs find that Swedish venture capitalists lack sufficient knowledge of clean energy technologies. This results in investors shying away from the clean tech market, preferring investments in IT or other, to them more familiar, sectors. At the same time, the clean tech concept is also perceived as becoming diluted, encompassing too wide a range of products and businesses. The definition of clean technology should therefore become more restrictive in favour of products and solutions that seriously benefit the environment and mitigate climate change.

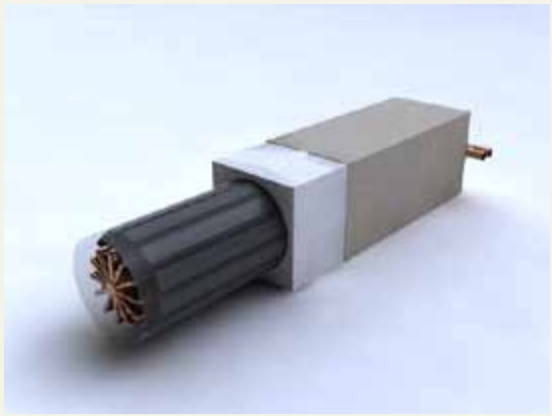
A lot of potential is seen in government regulations and public procurement. Strengthened energy-efficiency standards, increased criteria for innovative technologies and clean energy solutions in public procurement are highly requested government strategies. Other measures asked for are cost reductions such as tax-deductible investments in small clean-tech businesses, simplified application processes for public funds, and reduced demands on high co-financing.

Conclusions

Based on identified challenges and opportunities the following section summarises the proposed path forward for...

... Politicians

- Design national strategies for transitioning to smart low-carbon solutions by phasing out fossil-based technology – in collaboration with businesses and other organizations – and with a global perspective in mind.
- These strategies call for specific, long-term climate technology goals with quantifiable and measurable annual targets for numbers of businesses created and magnitude of exported emission reductions. To reach these targets, a well-funded centre for climate entrepreneurs should be created – a public programme to facilitate the entire innovation process, from research and development to commercialization and export. The centre should coordinate all existing forms of support and provide one-stop-shopping for climate entrepreneurs. Its staff should proactively seek out climate entrepreneurs and offer them help with the innovation, commercialization, and export processes. Four funds, with considerable financial resources, should be linked to the centre and give support throughout the innovation process.
- Policy makers and public authorities should continuously interact with the centre, to gain understanding for how legislation and regulation need to be improved to support the new low-carbon economy transition. The government should engage in capacity building abroad by promoting the formation of similar centres in other countries.
- Public funds should assist climate innovations to reach the global market faster by supporting the establishment of climate innovation zones where low-carbon innovations can be demonstrated in full-scale operation in a relevant context (e.g. energy or transport systems).
- The climate challenge is not just, or mainly, an environmental issue, but a matter of fundamental importance throughout the political arena. Climate change has to be handled as a long-term and strategic task within all political fields, but most importantly in all commitments regarding innovation, trade, finance, enterprise, energy, research and development, export, and infrastructure.
- Low-carbon innovation needs to be supported not only on the supply side but also on the demand side, through public procurement programmes and public construction investments with climate innovation quotas. Public-private technology procurement programmes should be promoted so as to involve the private sector and expand the market. Another policy measure to promote new technologies that has proven to be successful is feed-in tariffs, in use in Germany since 2004 and now being introduced in several other countries.
- Policies need to break away from current technology lock-in and patterns of excessive energy and resource consumption. This cannot be accomplished by consulting only large corporations with a dependency on conventional solutions, when planning infrastructure development and public investments. This means that supporting technology innovation requires financial innovation, to allow clusters of innovations to be implemented on a large scale as system solutions, especially within energy, construction, and transportation.
- Conventional climate-damaging technologies should be firmly phased out with the implementation of new legislation and regulation, especially where climate-smart solutions are already more cost-efficient and new investment has a quick payback. Where climate-smart technologies are available but not yet cost-competitive, urgent policy



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A systems-wide approach is needed for Swedish climate innovations to contribute to a resource-efficient economy domestically and globally.

measures are needed to enable the transition and to build up economies of scale.

- Major investments are needed to promote energy efficiency and to completely end any further funding or expansion of fossil-fuel based energy production worldwide. Increasing fossil production capacity is unacceptable; more than half of the energy produced today is wasted and is not being used to meet energy needs at the end user. New technology can make the use of energy radically more effective and increase energy productivity.
- Export policies and the financial regulatory framework should be adjusted to guarantee international support for climate-smart development – not the opposite. Government-controlled pension funds, export support, and official export loan facilities should be used to support the transition to a low-carbon world, not to support fossil-dependent technology and maintain a high-carbon economy. Developed nations need to act on the advice from several trustworthy institutions and commit percentages, rather than fractions of a percent, of GDP to the transition to the low-carbon society should be obvious.
- The focus will need to be system-wide, not fragmented or marginal. New investments as well as existing solutions need to be transformed within many sectors, especially energy. Climate efficiency must be an integrated part of societal and economic systems, rather than being reduced to a matter of individual consumer involvement. Market failures need to be addressed by smart policies and empowered institutions.

...businesses

- The third industrial revolution has already started, and has sustainability at centre stage. Fossil-dependent technologies will be replaced by greener solutions. Infrastructure will be modernised, and our buildings and transportation systems will be improved. Linear resource flows with input, process, and waste will be replaced by cyclical flows, which are more respectful of natural resources and climate impact. For businesses, these changes will pose new challenges and present new opportunities. Businesses hoping to survive the transition to a low-carbon economy have to start preparing strategy and operations now.
- For a business, managing the transition mainly involves:
  1. Minimising the emissions of greenhouse gases through the whole chain from suppliers to customers, not least to avoid future difficulties with internalized costs, legislation, and regulation.
  2. Transforming or modifying products and services, in order to maintain competitiveness and ensure demand in the future market. As we enter the low-carbon economy, fossil dependent products will become increasingly incompatible with the new and modern technological and institutional context. There are today great opportunities for lowering climate impact while at the same time increasing margins and profitability and radically reducing future risks.
- Low-carbon, climate-smart innovations should be the core of business strategies and be incorporated into all main activities. If some area of activity is not compatible with the low-carbon economy, executives need to seriously reconsider what business development is about. Climate entrepreneurs from all parts of the world are living proof of a wide range of powerful approaches to initiate this change. The potential offered by their climate innovations reflects what will be mainstream demands in a low-carbon future.

GLOBAL PERSPECTIVES ON CLIMATE INNOVATION SYSTEMS

As the assessments of the previous chapter have shown, climate innovations with great potential to meet climate challenges can be found all over the world. The assessments also reveal that the ability to create enabling environments for climate entrepreneurship varies greatly – each country still has a long way to go to reach its potential. International science and experiences should be shared among key stakeholders to build strong and coherent climate innovation systems in each country or region. However, it is important to acknowledge that any strategy or national plan developed has to be tailored to national policies and market conditions, and must capitalize on the opportunities and comparative advantages of each individual country.

In light of the nine innovation system assessments presented there are several context-specific factors that need to be considered in the strategy process:

- The level of development and size of the economy;
- The level of know-how among professionals, and awareness among the general public; technological resources and institutional capacities;
- Governmental policies and governance structures;
- The level of trust and efficiency of overall state-business relations.

This chapter will start with a brief examination of some of these factors and define some of the key elements to consider in building a strong and high-performing climate innovation system. This analysis is then complemented with current research findings and good practices, resulting in a core set of conclusions and recommendations on how to best strengthen climate innovation systems in order to enable a commercially viable 100% renewable global energy system that will contribute to keeping global warming below 1.5°C compared to pre-industrial temperatures.

Key messages:

- Countries' ability to create enabling environments for climate entrepreneurship varies.
- Policy makers need to geographically harmonize policy environments that: strengthen market conditions, address IPR concerns, promote knowledge sharing, leverage infrastructure investments, and involve civil society.
- Any progress or output is the result of a collaborative stakeholder exercise, nationally as well as internationally.
- Investors value government policy-making that signals intent and consistency.

Key elements of a high-performing climate innovation system

Similar to the findings of several well-known reports published in recent years in the field of technology development and transfer,[111] the national assessments presented in this report have illustrated that there is a wide spectrum of factors that determine a country's ability to stimulate investments and access to funding for low-carbon innovations and technological change. Without claiming to be completely comprehensive, these factors can be categorized as follows:

- Political leadership and governance;
- Market conditions
- The legal system
- Knowledge frameworks;
- Energy systems and (urban) infrastructure;
- Role of civil society.

111 See for example UNDESA (2008) and IPCC (2000).

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Building capacity to support climate innovations is an exciting and rewarding challenge.

These categories cover a wide range of issues – which ones should be considered as key elements in a high-performing climate innovation system that can enable a global implementation of transformative clean energy solutions? This has been the focus for a large number of research initiatives, governments, and experts for decades. Through well-developed theoretical models as well as increasing opportunities to test these models against government implemented strategies, we now have the knowledge needed. Among the dimensions mentioned above, it is clear that most attention to date has been paid to the role of markets and legal systems[112]. While these dimensions are of extreme importance and need continued scrutiny, it is also vitally important to address less tangible factors such as an enabling culture and individual values. Civil society can contribute greatly to creating alignment between these factors and in the transition to a low-carbon economy.

The national assessments have aimed to illustrate the status, challenges, and opportunities of climate innovation systems in a number of countries. By providing such national outlines, we are in this section able to aggregate the findings and highlight the key elements of each dimension. Conclusions from these findings will serve as the basis for a set of recommendations to key stakeholders on how to reinforce climate innovation systems and enable the transition to a low-carbon future.

112 UNDESA (2008).

Political leadership and governance

Development of any government plan for climate innovations requires first and foremost that there is sufficient access to reliable information for political decision-making. The level of awareness of climate change impacts, as well as available mitigation and adaptation solutions at national level, are both crucial in stimulating much-needed political leadership and government action. For this reason, governments that are in the process of strengthening national capacities in this area are advised to carry out climate change impact assessments and review national gaps, available climate innovations, and comparative advantages in tackling global warming. Consolidating and disseminating such assessment findings and clarifying government options for climate mitigation and adaptation strategies will help advance the level of awareness among the general population and create wide policy support, as well as market demand.

Literature shows that the role of civil society in government decision-making, the location of power, and the presence of formal or informal alliances involving government, industry, and the media are some of the factors that determine the opportunities for technological change.[113] The national assessments pay attention to these factors, but underline that the key basic factor shaping the national environment for investments in innovations is the level of political will and leadership within central government. Political leaders that have shown commitment to raising climate innovations as a policy priority high up on national or regional agendas have managed to achieve tremendous results in establishing effective policy frameworks as well as creating thousands of new green jobs. Examples of this can be found in Baoding (China) and California (USA).

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Global leaders need to be innovative and facilitate collaboration.

The location of relevant policies in respective central and local government structures has an impact on the overall effectiveness and sustainability of the climate innovation system. As we have seen, governments seem to greatly benefit from centralising public ownership and accountability of policy development to a strong ministry or agency that is given the mandate to shape progressive policy-making on climate innovations through coordination across relevant policy sectors. Strategies that on the contrary aim to mainstream innovative approaches to climate change into all relevant sectors risk diluting rather than effectively integrating ownership of this important policy area.

Also, the previous chapter highlighted that in some countries (e.g. India and China) a large part of the responsibility for renewable energy research and policy-making is placed under the management of local governments, while institutions for fossil energy are usually attached to the central government. While such a decentralised approach has the potential to stimulate valuable competition between municipalities, it also risks creating national policy uncertainty, hampering national rollout of advanced technological innovations. Given the relative high levels of cost and risk-taking in the climate innovations sector, it is important for governments create a geographically harmonized policy environment for private and public sector technology development, to allow for transparent and predictable decision-making as well as political stability. To enable the continuous improvement

113 UNDESA (2008).

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Better conditions for large scale deployment of climate innovations must be urgently put in place.

of these policies a strategy for regular monitoring and evaluation needs to come with the frameworks.

As illustrated in previous chapters, the clean technology sector is characterised by serious risks that call for active management in a number of areas. Simultaneously, in climate change we're facing risks that cannot be addressed with incremental improvements alone. Criteria used in the innovation systems should reward radical breakthrough solutions. However the current situation tend to be the opposite, i.e. transformative solutions have more difficulties in attracting support from investors and other key stakeholders – a policy lock-in that must be resolved. When it comes to policy risks, it is important that governments develop policies that are aligned with the fundamental characteristics of clean technology development. For example, experience shows that national goals to develop and commercialize certain solar energy technologies may need to be undertaken over a 20-year period. However, the average validity period for governmental programmes is 5-10 years. This results in unpredictability about possible future policy changes that risk hampering much needed long-term investments. Therefore, in order to mitigate such policy risks and incentivize market-leveraged support to climate innovations, governments need to employ policy processes that produce measures that are tailored to the dynamics of the sector.

Market conditions

Adding to the policy risks, there are also market risks that need to be systematically addressed in order to maintain targeted investments in the innovation process. As a private investor it can be difficult to estimate how potential new technologies will be received

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Corporate leaders must put climate change at the core of their strategies.

by customers. This is particularly valid when it comes to technology-push innovations where market stimulation by, for example, information campaigns, is critical. As previously discussed, one of the key elements of a successful shift towards clean energy development and use is the ease of market entry for new firms and technologies. This could be promoted through many different measures, which all will be discussed in more detail in a separate section below. For now it is sufficient to conclude that the national assessments have illustrated that any of the measures at hand aim towards basically two sets of goals; *reducing costs* and *mitigating risks*.

Public funding as well as progressive subsidies and tax systems can help fill gaps in critical stages of technology commercialization. Governments can furthermore promote balanced risk-taking by investors, entrepreneurs, and corporations by: providing guarantees and risk-sharing schemes; ensuring unhindered information flows; and making favorable insurance options and other market mechanisms available. This seems generally to be of particular importance among less-developed countries where the majority of the world's investors are relatively far away, enabling policy frameworks are less developed, and entrepreneurs are fewer and less experienced.

As addressed in the assessment for India, and true in many countries, is that the perceptions of risks and the approaches to investment opportunities vary among groups of entrepreneurs and investors. Venture capitalists active in various parts of the world's clean energy market recognize that entrepreneurs in one country can act quite differently from entrepreneurs in other countries. Some entrepreneurs seem to value full control of their companies far more than others, with first-time entrepreneurs often perceived by venture capitalists as having skewed expectations regarding the valuation of their company. The perception of risk may also include aspects like social acceptance and status, which can limit a country's ability to benefit from climate innovations. These differences in cultures and experiences need to be acknowledged and properly managed in order to facilitate productive business collaborations in climate innovations development and commercialization.

Furthermore, systematic implementation of ambitious standards for energy efficiency across a number of sectors has proven to drive the development of technologies and markets in similar sectors. Higher demands from the private as well as the public sector will stimulate the demand for climate innovations, too, and are called for by climate entrepreneurs.

Finally, government strategies should include incentives that ensure a balance between entrepreneurship based on technology-push and market-pull forces. As the country studies reveal, many entrepreneurs tend to build their businesses around a technology that they have been part in developing or acquired. Increasing incentives for entrepreneurs to adopt more customer-centric and service-oriented business models are likely to result in enhanced market diversification, which may increase the number of new clean energy technologies that make it all the way through the innovation process into widespread market diffusion. While some countries have much to offer on the technology development side, others – like India – are a source of equally-important skills in business modelling and up-scaling.

The legal system

A well-established legal and regulatory system is a significant factor in facilitating efficient relations between political will and market forces. The legal system sets the rules of the game, and regulates the level of risk-taking in the development of and investment in technologies. One key component of the legal framework is the establishment and strengthening of the patenting system of intellectual property rights (IPRs). As we have seen, the existence of a solid and effective patenting system for IPR constitutes an important prerequisite in influencing the willingness of entrepreneurs and investors to engage in the development and commercialization of promising ideas and innovations. It is common business sense for inventors and entrepreneurs to seek the environments where their full rights as sole owners to new technologies are best protected. This has been a major reason why some countries have successfully managed to attract innovative ideas and investments while others suffer from a lack of them.

The need for improved IPR systems has been stressed in several of the national assessments, indicating that domestic entrepreneurs in some countries even tend to shy away from seeking patents due to long application periods and burdensome bureaucracy. As a consequence, the quality of research and innovation risk a loss of international competitiveness. In these cases, governments may want to consider including measures that strengthen the reliability of the IPR system in their climate innovation strategies, and increase access to these much-needed support frameworks through, for example, introduction of single-window clearance procedures. At the same time, patents are also identified as part of the problem in the debate on technology transfer, in particular transfer to developing countries. The argument is that new solutions for meeting the climate challenge are being held back for economic and competitiveness reasons, which limits the opportunities for wealth-building and development in developing countries as well as for global distribution of climate innovations in general. To overcome these situations, novel approaches to IPR have been introduced, e.g. patent pools (sharing IPRs) and open-source solutions (IPR-free). Further development of both the IPR system and IPR-free models are needed to eliminate barriers in the transition to a low-carbon future.

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Support and incentives are needed to facilitate collaboration between academia and industry.

Finally, the strength of the legal system is to a large degree dependent on the government's capacity to ensure compliance with adopted standards and legislation. Renewable energy, energy efficiency standards, and other relevant legislation must be properly implemented and enforced if markets are to work. Governments need to review areas of weaknesses in policy compliance and take appropriate action to make sure that rules and legislation achieve the results that they were designed for.

Knowledge frameworks

Efforts to continuously enhance research and expand the national knowledge base on climate innovations should constitute a central element of governments' climate innovation strategies. Governments are increasingly recognising the need for strong linkages between the national level of knowledge creation and successful market implementation. As all national assessments show, the current level of funding for R&D is insufficient

and needs to be increased by a factor of 3-6.[114] However, these studies also confirm that direct financial stimulation is far from the only action that the public and private sectors have at their disposal when it comes to commercializing research findings and facilitating large-scale dissemination of climate innovations.

In order to ensure that universities and national research centres put a strong focus on climate innovations with technological application, a national climate innovation system should include various types of reward mechanisms and incentives for knowledge institutions as well as for individual researchers to engage in collaboration with the business community, government and municipalities. Inspiration is available in many countries. Entrepreneurial leave, as practiced in USA is one example, i.e. university staff getting permission for three years to start their own business with the opportunity to come back if they fail. The Entrepreneur In House initiative is also interesting, in which entrepreneurs supported by potential funding are brought into university laboratories in order to commercialize research with commercial potential. Such outreach engagements are not always rewarded, and in the absence of targeted incentives many universities tend to be more focused on teaching than research. Furthermore, in some country contexts, graduates with specialized high-quality training tend to avoid the risks of joining a start-up firm in the clean energy sector and prefer to work in other more traditional and well-established technology sectors.

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Rapid urbanization is an opportunity for low carbon development.

A national government program on clean energy research is thus recommended to encourage demand-driven research and stronger links between the academic, public, and private sectors. This is of critical importance, as investments in research can have very minimal effects on national development if the research findings are not effectively communicated to entrepreneurs and firms and made available for further development and commercialization. Together with key stakeholders, governments should consider establishing climate innovation knowledge centres to promote trans-disciplinary R&D projects, in combination with a coherent pathway to the markets and public sectors where these solutions are needed.

Energy systems and (urban) infrastructure

The world is currently experiencing a massive urbanisation trend. More than half world's population lives in urban areas today. At the same time, studies show that close to 80 percent of CO2 emissions stem from activities undertaken in cities. Urban infrastructure, housing, and transportation are three primary sectors causing these city-centred emissions. Consequently, transforming the technology base of these three sectors into low or even zero-carbon solutions constitutes a tremendous opportunity for global climate change mitigation. Given the estimated $350 trillion that will be spent on urban infrastructure and use over the next three decades, it is essential that these investments are allocated in such a way that urbanisation contributes directly to the low-carbon transition. If spent based on a business as usual scenario, these enormous investments will result in a high-carbon lock-in effect[115], with

114 Major Economies Forum (2009).
115 See for example Energy Policy 28 (2000), Oak Ridge National Laboratory (2008) or Tyndall Centre (2009).

irrevocable consequences for the climate. The key lies to a large degree in the status and direction of urban planning, which plays a big role in determining whether cities become part of the solution or part of the problem.[116]

The decisions for urban planning taken today all over the world are crucial for our ability to keep global warming below 1.5 o C. Cities in the process of reinventing themselves can make considerable contributions while enabling their own transitions simultaneously.

To see just how influential urban planning is on CO2 emissions, the report "Reinventing the City – Three Prerequisites for Greening Urban Infrastructure", commissioned by WWF, compares U.S. and European transportation emissions. "Since the 1950s, a period during which the U.S. experienced a high urbanization rate, most cities have been planned to accommodate auto transportation for every individual. In contrast, European cities were largely planned before the widespread ownership of cars. As a result, transportation emissions per capita are almost three times higher in the U.S. than in most European countries, including Germany, the United Kingdom, and France."[117] This example illustrates the important role of urban infrastructures for enabling low emissions. The decisions for urban planning taken today in thousands of small but rapidly growing cities all over the world are crucial for our ability to keep global warming below 1.5 degrees °C. The other insight is that the technological solutions that mayors and central government decision-makers need to seek must offer transformational change, rather than today's incremental levels of improvement. One powerful tool to spur transformative and sustainable urban development is information and communication technology (ICT) which should be systematically employed from the very first steps of planning for cities. Reinventing the city is indeed a genuine key mission towards achieving sustainability and climate resilient ways of living.

As stressed in previous chapters, assessments indicate that both developed and developing countries recognized the need for switching to a new generation of energy systems and infrastructure - predominately for urban development but also for rural areas, and equally important for mitigation and adaptation. The process is already started, and it is crucial that governments and industries use this opportunity to ensure a decisive transition to new clean and energy-efficient technologies. Should this currently not be available, countries need to employ other means to reduce their carbon footprint, implementing an approach that allows for introduction of emerging technologies as they enter the market during the time period up to 2050.

A number of technological risks face innovators, investors and other stakeholders involved in enhancing climate innovations. How early stage innovations will perform as full-fledged market technologies, and the kind of technological glitches that will need to be fixed during the innovation process are typical issues creating uncertainty and affecting public and private sector interest in providing necessary funding and support. In order to achieve a shift into a new generation of technological systems, it will be crucial that technological risks are anticipated and mitigated. This is best done through comprehensive laboratory testing and early involvement of industrial partners during the demonstration phase. However, as we have learnt in previous chapters, full-scale demonstrations of clean energy technologies and climate innovations are capital intensive by nature, requiring exceptional commitments and investments from both government institutions and market actors. Bridging the Valley of Death is thus an exceptionally challenging step for climate entrepreneurs, and cities in the process of reinventing themselves can make considerable contributions while and enabling their own transition simultaneously.

Role of civil society

The prevailing culture in a given society is a strong driver for its energy and resource consumption. Technology is part of the puzzle, in the way it is used for establishing individual identity, status, and social bonds. The willingness among individuals to accept

116 WWF (2010 E).
117 WWF (2010 E).

Civil society can share knowledge about climate impact and available innovations, e.g. how to produce biochar.

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changes in lifestyle based on perceived intangible effects of global warming is in many places low. Efforts to promote such individual change are often hampered further by the social inertia resulting from the tragedy of the commons. It is therefore of great importance that the role and responsibility of each member of civil society is better defined and supported. Wide-spread information campaigns and showcasing best practices are important tools for informing people of the negative impacts of climate change, as well as the various solutions at han.

The level of public awareness and attitudes towards the challenges of climate change is one of the success factors in high-performing climate innovation systems. Knowledge about user's needs is necessary for product development. Awareness is a prerequisite for market demand. While this dimension is quite poorly examined in the research field, the national assessments commissioned by WWF continuously return to the fundamental need of civil society support as a key element for successful government policy-making and market expansion for climate innovations. Civil society leaders and organizations can act as facilitators in the dialogue between central government and the local population. Such dialogue can promote a bottom-up approach where grassroots needs and ideas are brought to the attention of policy-makers as well as a top-down process where users are made aware of available new technologies and solutions.

Government and private actors should involve civil society when developing and launching national strategies for climate innovations. Such an approach would not only contribute the exchange of information, but also help build trust and cooperation between civil society and other key stakeholders of the national climate innovation system.

Increase collaboration, coordination & networking

National partnerships and cross-sector cooperation

The strength of a national climate innovation system is only measured by its weakest element. There is little use of an active private sector for climate innovations if neither public policy nor knowledge institutions actively facilitate the development and diffusion of climate innovations in society – and vice versa; outcomes of public policies and research spending will be limited if the business community doesn't invest in climate

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Global collaboration can make everyone a winner in the fight against climate change.

innovations. Furthermore, the private sector would have difficulties in finding reasons to become active in contexts where governments and other society actors choose not to engage in stimulating climate innovations and entrepreneurship. The WWF commissioned assessments confirm this relationship, and several other studies indicate that the capacity and commitment among key stakeholders in innovation systems varies greatly.

These circumstances have serious implications for the performance of a climate innovation system, since any progress or output is the result of a collaborative stakeholder exercise. The specific capacities and comparative advantages of government agencies, R&D institutions, and private sector actors must be used in coordinated and synergetic ways. Action in isolation is bound to fail. Cooperation is key.

For example, in the early research stages, governments that invest millions of dollars in research and academic institutions each year to stimulate new innovations and low-carbon technologies need to ensure that the R&D institutions run active demand-driven research programmes and cultivate links to the private sector and the communities in which they operate. Otherwise (which is the case in many nations today) research findings stay inside these knowledge hubs with minimal impact on development in society. While acknowledging the importance of increased funding towards climate innovations research, experience emphasizes the need to go beyond counting the economic input to research processes, and in addition start measuring the level of national performance by the concrete outputs of R&D investments.[118] Through R&D investments, governments should strive towards maximising the number of high-quality innovations that are brought to the market, creating increased business opportunities and green jobs and help solve the climate challenge.[119]

All the national assessments included in this report call for continued establishment of collaboration and coordination mechanisms at national and local level for climate innovations. National policy on climate innovations includes active involvement of public and private actors from a set of different sectors. At central government level, the ministries for infrastructure, national planning, research and education, and finance as well as trade might be as urgent as policy areas to address for an effective national climate innovation system as the ministry for environment is. In order to efficiently transfer and use knowledge and resources from all these sectors, governments need to establish appropriate institutional capacity and implement policies which ensure that climate innovation knowledge is adequately shared and employed. The national climate innovation system has to be an open and heterogeneous system that allows flexibility, while at the same time directs progress to the challenges at hand. Furthermore, the system should provide financial and technical resources and promote public-private partnerships.

At sub-national level, technology innovation centres, business incubators and other similar intermediaries have a significant role to play, as discussed in Chapter 3. Such institutions, most often established through government funding, make sure that innovators

118 Edquist et al (2000).
119 VINNOVA (2010).

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The market for a climate innovations can often be found far from where it was originally developed.

receive the help needed and that embryonic innovations are picked up and supported by public and private players towards fully-developed market technologies and products. To strengthen this process, a partnership with the ICT sector is likely to be very fruitful to enable information exchange, match-making and open source platforms as discussed in the Indian study. The existence of these centres facilitates a perfect way for the government to work in partnership with the private sector, by using public money to reduce the risks of private sector investment, and promoting technical collaboration between public and private sector researchers on specific projects. In this way, the government can make sure that resources and activities are focussed towards the development and/or adaptation of the most appropriate energy and climate technologies for a country, given its capabilities, resource base and needs, and at the same time ensure that the developed technologies are market-oriented. In addition, the technology innovation centres are proactive in identifying and addressing barriers throughout the climate innovation chain.[120]

The reason these centres seem to constitute successful mechanisms in developing climate innovations is, according to UNDESA, that they are "well placed to work in ways that traditional government approaches cannot, by drawing on expertise and resources from not only government, but also business, industry associations, the energy sector, and the finance community and investors. As independent organizations they can impartially identify low-carbon technologies with high potential, and seek the most appropriate pathway for commercialising them. Their specific competence and business-oriented approach would ensure that all activities would be focused on increasing the commercial potential of clean energy technologies and leveraging private sector investment alongside public funding"[121].

120 UNDESA (2008).
121 UNDESA (2008).

Increased national collaboration – either through technology centres, university networks or private business associations – serves the purpose of scaling up domestic efforts on climate innovations and energy efficiency. Markets can thereby be stimulated to rapidly expand and create new much-desired business opportunities and an increasing number of green jobs.

International networking and technological cooperation

Similar to domestic cooperation, mulitlateral collaboration between governments, research centres, and the private sector can achieve scale and build international markets for new innovations and help drive economic growth in all countries involved. As discussed in previous sections of this report, the development and deployment of climate innovations is relatively cost-intensive, yet it offers great opportunities for cost-savings in the long-term usage phase. In a global market the deployment costs can be substantially reduced through economies of scale. Entrepreneurs as well as corporations may find it wise to identify and benefit from innovation hot spots[122] around the world, and actively participate in the formation of climate innovation hot spots in relevant regions. Governments have much to gain from stimulating multilateral trade and investment in low-carbon and energy-efficient products, services and technologies. Since the 1970s, the costs of energy production from a majority of technologies have systematically fallen via development and large-scale manufacturing, and there are still opportunities for further cost reductions.[123]

In addition to the clear economic incentives for increased international cooperation, it is worth reemphasizing that considering the immense global challenge put forward by climate change, no single country is able to address it on its own. As discussed in chapter 2, active engagements of both developed and developing countries are critical in order to set the planet towards a 1.5°C trajectory. Climate change is manifested across borders, independently of whether a country is contributing to the cause of climate change or not. Only joint action and collaborative approaches can cultivate the much-needed solutions for the increasingly adverse impacts of global warming all around the world.

The speed of global diffusion for climate innovations need to be radically increased. There are many factors complicating or even preventing governments and domestic actors from collaborating internationally. These barriers range from insufficient national markets and low-income consumers, to lack of access to information and inappropriate IPR systems. In addition to this, nationally-oriented export strategies and measures to protect the domestic market from outside competition often limit the possibilities for international cooperation. As an example, IPR is frequently a tool used mainly by large corporations to stall and hinder development and use of necessary climate innovations. As a Chatham House Report on this issue notes, "Concentration of patent ownership is not synonymous with blockage or monopolistic behavior, but IP can be an important factor in determining the speed of technological demonstration and diffusion. A patent portfolio is a currency – for attracting venture capital, entry into strategic alliances, protection against litigation, as well as opening opportunities for mergers and acquisitions… Many of the energy patents owners listed in this report are established industrial giants. Their perceptions of market conditions and level of IP protection in developing economies will determine the roll-out of the next generation of low carbon technologies – whether through investment, licensing, joint ventures or other forms of knowledge-sharing."[124]

Mindful of the need to reduce the time it takes for a climate innovation to pass through the stages of the innovation process, one of the most effective ways to improve the performance of climate innovation systems is to increase international cooperation. The past years have shown that governments are not keen on establishing new international

122 Harvard Business Review (March 2009 B)
123 Chatham House Report (2009).
124 Chatham House Report (2009).

organizations. However, looking ahead, there is an urgent need for national initiatives to enhance transparency and awareness, and for action-oriented exchange across borders between them. Climate change presents the global community with borderless challenges. Meeting them also offers significant opportunities for creating stronger economies. For this, concerted global action is required – without it everyone will lose out.

In December 2010 during COP16 in Cancun, world governments decided to establish a Technology Mechanism under the UNFCCC that includes a Climate Technology Centre whose objective is to facilitate a network of national, regional, sectoral and international technology networks. At the request of a developing country these centers should facilitate prompt action on the deployment of existing technology, provide advice and support related to the identification of technology needs and the implementation of environmentally sound technologies, practices and processes. They should also stimulate collaboration with the private sector, public institutions, academia and research institutions around climate innovations and promote North–South, South–South and triangular partnerships with a view to encouraging cooperative research and development. The UNFCCC decision fits well with the needs discovered in Tanzania and other developing countries researched by WWF. It is important that substantial resources are put behind this decision in order for it to properly address this identified gap.

Statistics show that the level of such cooperation among countries and key stakeholders is still much too low.[125] However, partnerships established among corporations in OECD and non-OECD countries have proven to be very effective in developing and transferring technologies. For this to occur, the partnerships need to be built on mutual dependency and risk sharing, and involve a long-term commitment to share knowledge, increase technological capacities, foster research and innovation as well as strengthen each other's competitiveness. With these elements included, the partners can gain access to new research areas, training and education, new ideas and methods.[126]

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Policies need to attract accelerated investments in climate innovations

For developing countries this type of collaboration brings opportunities for national leapfrogging into low-carbon systems and infrastructure. However they depend, to a large degree, on how well the innovation process is able to take local needs and priorities into consideration. For this reason, developing countries should strive for increasing its capacities to assess, analyse, and choose technologies based on domestic conditions and development priorities. By employing global markets and knowledge in the fight against climate change, all countries and stakeholders will benefit from enhanced international technology cooperation. This is not only possible, it is necessary to enable the transition to a low-carbon future.

Clean energy policy for accelerated investments

Financial institutions need to recognize that longer term financial stability rests on building overall climate resilience in all the various sectors and segments of the population. Governments, knowledge institutions and civil society organizations need to influence the allocation of financial investment for longer term development and stability for all.

After the previous examination of the key elements and links of a climate innovation system, this chapter now turns to seek an answer to a final key question:

125 Chatham House Report (2009).
126 UNDESA (2008).

To stimulate investments in climate innovations it's important to send the right signals to the market.

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– Among the entire set of policy tools that governments have at hand to accelerate climate innovations, which ones should be recommended as most effective?

Today governments in many countries are showing great interest and commitment in developing and adopting clean and efficient energy technologies. The current economic downturn has the potential to create even more demand for new technology systems as governments seek to identify measures that can reignite economic growth and increase employment in new evolving sectors. Investments in clean energy are slowly beginning to rise again, and governments need to capitalize on this momentum by stimulating increased capital flows into the sector. By doing this they can also avoid locking the economy into high and unpredictable future costs. In order to support these efforts there is an urgent need to provide further guidance to governments on how to best utilise policy instruments to trigger such increased investments.

The answer to the question is not an easy one, and it has been the focus of many research papers during the last decade. First and foremost, it is worth reiterating that whatever the "best" mix of policy options is depends on the context-specific nature of the national clean energy sector and the capacity of its stakeholders.[127] Which form of policy is ideal also depends on the technology being deployed, and its range of use - from industrial power generation to smaller commercial-scale and domestic installations.[128]

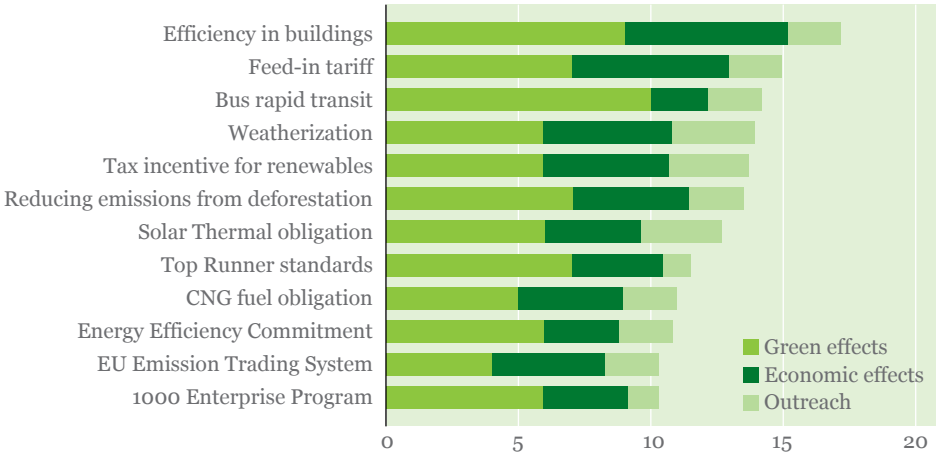
It is only in recent years that the international community has been able to test policies against each other as an increasing number of governments have adopted various standards, financial regulations, and other policy instruments with the aim of accelerating climate innovations. Nevertheless, recent years' empirical evidence presents interesting findings in this area.

The climate innovations sector requires large investments in order to go from embryonic innovation to development, demonstration, and commercial scale. This process in other sectors often involves only a fraction of these costs. This capital intensity, and the long time it takes before a new technology is ready to be diffused on the market, severely reduces investments by private investors. This is a major reason for the need of strong government engagement through an active use of policy instruments. Recent research findings show that although both market and government support is needed to manage these sector-specific barriers, policy regulations play a uniquely vital role because the barriers to entry are so high. A research paper published earlier this year concludes; "Indeed, we find no examples where climate innovations have entered the market unassisted by government intervention."[129]

127 Eric R. W. Knight (2010).
128 UNDESA (2009).
129 Eric R. W. Knight (2010).

Given the critical role of government involvement plays in climate innovations, governments need to be able to decide which set of policy instruments to use to ensure sufficient levels of investments. These policies and measures should combine substantially reduced emissions in the short and long term, generate substantial investments from the private sector, create jobs in the market and be possible to implement in most countries. In a scorecard from 2009, WWF and E3G ranked efficiency in buildings first among successful policies and measures implemented by governments in order to reduce greenhouse gas emissions, support the economy and provide useful models for other countries.[130]

Figure 23: Overview of "best policy measures"



SOURCE: WWF AND E3G (2009), SCORECARDS ON BEST AND WORST POLICIES FOR A GREEN NEW DEAL

As an example, effective measures for energy efficiency in the building sector have been implemented in Germany through a package of policy measures for energy-efficient buildings. It consists of a combination of building regulations prescribing maximum primary energy consumption for new buildings, a law on renewable heat use and differentiated support systems for exceeding these standards and for stimulating energy efficient renovation. These policy measures have been very effective. One example is the CO2 Building Rehabilitation Programme, the funding program for energy efficiency related building retrofits and energy efficient new houses.[131] For every EUR provided in the financial support schemes for efficient renovation in 2009 and 2010, another 9 to 12 EUR were investmented in building retrofits. The success factor for the energy-efficient buildings program has been the combination of efficiency obligations, prefinancing, information campaigns and additional capacity building integrated in a coherent package.

However successful this combination of measures, the ambitions and resources put into this program would need to be maintained and substantially increased in order to support a full decarbonization strategy for the German building stock. The program is currently jeopardized through deep cuts in the financial support schemes, with an unpredictable future for policies in Germany as a result.[132]

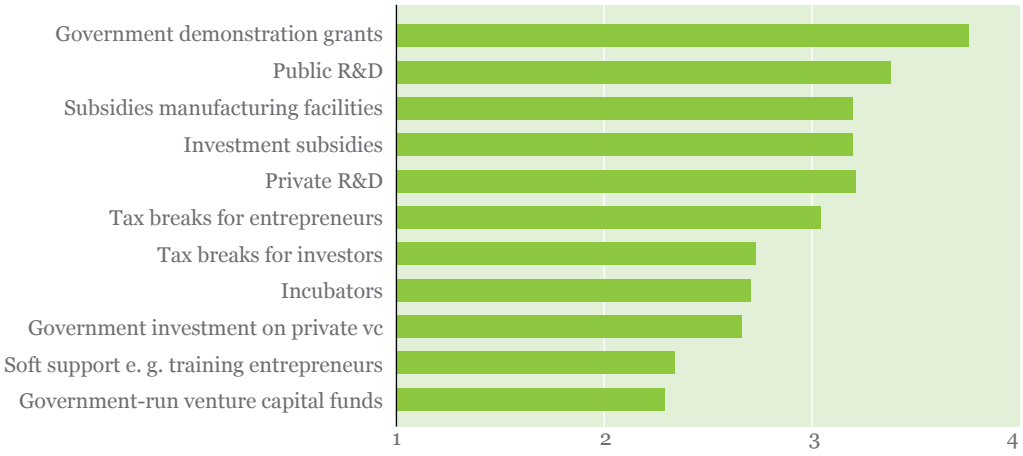
Another example addresses how policies can mobilize investments in renewable energy. A research paper by Mary Jean Bürer and Rolf Wüstenhagen presents a survey of venture capitalists' preferences for public policies to stimulate renewables.[133] Through interviews with 60 senior fund managers in Europe and the U.S., the researchers asked them to rank (from 1 to 5) the effectiveness of policies in terms of their ability to stimulate investment in renewable energy. Distinguishing policy instruments that aimed towards

130 WWF and E3G (2009).
131 KFW Bankengruppe (2011)
132 WWF (2010 I)..
133 Bürer, Mary et. al. (2009).

creating incentives for technology push and market pull respectively, this research shows the average scores given to various policy tools within each of the two categories.

Worth noticing at a first glance is that no policy tool for technology-push attracted higher average points than 3.75. While it is fair to believe that these results reflect venture capitalists' general skepticism towards government attempts to influence the private sector, it could also serve as a good illustration of governments' struggle to find truly effective policy instruments that can stimulate sufficient levels of private investments. Furthermore, almost half of the ranked instruments did not make it above 3.0. Among those are government support through incubators, and soft support such as training provided to entrepreneurs. Consequently, while these policy measures are often highly demanded by individual entrepreneurs and are thereby frequently part of government innovation policy packages, they don't seem to result in any particular increases in investor interest.

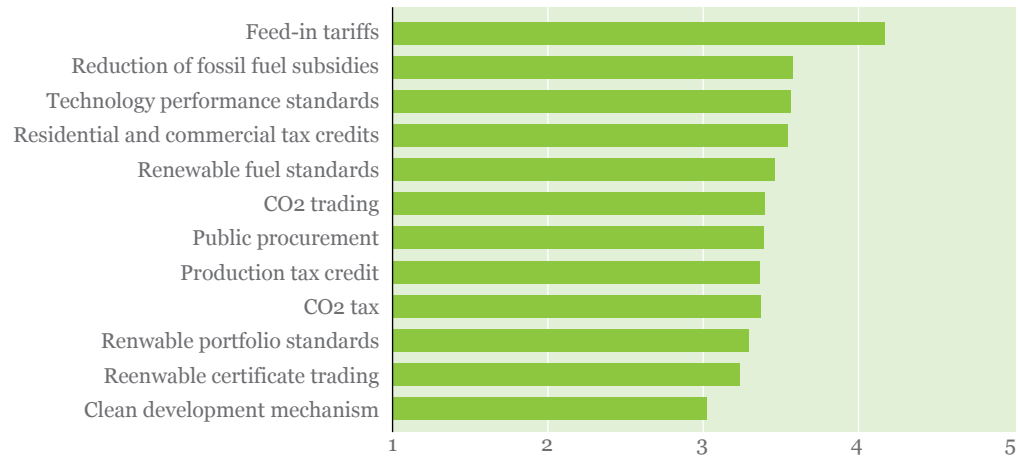
Figure 24: Investor preferences for technology-push policies



SOURCE: SOURCE: ADAPTED FROM BÜRER, MARY ET. AL. (2009)

On one side of the spectrum, government grants for renewable energy demonstration are viewed by venture capitalists as the most important technology-push policy – see figure 25. As Bürer and Wüstenhagen observe, this result confirms that there is a particular need for external investment support when newly developed technology innovations are positioned in the demonstration stage of the innovation process, i.e. passing through the Valley of Death. Thus the critical role of government engagement beyond the early stages of development and commercialization seems also be appreciated by private market investors.

Figure 25: Investor preferences for market-pull policies



SOURCE: SOURCE: ADAPTED FROM BÜRER, MARY ET. AL. (2009)

Interestingly enough, the market-pull policy instruments for renewable energy investments received on average higher scores than the technology-push regulations assessed above – see figure 26. This indicates that, contrary to governments' tendencies to focus on influencing technology-push measures on innovation, the investors prefer a market-pull approach for renewable energy. In addition, traditionally-favored policy options such as renewable portfolio standards and tradable renewable certificates came out in this survey as some of the least-effective instruments.

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Private investors prefer policies that stimulate market demand before measures for technology push.

Confirming the findings of previous reports,[134] the fund managers in the survey attributed the highest score to the effective role of feed-in tariffs. This policy mechanism provides lower risks to both the investors and government, and the costs for the end-users are relatively small. A feed-in tariff is deployed when the government mandates electricity or other utility companies to purchase a portion of their power from clean energy sources. Because renewable energy has traditionally been more expensive than fossil fuels, utility firms have been forced to pay a premium negotiated by the government. The utilities, in turn, pass on this cost to their customers in the form of higher monthly bills. The end result is that with feed-in tariffs electricity firms are bound to supply a certain percentage of electricity from clean energy sources, while the individual consumer costs are only marginally increased.

While recognizing that some of the policy mechanisms available to governments seem to be more effective than others, at the same time it is important to emphasize that investors attach a high value to government policy-making that signals intent and consistency. This is why the process leading up to a government's choice of appropriate policy regulations can be as important as the mechanisms themselves. As shown in this chapter, there are a range of elements - including public and private actors, research institutions, and civil society - which determine the performance of a climate innovation system. Climate innovations are able to thrive in countries and regions where relevant stakeholders cooperate to establish a progressive, enabling environment for entrepreneurship and original ideas. By making sure that the key stakeholders, resources, and processes of a national climate innovation system are in place, governments have the opportunity to enable the transition a low-carbon future.

134 IEA (2008 A).

Checklist for high-performing climate innovation systems

- Ensure that basic environmental legal and regulatory systems are in place – including an efficient and widely accepted approach for intellectual property rights.
    - Focus a significant portion of economic stimulus packages and infrastructure investments on development and use of low-carbon technologies and energy efficiency as a method to accelerate both prosperity and global emissions reductions.
- Explore and implement the most efficient policy vehicles (e.g. energy-efficiency standards, feed-in tariffs and tax incentives) as a key government contribution towards accelerated domestic and foreign direct investments in climate innovations.
    - Institutionalize support for climate innovations by ensuring government ownership and accountability through a dedicated ministry or agency with a central role in national planning. Mandate this body to coordinate cross-sector public engagements, sufficient capacity-building and to drive a nationwide technology shift towards climate innovations in housing, transport, industry and agriculture.
- Make sure that standards and targets for energy efficiency and clean energy are set high and favor transformative solutions in public and private procurement, thereby stimulating market demand for climate innovations.
    - Increase transparency and accountability around policy-making on climate innovations, through increased outreach and involvement of civil society organizations and private sector in national dialogue and decision-making.
- Enable stronger support for technology demonstration and market deployment in order to facilitate the survival of climate innovations through the so called 'Valley of Death.'
    - Establish a national platform that facilitates increased awareness of current climate impact and existing solutions, and the collaboration among climate innovation stakeholders. Through this platform, engage in international cooperation to exchange experiences and best practices, and employ climate innovation policies and tools from all over the world.
- Foster and strengthen a collaborative attitude among all stakeholders in the climate innovation system so that more climate technologies are able to serve the global markets.
    - Expand the opportunities for climate entrepreneurs to receive one-stop support from facilitators like business incubators. Reduce administration required for grants, demonstration support and commercialization by encouraging more entrepreneurial policy practices.

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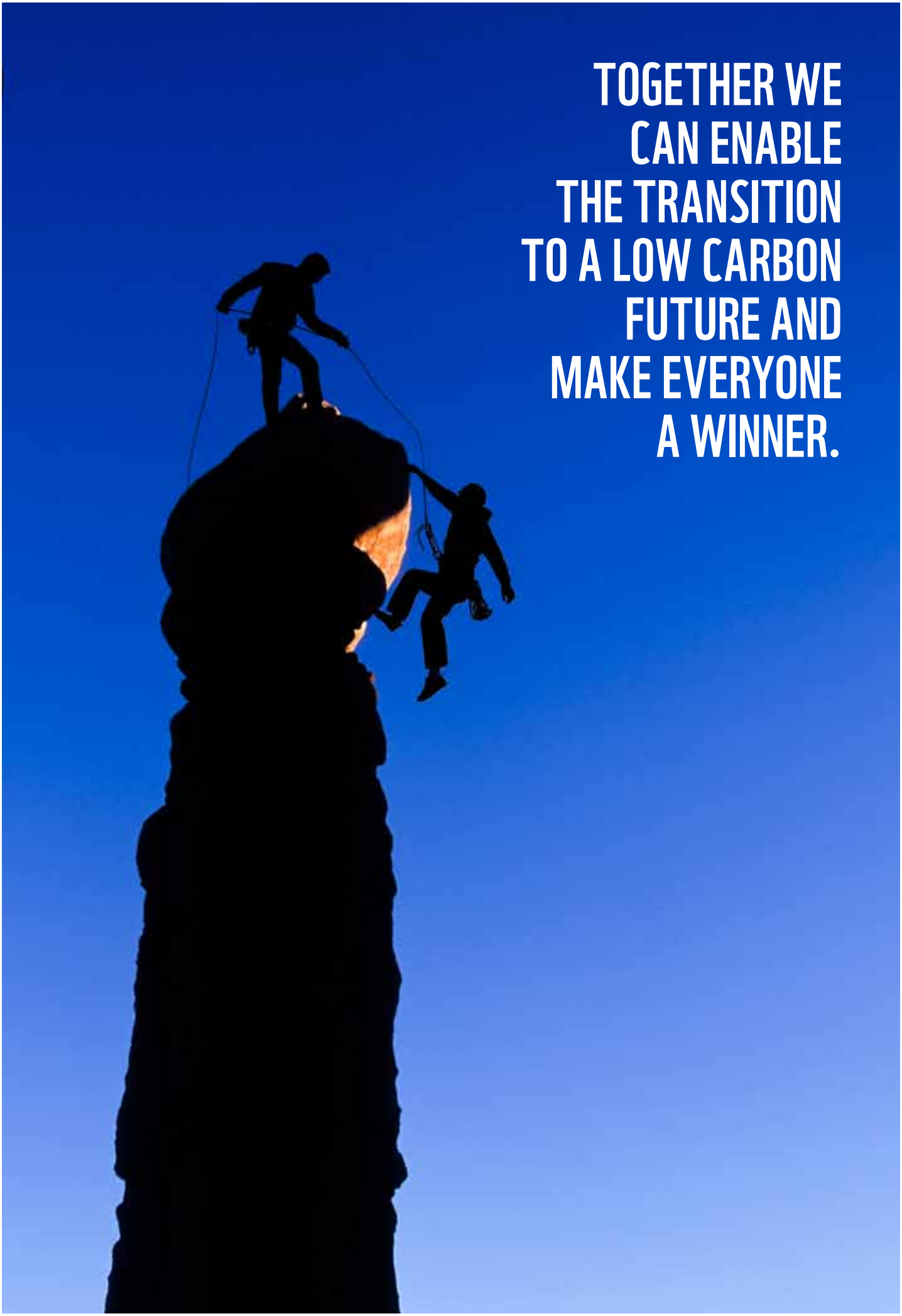

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Enabling the Transition

Climate Innovation Systems for a Low-Carbon Future

FSC MIXED SOURCES

ASSESSMENTS

Summary of nine studies: China, India, Kenya, Tanzania, Uganda, European Union, The Netherlands, Sweden.

INNOVATION SYSTEMS

The ecosystem for entrepreneurs; key stakeholders, resources and processes; capacity building for improved performance.

POLICY

Enabling frameworks; harmonized, long-term legislation; ambitious targets; stimulate demand; reduce risk; access to capital.

TECHNOLOGY

... isn't the issue; create momentum for proven solutions; attract capital for global deployment at speed and scale.

INVESTMENTS

Universal lack of access to capital; increase at least fivefold; majority to come from private capital; attract investors to climate innovations.

COLLABORATION

Awareness raising and interaction; establish local and global platforms; concerted efforts can make everyone a winner.

WWF

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.climatesolver.org

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