The Diffusion of Innovations for the Sustainability Transition

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Abstract: A sustainability transition requires transformation processes in different fields, including new technologies, products and infrastructures as well as new social rules, norms and innovations. Greening the economy rests on the rapid and effective dissemination of climate-friendly technologies, in particular renewable and efficient energy systems. To involve the economic and technological capacities of all countries, the international diffusion of know-how, innovations, investments and technologies needs to be strengthened which requires large finance and smart governance. To build-up production capacities and demand for low-carbon goods and adapt technologies to local needs and circumstances, business and governmental actors have to establish international cooperation to manage the transformation to a low-carbon society and the diffusion of innovations. Various mechanisms are analysed and discussed

A. Towards a Green New Deal for a Sustainable Energy Transformation

1. The innovation challenge for environment and development

The world is facing two major challenges which are closely related. On the one hand, atmospheric CO2 concentrations need to be stabilized at a level that avoids catastrophic climate change. On the other hand, access to affordable, reliable, and clean energy is required for a growing world population to alleviate poverty and drive economic development, first of all for the 1.5 billion people of the developing world in rural areas without connection to the power grid. To address both problems at the same time, the current fossil-based energy system needs to be replaced by a sustainable and low-carbon energy supply. Renewable energy sources, together with complementary efforts for improving energy efficiency and other low-carbon energy options, can play a key role in simultaneously addressing the challenges of global warming and energy access for a growing world population.

Technical innovations will be essential to solve the double challenge, and innovation must occur fast enough to prevent global climate disaster. Since fossil-based technology is part of the problem, a radical change in technology is needed that is environmentally sound, sustainable and low-carbon. Although no technology may be completely “clean”, “green” or “climate friendly”, those technologies may be acceptable that are practically available and meet sustainability criteria to a sufficient degree.

Innovations are also on the agenda in the social and political realm. The global climate policy debate is no longer about whether to take action but about how, when and where to act, which

[1] This paper is based on an unpublished working paper in preparation of Santarius/Scheffran/Tricario 2012.

actions need to be taken and by whom. While the struggle against global climate change ranks high on global political agendas, policymakers are struggling to find and agree upon the best policy frameworks. Various conflicting issues need to be bridged and integrated in the future: economics and the environment, science and society, international and domestic policies, global and local governance, public and private spheres, governments and civil society, North and South.[2] Overcoming these differences requires a level of coordination and cooperation unprecedented in history. It also implies that the problems can only be solved in conjunction.

Managing the energy revolution requires tremendous technological and financial resources, and recent years have already seen considerable changes. Countries all over the world, from China and India to Germany and the USA, are spending huge amounts of money to transform the energy base of their economies. Up to 1.000 billion US-Dollars per year are needed to make investments climate-friendly over the coming decades. Given the sheer magnitude, it is clear that public finance is not sufficient to address the problem but that a major part has to come from the private sector. Public initiatives are essential to leverage private capital and to catalyze it into the most climate-friendly direction.

Since businesses can be seen as both, part of the problem and part of the solution, climate change policies need to encourage business to make a more constructive contribution. This requires incorporating international investment policies into the climate change framework, including guiding principles on transnational corporations (TNCs) and foreign investment. Public and private sectors have to be synergized to galvanize low-carbon investment for climate change mitigation. That this is a timely issue, can be seen from the fact that an increasing number of TNCs have attempted to integrate sustainable development issues into their strategies, which to a large extent has resulted from pressure by consumers and advocacy groups, as the 2010 World Investment Report notes. At the end of 2009, more than 5200 corporations had signed up to the United Nations Global Compact, including almost 170 from the *Financial Times* list of 500 of the world's largest companies (WIR 2010).

A few countries are already strong producers and exporters of climate-friendly technologies but a worldwide energy revolution and sustainable economic transformation will only succeed if the economic and technological capacities of all countries are involved. To govern the transformation, the main task is to significantly scale-up production capacities for clean and energy-efficient technologies all over the world, in particular in the global South. Know-how from forerunner countries and companies needs to be tapped and made available for worldwide application and constant improvement.

2. The shifting international context of climate finance and technology transfer

The importance of technology transfer has been realized in the agreements achieved at the 1992 UN Conference on Environment and Development (UNCED). In its Chapter 34 on the "Transfer of environmentally sound technology, cooperation, and capacity building" Agenda 21 calls for access to scientific and technical information, promotion of technology transfer projects, promotion of indigenous and public domain technologies, capacity building, intellectual property rights, and long-term technological partnerships between suppliers and recipients of technology (UN 1993). It points out: "Technology cooperation involves joint efforts by enterprises and governments, both suppliers of technology and its recipients.

[2] The terms North and South are used in this study respectively to represent the groups of developed and developing countries.

Therefore, such cooperation entails an interactive process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology"(UN 1993). The document also recommends the utilisation of existing technological information, and the promotion and development of research partnerships and assessment networks,

The UN Framework Convention on Climate Change (UNFCCC) in its Art. 2 defines as the ultimate objective “preventing dangerous anthropogenic interference with the climate system” by stabilizing greenhouse gas concentrations (UN 1992). Article 4.1.c requires that the parties, “promote and cooperate in the development, application, diffusion, including transfer, of technologies, practices, and processes that control, reduce, or prevent anthropogenic emissions of greenhouse gases’’.The promise of access to new technologies was a central incentive for developing nations to support the UNFCCC in 1992 but success has been widely questioned and many developing nations feel frustrated about the lack of technology transfer in practice (Feldmann 1994). The importance of technology transfer was also recognised in the Kyoto Protocol, which in its Article 10c asks all Parties to:

> "Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all possible steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for … the creation of an enabling environment for the private sector".

The Kyoto Protocol has created mechanisms to reduce emissions, including the Clean Development Mechanism (CDM), which is focussed on low-carbon technology transfer to developing countries. While developing countries are not obliged to binding climate change policies, they are free to choose whether they want to move towards a low-carbon economy, and to what extent. There is a continuum of options with varying implications, development benefits and costs. Although the CDM and its Certified Emissions Reductions (CERs) as well as joint implementation and the Emissions Reductions Units (ERUs) were expected to generate foreign investment and technology flows, this expectation has largely not been met. Problems have occurred in the issuance of carbon credits, the determination of emissions baselines, the setting of allowance/credit values or carbon prices, the levying of carbon taxes, and imposition of rules and procedures for carbon trading,.

Because the Protocol’s mechanisms were designed for compliance with emission reduction targets at the national level, this left individual governments to decide how best to involve the private sector in the process. Uncertainties about the post-Kyoto framework weakened the private sector’s ability and willingness to make decisions in the area of climate change. What the private sector needs is a strong international and national commitment by governments. In recent years this commitment was missing. Negotiations on the issue have been controversial, with clean technology nearly ignored at COP 13 in Bali 2007 due to disagreements between the United States and G77/China. The Copenhagen Accord of December 2009 agreed on annual climate finance in the range of US$ 30 billion as financial transfer from the developed to the developing countries during the years 2010-2012, with additional finance up to US$100 billion be provided in the following years. Following Copenhagen future emission targets, the nature of the institutions, concrete policy mechanisms and sources of funding remained unclear. Emphasis was on domestic actions as demonstrated by country pledges, submitted to the UNFCCC, in line with domestic legislation.

A new chapter was opened with the agreement achieved at the climate summit in Cancun (COP-16) in December 2010. The decision made by the "Ad Hoc Working Group on long-term Cooperative Action under the Convention" introduces several new elements. The largest section "IV. Finance, Technology and Capacity Building" contains a number of concrete measures for technology transfer and investment. Various opportunities for collaboration between public and private sectors are identified.

New regulations and reformed legislation are needed to enable an environment for climate friendly innovations to achieve a breakthrough. One of the critical questions will be how nations can realize the needed financial obligations without excessively taking money from taxpayers. A possible approach to raise $100 billion has been discussed in a November 2010 report of the UN's Advisory Group on Climate Change Financing (AGF 2010) which calls this amount "challenging, but feasible" if policy would "lay out a clear road-map for making this funding a reality." Besides $100 billion from the public sector the report suggests that the private sector could mobilise up to $500 billion a year. With such large amounts of climate finance an unprecedented scale of investments for energy efficiency, renewable energy and low-carbon technologies can be expected.

In a different context, at Gleneagles in July 2005 the G8 highlighted the importance of strengthening technology cooperation to develop low carbon energy options. Many developing countries pressed for a new approach to international cooperation in the area of clean energy technologies. As a follow-up, the UK Government and the Government of India decided to collaborate on a study to assess the barriers to the transfer of low carbon energy technology between developed and developing countries (Mallett et al. 2009).

To reorient its business strategies the private sector needs a clear, stable and predictable policy framework. Regardless of progress on a global regime it is left of to national governments and private investors to contribute to such a policy framework. It has become clear that creative mechanisms are in demand both at national and international levels to effectively mobilize the private sector's contributions to cross-border capital flows and technology diffusions, especially to poor countries.

3. Public policy and private investment: Mobilizing a virtuous cycle

Preventing dangerous climate change and achieving sustainable development on a global scale will require radical technological, economic and societal changes in both developed and developing countries. Economic development is most rapid in developing countries, but it will not be sustainable if these countries follow the historic emission trends of developed countries. Although most new carbon abatement technologies are being developed in industrialised countries, much of the potential for low-carbon energy production and emission reductions is located in developing countries where fossil fuel consumption is still increasing rapidly. Renewable energy investments in the developing world deliver lower carbon abatement costs than in the developed world, while also achieving a broad range of additional social, economic, and environmental benefits. Thus, the transition of global energy systems to lower carbon pathways depends upon North-South collaboration (Ipsen et al. 2001) and the successful transfer to and absorption of low carbon technologies within developing country economies (Mallett et al. 2009).

In responding to climate change and moving towards a low-carbon economy, developing countries are facing two major challenges: first, the mobilization of needed finance and

investment; and, secondly, the acquisition, generation and dissemination of relevant technologies. In both areas foreign investment can make valuable contributions (WIR 2010). While the future international climate change regime – including specific carbon reduction commitments and financial and technological support for developing countries – is still to be agreed upon, countries need to examine how to facilitate low-carbon domestic and foreign investment. This will first of all include technology transfer from North to South but transfer from and within the South should be considered as well.

Weaving together the complementary challenges of investment support in the North and investment governance in the South, has been framed by the United Nations Environment Programme as a "Green New Deal" in global climate policy (UNEP 2009). This approach aims for "reviving the global economy and boosting employment, while simultaneously accelerating the fight against climate change, environmental degradation and poverty."[3] In particular, it is recommended that a significant portion of the estimated US$3 trillion in pledged economic stimulus packages be invested in five critical areas (ibid.):

- Raising the energy efficiency of old and new buildings;
- Transitioning to renewable energies including wind, solar, geothermal and biomass;
- Increasing reliance on sustainable transport including hybrid vehicles, high speed rail and bus rapid transit systems;
- Bolstering the planet's ecological infrastructure, including freshwaters, forests, soils and coral reefs;
- Supporting sustainable agriculture, including organic production.

While the UN approach suggests a globally coordinated effort to address these challenges, measures on a national or business level could well support this goal before global agreements or activities have been achieved. The core idea is to build public support to unleash private capital for foreign investments while establishing sustainable framework conditions to maximize the mitigation and development potential of these investment on the ground. In this context, foreign investments can be a valuable tool to support the transfer of technology transfer and related know-how and capacities, if an enabling environment is established. In this environment private investments are attracted by new opportunities to overcome limited demand or market size while the companies' financial risks are reduced by public money, adequate regulation and standards to make foreign investments work for climate protection. To operationalize such a "virtuous cycle", complementary steps are required by North and South, affecting the public and the private sector.

While the merits of such an integrated approach can best be realized if ambitious mandatory emission reduction targets are set and implemented, they are not dependent on a global agreement. It is not necessary that a national investment support or bilateral investment governance are managed by a global fund. As many decisions as possible can be left to each country's national policies that set up the framework conditions for technology transfer in a market environment. Global top-down decisions and one-size-fits-all prescriptions on the kind of technologies best supported can be avoided. Bottom-up approaches could be designed to reap the benefits and overcome the barriers.

To elaborate and discuss the concept of the "Green New Deal", it is important to analyse the conditions and environments needed in developing countries to enable transfer of low-carbon technologies, and discuss key areas for future action.

[3] See http://www.unep.org/greeneconomy/GlobalGreenNewDeal

4. Clarifying benefits and incentives

To succeed with the envisaged "third industrial revolution" required for a sustainability transition, it is essential to understand the significance of the task. At the core of the transformation process are energy systems which are a key driver of economic growth and social progress. They are "essential to fueling industry, powering infrastructure, connecting goods, people and services to markets, and delivering basic services such as heating, lighting and cooking." (WBCSD 2007) For the billions of people without access to modern energy services to escape poverty and enter into productive economic activities, investments in energy infrastructure (on-and off-grid) are needed.

With the growing energy demand from developing countries, their share of GHG emissions is also expected to rise, from 39% today to 52% by 2030, with China responsible for 29% of the predicted rise. India is already the fifth biggest emitter of CO2 emissions, yet approximately 45% of its population does not yet have access to electricity and approximately 85% of the population lives on less than US$2 per day (UNDP 2006). Clean energy could possibly help satisfy the growing energy demands of developing countries and at the same time cut their carbon emissions.

Growing oil prices and dependence on energy imports from the Middle East have increased the demand for alternative energy paths. In response to the OPEC oil embargos and subsequent price shocks of the 1970s, incentive programs were implemented to encourage the development of renewable energy. Despite these programs and increased research efforts, renewable energy production grew only slowly through the 1980s, stagnated during the 1990s and exploded in the first decade of this millennium. With increasing oil prices, the competiveness of renewables will further improve but can be slowed down with the current lock-in of high-carbon fossil energy in most sectors. The transportation sector is almost completely dependent on energy from fossil fuels such as gasoline, diesel and kerosene. Particularly dependent (and thus vulnerable) are developing countries whose oil supply largely relies on imports.

Climate change is expected to have many negative impacts in vulnerable developing countries that could also affect commercial interests. Thus, reducing carbon emissions contributes to preventing the long-term economic, social and environmental costs and risks of climate change and helps to accomplish the targets for GHG emission reduction as set in the UNFCCC and the Kyoto Protocol.

The quest for energy security and concerns about global warming spur the search for low-carbon energy alternatives to fossil fuels. A large-scale production of renewables would significantly reduce oil imports and diversify the energy sources. Home-grown domestic energy sources offer great development perspectives to structurally weak rural areas and can lead to beneficial structural changes in land-use and agricultural practices. Promises are particularly strong for the agricultural community which expects fast expanding future markets for energy and land resources, creating new income and job opportunities to the agricultural sector, and a resulting increase in farmer's income. According to UNEP (2009:20) renewable energy generates more jobs than employment in fossil fuels. Projected investments of US$630 billion by 2030 would translate into at least 20 million additional jobs in the renewable energy sector.

At the same time, it is essential to establish renewable energy sources in a sustainable manner. While renewables are highlighted as being largely carbon neutral, GHG savings can vary

significantly for the specific production and conversion paths and their fossil fuel inputs. There is an on-going debate about the carbon balance of biofuels and their impact on land use and food security in developing countries (Scheffran/Summerfield 2009). If not addressed properly, these and other concerns about possible adverse implications of renewables may undercut the support for renewables, demanding that renewable energy production and consumption is established in a manner that facilitates sustainable development in the South.

Stabilising the atmospheric CO2 concentrations at non-dangerous levels will require a rapid increase in the scale and speed of low carbon innovation and technology. To achieve a 450-ppm scenario by 2050 global emissions need to be reduced by 50 Gigaton (Gt) CO2 compared to 2005 (IEA 2008). The same source also estimates that an additional US$ 45 trillion total investment will be required by 2050 for a 450-ppm scenario. With an increase in energy demand in non-OECD countries that is expected to account for 85% of the increase of world energy demand, a major challenge is to accelerate the diffusion of low-carbon technologies to developing countries. In both developing and developed countries, there is a significant growth potential of innovative technologies for heating, electricity generation and transportation fuels. Recent years have seen a dramatic shift in policy support in many parts of the world; the growing demands and subsidies for renewables have broadened their economic basis (WBCSD 2010). This is expected to lead to a large expansion of sustainable energy and energy efficiency technologies over the next decade and beyond. To succeed, renewable energy systems will have to become fully competitive with fossil energy and avoid some of the current market distortions such as domestic subsidies and import barriers.

To address concerns about climate injustice, countries and communities around the world have to get a fair share of the fruits and benefits of the technological transformation. To win support from governments, private sector and the public in recipient countries, it is essential to clarify the opportunities, benefits and incentives. The question is who will benefit from new climate-related investments and financial transfers and how the benefits, costs and risks are distributed among the different regions and the public and private sector.

Although North and South have different responsibilities and capacities, a smartly designed transformation of the global economy can bring benefits for both. While developed countries are expected to be the main source of the finance needed for the transition, this may become an opportunity rather than a burden for them. Increased foreign investments into environmentally sound technologies will diversify the portfolio of companies, link them to international markets, create new jobs and generate return on investments. Financial transfers can create social and economic benefits to rural and urban communities, including employment opportunities, reduction of poverty and access to advanced technology. Investments can further strengthen domestic markets and develop future export markets, leading to economic diversification, accelerated commercialization and competitive advantages. Successful investment in developing countries translates into new jobs and infrastructure development, leads to local GDP increase and a reduced share of GDP spent on energy imports, either through energy efficiency or the use of local renewable sources (WBCSD 2010). Protecting the environment and preserving natural resources can provide additional economic benefits, notably reduce the vulnerability to climate change. Although many developing countries are not major GHG emitters, new technology and investment would help them to enter low-emission pathways, avoiding the polluting development paths that industrialized countries pursued in the past. This will help in building up clean domestic production capacities and job opportunities, diversify economic activities and achieve greater energy independence.

The green transformation is significant for the public sector which in the past has been a main source of political and societal interventions driving technology development and transfer, such as direct governmental expenditures, public choices, regulations and policies. Renewable energy systems receive a high level of public support that is justified by the expected energy, economic and environmental benefits of renewables, including a number of co-benefits, such as sectoral effects of rural electrification; energy security through energy diversification and improved efficiency; local environment benefits; and international funding opportunities.

There are also major advantages for the private sector to pursue climate change mitigation and transfer of low carbon technologies. They may yield financial benefits to the companies involved in the transfer process and are likely to help improve production processes, including enhancing their energy-, material- and resource-efficiency. Early adopters profit from strengthened productive capacities and enhanced export competitiveness, giving them an edge over competitors. Driving this process would accelerate a developing countries' transition and facilitate leapfrogging into a green economy that is in the best long-term interest of the business sector, assuming that there will be an increasing market and new export opportunities for low-carbon products and services. On the demand side, a growing pool of responsible consumers and the rise of a sustainability-oriented civil society shaping consumer preferences will help to establish such a market (UNCTAD 2010).

5. Global trends in sustainable energy investment

Sustainable energy investment

Since 2000 there was a significant growth of new investment in sustainable energy, with annual growth rates exceeding 50%. In 2008, a record number of $173 billion was reached, followed by a 7% reduction down to $162 billion in 2009, largely in response to the economic recession (Bloomberg 2010). Spending on new capacity (including large hydro as well as other renewables) was for the second year bigger than the investment in new fossil fuel capacity. Despite the economic downturn, the sector showed remarkable resilience. In response to the crisis, major economies began to spend some of the estimated US$188 billion in "green stimulus" commitments. Supportive policies for clean energy expanded. According to the Renewables 2010 Global Status Report, over 100 countries had some type of policy target or promotion policy for renewable energy by early 2010 (Bloomberg 2010). As export markets weakened, domestic demand surged, especially in the wind sector. Energy-smart technologies such as power storage and efficiency were strong. Accordingly, there was a marked improvement in the cost competitiveness of renewable power generation which resulted in a significant rise in renewable power capacity up to 36%, compared to fossil-fuel electricity generation (Bloomberg 2010).

The most remarkable trend of recent years was the decisive shift towards investments by developing countries, in particular China and other parts of Asia. Wind farm development in China was by far the strongest trend. While Europe and North America stagnated or declined, Asia and Oceania produced a sharp increase in financial investment in 2009, from $31.3 billion to $40.8 billion. China experiences a surge in investment and for the first time was first place in 2009 for overall sustainable energy investment, pushing the United States to second place (Brazil and India ranked fifth and eighth in the world). Out of $119 billion invested worldwide by the financial sector in clean energy companies and utility-scale projects, $33.7 billion took place in China, up 53% on 2008. In 1999 China made 1% of the world's solar panels; by 2008 it was the world's leading producer with a 32% market share. The close-to 14 Gigawatt (GW) of new wind capacity built in China during 2009 was nearly 15% of the total

new generating capacity added to the grid. South America saw no such boom but a drop of investment from $14.6 billion to $11.6 billion, while the Middle East and Africa enjoyed a modest increase to $2.5 billion in 2009, from $2.1 billion (Bloomberg 2010).

Trends in low-carbon foreign investment

Global foreign direct investment (FDI) inflows experienced a 16% drop in 2008 and a drastic decline in 2009 by a further 37% to $1,114 billion, while outflows fell some 43% to $1,101 billion. In the first half of 2010 FDI witnessed a modest, but uneven recovery. In 2010 global flows were expected to exceed $1.2 trillion in 2010, rise further to $1.3–1.5 trillion in 2011, and move towards $1.6–2 trillion in 2012 (WIR 2010). However, these prospects are bound with risks and uncertainties, including the fragility of the global economic recovery.

The nature and role of FDI varies among regions. Developing and transition economies attracted half of global FDI inflows, and invested one quarter of global FDI outflows. They are leading the FDI recovery and will remain favourable destinations for FDI. Africa is experiencing the rise of new sources of FDI. Industrial upgrading through FDI in Asia is spreading to more industries and more countries. Latin American Transnational Corporations (TNCs) are going global (WIR 2010). Overcoming barriers for attracting FDI remains a key challenge for small, vulnerable and weak economies. Overseas development assistance (ODA) can act as a catalyst for boosting the role of FDI in least developed countries (LDCs). Focusing on key niche sectors is crucial if small islands developing States are to succeed in attracting FDI.

Low-carbon FDI have reached roughly US$90 billion in 2009 in three key industries: (a) alternative/renewable electricity generation; (b) recycling; and (c) manufacturing of environmental technology products (such as wind turbines, solar panels and biofuels). These industries form the core of initial new low-carbon business opportunities. The following trends can be observed for these industries (WIR 2010):

- There has been a rapid increase in low-carbon FDI in recent years, though it declined in 2009 as a result of the financial crisis.
- Around 40% of identifiable low-carbon FDI projects by value during 2003–2009 were in developing countries..
- Established TNCs are major investors, but new players are emerging, including those from the South. TNCs from other industries are also expanding into the field.
- About 10% of identifiable low-carbon FDI projects in 2003–2009 were generated by TNCs from developing and transition economies. The majority of these investments were in other developing countries.

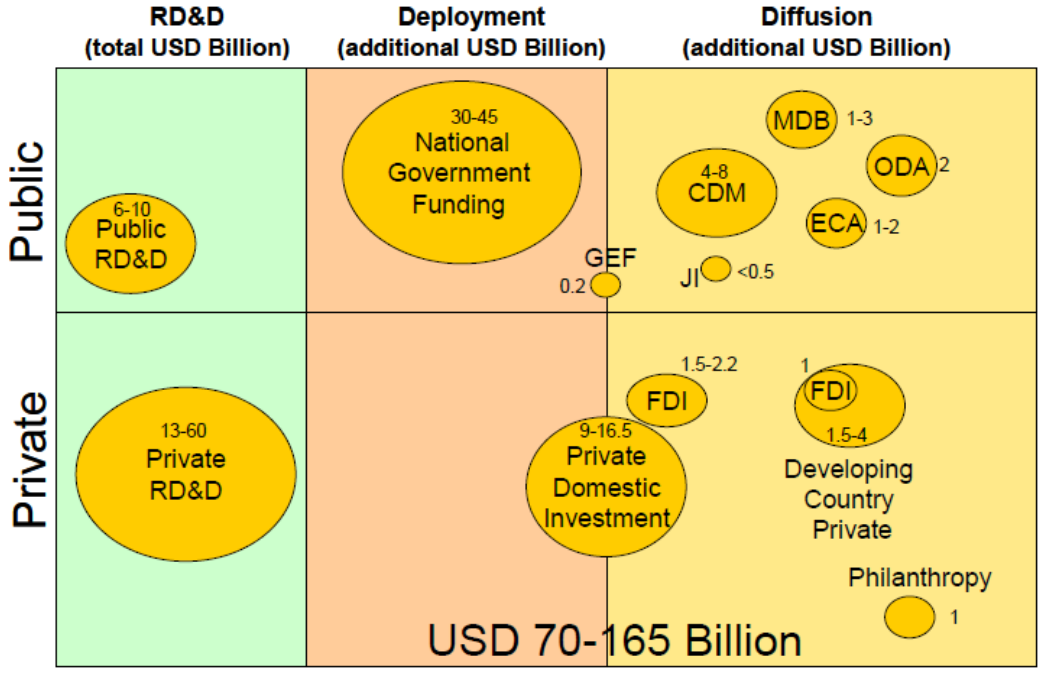
Over time, low-carbon investments are expected to permeate all industries,

Future investment needs and prospects

While foreign investments have been increasing in recent years, significantly more is required for the envisaged sustainability transformation. The global scale of the challenge in reducing GHG emissions requires an enormous financial and technological response. For 2010–2015, one estimate indicates that US$ 440 billion of recurring additional global investments per year are required to limit GHG emissions to the level needed for a 2 ºC target to be met, as referred to in the Copenhagen Accord (WIR 2010). By 2030, the estimates range even higher, up to $1.2 trillion per year.

Various studies emphasize that the financial contribution of the private sector is essential for achieving progress in making economies more climate-friendly, particularly in view of the huge public fiscal deficits worldwide. TNCs can make significant contributions in the transition towards a low-carbon economy, because they are significant emitters across their vast international operations, but also because they are in a special position to generate and disseminate technology and to finance investments to mitigate GHG emissions (WIR 2010). Thus, TNCs are not only part of both the problem but can be also part of the solution.

A challenge in this area is the uncertainty on the financing resources currently available, partly due to the lack of an agreed list of these technologies; there are also no agreed definitions of the costs of technology research, development, deployment, diffusion and transfer. Estimates of the financing resources currently available are classified in UNFCCC (2009) by stage of maturity of the technology they are intended for, whether the resources are from the public or private sector, and whether they are under or outside the Convention. The estimates for mitigation technologies, shown in figure 5, are between US$ 70 and 165 billion per year. For technologies for adaptation, R&D is focused on tailoring the technology to the specific site and application. Current spending on adaptation projects in developing countries is estimated at about US$ 1 billion per year, while future spending needs are estimated at between tens and hundreds of billions of US$ per year. Current financing support for technology transfer is likely to amount to less than US$ 2 billion per year (UNFCCC 2009).



Abbreviations: CDM = clean development mechanism, ECA = export credit agency, FDI = foreign direct investment, GEF = Global Environment Facility, JI = joint implementation, MDB = multilateral development bank, ODA = official development assistance, RD&D= research, development and deployment.

Figure 1. Estimates of current financing for mitigation technologies (Source: UNFCCC 2009)

Several estimates are available of the additional financing that will be needed for RDD&D of mitigation technologies in order to stabilize levels of GHGs in the atmosphere. The estimates are sensitive to the baseline and mitigation scenarios used. As shown in Figure 6, they indicate that current financing for mitigation technologies needs to increase three- to fourfold. Such increases are consistent with current R&D targets and priorities for developed countries and regions with large R&D budgets. Economic and social benefits of investing in climate

change technologies are likely greater than the cost of making those technology investments (UNFCCC 2009).

B. Assessment of Technology Transfer

Technology transfer is widely seen as the main instrument to bridge the technology gap between North and South. Technology comprises processes creating new pathways for action or allowing to realize actions more effectively according to given criteria, such as cost or resource efficiency, benefits or risks). To facilitate technology development in other parts of the world the necessary enabling environment and infrastructure need to be created. Technology transfer seeks to establish an enabling environment for the technology in the recipient country, including three separate technology flows: a) capital goods and equipment; b) skills and know-how for operating and maintaining equipment, and c) knowledge and expertise for generating and managing technological change. To create an enabling environment, particular attention needs to be on building the soft elements, such as intellectual property; organizational knowledge and managerial skills; even corporate culture, values, norms and standards (Ockwell 2010). Accordingly, Schnepp et al. (1990) define technology transfer as ‘‘...a process by which expertise or knowledge related to some aspect of technology is passed from one user to another for the purpose of economic gain’’. This implies that the infrastructure for establishing the soft skills is required, including education and research facilities to communicate the scientific-technical knowledge about the principles of how a technology works and can be practically used.

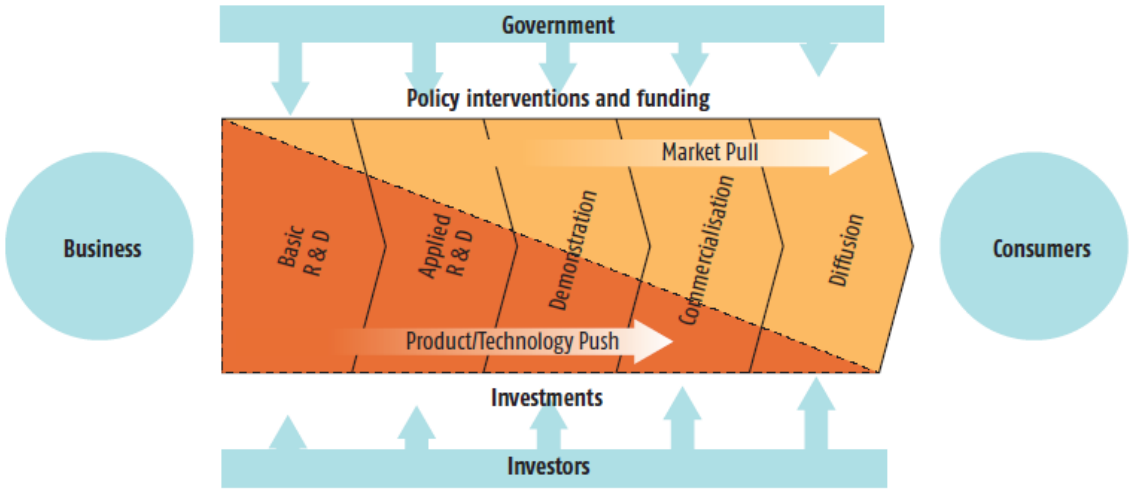
A viable technology infrastructure requires a “manufacturing capacity, supply chain capacity, end-of-life/waste disposal, institutional capacity and sustainability of the whole process and the social networks between them” (Karakosta 2010). Different from traditional accumulation theories that see knowledge as a transferable entity following investment flows, assimilation theories of technology transfer consider the impact of the knowledge and the characteristics of suppliers and recipients who assimilate the knowledge (Ockwell et al 2010). This mutual dependence needs to be considered for the transfer of the technology and is one of the reason why technology transfer has to be treated as a complex process in which local organisations and communities are involved.

In the context of climate change the choice of energy technologies is driven by criteria of sustainability and decarbonization, favoring technologies that support adaptation and mitigation strategies. Low-carbon sustainable technologies need to be adopted both by developed and developing countries, which requires that developing countries avoid being locked into old unsustainable practices and technologies and move quickly to environmentally sound and sustainable practices, institutions and technologies. With renewable energy and energy efficiency the basic technologies already exist which are promising to address the problem of climate change. The transfer or innovation processes must be fast enough to prevent dangerous climate change and make them readily available where they are needed most. Technology transfer from the countries and companies that developed them to other countries to reduce GHGs has been a main theme in the UNFCCC.

Throughout the process of technology development and transfer, various stakeholders are involved. Their decisions and actions differ depending upon the stages and pathways of technology development, and the type of technology. To overcome the barriers to technology transfer the interests and influences of stakeholders at each stage need to be considered and incorporated through stakeholder dialogues. Among the diverse stakeholders in North-South

transfers are “project developers, technology owners, technology suppliers, product buyers, recipients, users of the technology, financiers and donors, governments, international organisations, NGOs, and community groups.” (IPCC 2000) Not mentioned are institutions for research, trade and education. Technology transfer can take place between government agencies, within vertically integrated firms, and partnerships across a network of diverse entities (e.g. information service providers, business consultants, financial firms) (Karakosta 2010). Networks in technology transfer are critical for market creation and the generation of a social pool of knowledge (Teubal et al 1991). The relevance of the information is different for different stakeholders: governments and end-users need to understand the costs and benefits of a technology; innovators need to understand how to adapt it; firms how to market it and consumers how to use it.

Investments should be designed to increase a country’s ability to absorb new technology and improve its innovative capacity. Technology transfer is part of the process of the innovation chain that ranges from research and development to the commercialisation and diffusion of the technology. Developing countries consider three areas of innovative capacity: *disruptive innovation* (radically different from current technologies, e.g. small scale power generation with thin film solar cells); *orphan areas of research* (neglected by industrialized world, e.g. small scale desalination); *adaptive innovation* (e.g. adapting technology to local renewable resources). There is also a need for *incremental innovation*, where user and producer interfaces are important. Innovation incorporates “push” and “pull” factors along the innovation chain, with varying levels of public-private finance and policy interventions at different stages (Figure 2). Push factors drive investors to invest abroad, including government policies, market conditions, costs of production and business conditions that all influence investment decisions. Some factors are climate-specific such as green branding strategies, regulations and pressure from consumers and investors to avoid climate risks or pursue green energy technologies. Pull factors are locational host-country specific determinants that influence where investors choose to invest, such as policy frameworks, economic conditions, resource endowment and access to skilled labour.



Source: Adapted from Grubb, 2004

Figure 2: Innovation Chain (source: Tomlinson et al 2008)

Going beyond a narrow focus on technology transfer that predominantly seeks to support access to specific technologies, diffusion of new innovations will require a broad approach to capacity building to enable developing countries to generate their own innovation system.

Increases in low-carbon diffusion rates across countries can be achieved at differing development stages through system-wide capacity building to improve internal innovation and absorption. International collaboration will be vital to achieve a commercial scale for low carbon innovations (Tomlinson et al 2008). International technology dissemination entails the acquisition, mastery, diffusion and indigenization of knowledge, technology and skills in a host country which are not only transferred across borders, but also absorbed by local actors (WIR 2010).[4]

C. Barriers and Obstacles to Technology Transfer and Investment

To develop and utilize the huge potential for low-carbon technology in the developing world, a number of barriers and obstacles need to be overcome that limit their availability and efficiency**.** Barriers arise at each stage of the technology transfer and investment process, including infrastructure and ownership, cost and finance, regulation and policy. These factors may vary across developing countries, depending on national context and economic sector, project, pathway and technology, application area, region and geography. This section discusses some of these barriers.

1. Lack of capacity building and domestic infrastructure
2. Macro-economic conditions and market failure
3. Lack of access to and sharing of data, information and knowledge
4. Lock-in due to lack of innovation and diffusion
5. Failure of R&D spending policy for low carbon innovation
6. Tensions and competition undermine international collaboration potentials
7. Intellectual property rights (IPR)
8. Financial and political obstacles for foreign investment

These and other obstacles and barriers can undermine the efficiency of technology transfer and investment policies. They can result in social costs, ranging from job losses to the reduced affordability of essential services, and/or reduced taxes. The consequences are likely to hit low-developed and other vulnerable countries the hardest. When promoting low-carbon foreign investment policy makers have to weigh the advantages and disadvantages, both in terms of economic growth on the one hand, and environment, human health and sustainable development on the other.

To address the barriers and overcome the obstacles it is important to develop a practical framework for policy makers, facilitating technology transfer and foreign investments through public money; regulation and standards; and international cooperation. In each stage of the technological process – R&D, demonstration, deployment, diffusion and commercial maturity – there are barriers that need to be overcome to develop a commercially mature technology. Adjusting the response to the stage of the barriers helps to identify the financing vehicles appropriate to each stage. However, the limiting factors and barriers for technological transformation are not primarily technological but are part of the social, economic, political, and cultural milieus in which technologies are developed, diffused, and used. Market incentives, the structure of regulations, the content and quality of research and education, and social values and preferences all determine technological pathways (Heaton et al. 1991) To

[4] In this context, "acquisition" means movement of the technology to local players; and "mastery" requires that local actors are fully capable of using the knowledge and building on it (i.e. they have the "absorptive capacity" to do this). "Indigenization" of technology is a long-term concept, implying that the technology has become part of the national knowledge and innovation system, including diffusion to other enterprises and further research, development and innovation in the host country

develop effective policy tools it is important to tailor action to the specific barriers, interests and influences of different stakeholders.

D. Policies for Technology Transfer and an Enabling Infrastructure of Innovation

To address the challenges and overcome the barriers described above, it is essential to create the adequate framework conditions with incentives to cause a large scale technological shift toward a lower carbon and more energy efficient economy that also delivers affordable energy solutions. This shift relies on directing investment flows into the development and deployment of lower carbon technologies, as well as adapting behaviors and lifestyles to favor these technologies. Deploying low-carbon technologies to developing countries requires innovative mechanisms with joint efforts from the private sector, from developed and developing countries. Previous efforts to help developing countries create enabling environments for low-carbon growth have been insufficient and more needs to be done.

In this context, the private sector may serve as a major source of innovation, capital and capacity that can potentially make major contributions to a low-carbon global economy. Most low-emission energy technologies will however not be cost competitive at scale without some combination of investment support mechanisms, technological advances or regulatory regime improvements. A lesson from CDM proposals is that an abundance of potential projects, technologies or investment opportunities will not necessarily mobilize capital flows for implementation and optimization. Thus, although the private sector could offer innovative market-based solutions with no government intervention, in some cases, governments can accelerate or guide the process by creating adequate frameworks for investment, including specific regulations tailored to particular technologies and their stage of maturity.

To facilitate the release of private sector resources, governments need to understand how capital markets work and corporate investment strategies can be incentivized to deliver results consistent with energy and climate policy goals. It should be kept in mind though that there are quite different mental models and perceptions among policymakers which could result in inefficient policies that hinder rather than support the involvement of the private sector (WBCSD 2007).

National Systems of Innovation (NSI) "integrate the elements of capacity building, access to information and an enabling environment" for investment and technology transfer (IPCC 2000). NSI concepts rest on a complex mixture of institutions, public policies, business and social relationships, including networks and partnerships with public and private stakeholders in business, legal, financial and service domains. NSI can be enhanced by investments and low-carbon technology diffusion through international partnerships.

1. Assessment of information, needs and technologies

Many projects in developing countries fail because they use technology that is inappropriate due to lack of capacity building, ill-defined ownership, or lack of infrastructure. A new technology framework should minimize this risk and ensure efficient diffusion of the appropriate technologies. Often there is a substantial lack of reliable statistical data on issues such as energy use, infrastructure, or demand. Solid data will "help policymakers design the most cost-effective policy options and impact assessments, while business can reduce uncertainty and thus risk premiums" (WBCSB 2010). To overcome information barriers, governments have a key role in creating the necessary information assessment and monitoring capacity. comprehensive *technology needs assessment* (TNA) provides the

understanding required for informed decisionmaking about future technology options, to select the strategies most appropriate to the country, its capability and technology options. This implies to identify and assess specific needs for a technology and how it fits into the domestic environment. To fully undertake TNAs, developing countries might need administrative and technical support.

Technology roadmaps help to draw future pathways in terms of capabilities, locations and timelines. They prepare the ground for the promotion of technology prototypes, demonstration projects and extension services through linkages between manufacturers, producers and end users. They also facilitate planning about the identification and development of solutions to technical, financial, legal, policy and other barriers.

A number of factors might affect host government's prioritization and targeting of foreign investment to boost prospects for technology dissemination. For instance, a government may identify targets by comparing potential growth sectors and assessing the country's natural resources and created assets. For example, Morocco has chosen to enter into renewables power generation and environmental technologies manufacturing for a number of reasons (reduce dependence on foreign fossil fuels, supply and export power, encourage rural electrification), including an assessment of where the technology can best be secured, as well as an analysis of patterns of low-carbon foreign investment in the sector (WIR 2010).

Technology assessment allows to design synergies from a careful matching, harmonization and utilization of all technological resources and relevant actors from private and public sectors. Mechanisms can be put in place to adapt technologies to local needs, or generate new ones if necessary. Attracting low-carbon foreign investment is not only about new and emerging business opportunities, but also about encouraging foreign investments in traditional sectors, with a view to improving their energy-, material- or resource-efficiency.

2. Establishing a science and technology infrastructure

The basis of technology development and transfer depends upon its technology infrastructure, which comprises a set of specific, industry-relevant capabilities such as technology centres, research facilities and educational institutions that support the development of technical skills. Technology infrastructure requires considerable efforts and long lead times to establish; on the other hand it depreciates slowly. This includes information relevant for strategic planning and market development, forums for joint industry-government planning and collaboration, and assignment of intellectual property rights.

Technology infrastructure may lack direct economic value to firms, reducing their incentives to build technology infrastructure on their own. To develop a public technology infrastructure, government policies can invest public money, stimulate demand and attract technological capabilities that exist elsewhere but need to be imported, adapted, and absorbed in the local economy. Not less important is to induce institutional change and organisational development for adapting the technology infrastructure to various supportive measures. Finally governments can increase public awareness and spread capability through public networks (Justman/Teubal 1995). National policies and regulations are essential to build technological capabilities developed by domestic companies and induce foreign investment. Domestic progress in low-carbon processes can then be distributed throughout the international network of operations of TNCs, thus attracting further foreign investment (WIR 2010)

A vital resource in the technical infrastructure is energy which should be integrated into national development strategies. Energy is necessary to cook food, heat and light homes, maintain schools and hospitals, drive industry and connect people and goods to markets.

Public policies should focus on improving grid transmission and energy storage systems, and renewable energy is essential for both. The IEA estimates that some US$ 5.2 trillion is required in generation investments, and an additional US$ 6.1 trillion for transmission and distribution networks from now until 2030 (WBCSD 2007).

Investing in research and development (R&D) is an essential precondition to build the technology infrastructure of a country. Historically, governments have played a key role in supporting research and development through national laboratories, universities, and through international collaborative ventures. Public funding remains a major source for R&D activities in both industrialised and developing countries, involving either general support to national R&D institutions and laboratories, or direct funding of specific projects according to set government priorities. Effective R&D policies alleviate technical barriers and reduce costs by improving materials, components, system design and tools for installers and users.

The track record shows that in the absence of strong policy support mechanisms and incentives, and while fossil fuels are cheap and readily available, public and private funds are unlikely to deliver the necessary technologies at a cost and scale necessary to address climate change unless there are major changes in investment frameworks (WBCSD 2007).

3. Building human, social and absorptive capacities

Developing countries do not only require finance for energy projects but also capacity building and related funding from public and private sector investors. Capacity building programmes and enabling environments that reduce the risks and restrictions associated with the low-carbon technology transfer will increase the flow of technologies close to the commercial margin. Capacity building targets technology acquisition, development of skills, and local policies and institutions to support the technology transfer process. Capacity building has focused on enhancing scientific and technical skills, capabilities, and institutions in developing countries as a pre-condition for assessing, adapting, managing, and developing technologies (UNCTAD 1995). But the need for enhanced skills and capabilities can also occur throughout all stages of the technology lifecycle. Several studies acknowledge that capacity building needs vary greatly from country to country (see Mugabe 1996).

The transfer of green technologies demands a wide range of technical, business and regulatory skills. Human and institutional capacity is needed to assess, select, import, develop and adapt appropriate technologies, including the capacity to optimise and innovate. Not only specific know-how should be transfered, but also related systemic knowledge of the relevant technologies so that recipients can add value. As previous experiences demonstrated, an absence of human capacity was a major cause for many failures of technology transfer. This makes adequate human capacity essential at every stage of the transfer process.

Education and training is important to develop human capital for business, municipalities and government. Training of employees, engineers, operators and users builds local competency in the use of the technology. Training helps to overcome the lack of knowledge which is an important barrier to technology diffusion (e.g. for advanced solar technologies). Training should not focus only on the technical aspects, but also involve sales and marketing aspects. Training and support services could be largely public but may involve multi-nationals and consulting firms that have extensive training and technical capacity but rarely divert those resources from commercial activities.

Future approaches can be more effective by better stressing the integration of technology transfer and human resource development, focusing less exclusively on developing technical skills and more on creating improved and accessible competence in associated services, organisational know-how and regulatory management. High quality training is needed to embody in personnel of the receiving firm the skills, knowledge and expertise applicable to particular products and processes. This is an important consideration for developing countries, because the work force requires a continual cumulative learning. Human capacity building needs to be tackled for large-scale infrastructure projects as well as for small-scale solutions, driven and implemented by local entrepreneurs. For large-scale projects, it is crucial to strengthen the strategic planning capabilities and project management skills of both regulatory authorities and project developers. For small-scale solutions, knowledge of the local market is crucial and needs to be complemented with strengthening of business skills and adapting technologies to local needs (WBCSD 2007].

Training skills and learning are an important part of any technology transfer package and can serve as a learning vehicle for the work force of the recipient firm (Brooks 1995). In those regions of the developing world where existing capabilities are weak in specific technology areas, a basic level of technological capability could be built via the establishment of regional institutes that provide training in technology assessment and management. The experience with implementing the Montreal Protocol provides a useful example for capacity building within enterprises where a multilateral fund established by the treaty supports training, research and network building

Due to the failure of top-down and technology-centered approaches, it is now widely recognised that involvement of community institutions is an essential contribution to environmental projects and is therefore an important factor for successful technology transfer. The involvement of local government agencies, consumer groups, industry associations and NGOs can help to ensure that the technologies being adopted within their particular country/region are consistent with their sustainable development goals. Besides the involvement of such community institutions, lessons from technology intensive economies teach that technology increasingly flows through private networks of information and assessment services, management consultants, financial firms, lawyers and accountants, and technical specialist groups. Governments can strengthen the growth of such networks for technology transfer (IPCC 2000). This includes a national dialogue of different stakeholders representing various private as well as public interests. Participatory approaches can engage private actors, public agencies, NGO's and grassroots organisations to engage at all levels of environmental policy-making.

Absorptive capacities of local firms determine whether they can acquire and master technologies which depends on technical competencies and commercialisation skills. Host developing countries can put in place policies to develop domestic capacities to absorb technology and know-how. To strengthen absorptive capacities, policy seeks to enhance the innovative and competitive performance of firms. Here innovation and diffusion are two facets of the same process. To reap the benefits of incremental innovations in developing countries, technology transfer should foster technological innovation in recipient firms so that they also have the technical capability to generate improved processes and products. In this context, government-driven R&D in green technologies can play an important role, because private investors tend to under-invest in public goods, such as the environment.

The ability to absorb new technology depends on the stages of technology development and transfer, and can be acquired through collaborative initiatives in research, development,

demonstration and deployment of low-carbon technologies. It is important to take into account the potential for regional partnerships to absorb and disseminate information to local business on the best available technologies that suit the local circumstances. To enhance absorptive capacity and build trust between technology developers and user, governments and the private sector could develop local management capabilities and partner with business for solutions. They could address installation and maintenance as a key element of technology deployment (WBCSD 2010).

Generation of inter-firm linkages through regular local production by foreign operators is also seen as integral to generate knowledge resulting in new technological capacity in recipient countries. Saad/Zawdi (2003) point out how the transfer of plant and equipment to developing countries has often been based on 'turnkey' and 'product-inhand' contracts that focus on boosting industrial growth rather than fostering innovation. They also highlight the fact that restrictive terms of contracts between TNCs and firms based in developing countries have limited the scope for fostering innovation through 'reverse engineering'.

4. Creating a legal and regulatory framework

To attract investment in low-carbon infrastructure projects and create new markets for low-carbon products, credible, consistent and non-conflicting regulatory obligations are needed that address the long-term nature and high capital cost of energy infrastructure projects (WBCSD 2007). To operate under the rule of law, business requires stable political and legal systems that ensure a sound investment environment. Harmonizing regulations and standards are important, especially in sectors that are subject to strong international trade. Open markets, fair trade and competition rules are essential to enhance technology diffusion to developing countries.

Governments in developing countries can make significant contributions to build or strengthen regulatory frameworks and institutions to stimulate technology transfer and investments. On the one hand, legal barriers need to be removed that slow or diminish access to low-carbon technology by local business. On the other hand, developing new international standards and regulations is particularly relevant for energy efficiency and could create demand to support the innovation and diffusion of more efficient end-user products. If designed properly, markets will respond to regulatory policies to promote the reduction of GHG emissions.

A number of strategies can create a political and regulatory framework to facilitate the implementation of emission reduction options in the energy sector. These strategies could include but are not limited to:

- Allow full cost pricing that includes the external costs of fossil energy and recognise the indirect benefits of renewables such as improvement of the environment, creation of more local jobs, balance of trade, etc.
- Encourage the implementation and enforcement of energy and environmental standards, including recruitment and training of enforcement personnel together with the necessary tools and administrative support for credible implementation of sanctions. Developing countries can learn from existing environmental standards, e.g. the CAFE standards for vehicles in the US, the Top Runner Programme of Japan or the EU Eco-Design Directive. WTO standards can be influenced to facilitate the trade of products and goods produced from the use of low-carbon technologies.

- Promotion of so-called "green-labelling" programmes and certification systems for sustainable energy technology to employ trademark or related principles, such as an environmental seal to satisfy and approve certain requirements to products and vendors.
- Establishment of requirements for environmental impact assessment and environmental reporting.

Establishing criteria for measurable, reportable, verifiable (MRV) action would set out the conditions under which national R&D and development spending would qualify as a contribution to UNFCCC commitments on technology, financing and capacity building support. These conditions would be additional to existing development assistence and R&D spending and have a demonstrable link to a developing country's low carbon development plan. They should meet criteria for enhanced developing country access to new technology and increase its capacity to innovate and adapt.

A major focal point for regulation is to ensure protection of intellectual property rights (IPR) which is essential for technology development and transfer in any country (WBCSD 2010). Issues of transferring or purchasing IPR polarises the interests of parties and prevents progress in global climate negotiations. In some cases companies seem to have strategically withheld or delayed technology from certain markets in order to maximise profits. This contradicts the need to spread technologies into developing countries and is not a sustainable strategy for addressing climate change (Tomlinson et al. 2008). There is no firm evidence from previous case studies of how IPR affect the diffusion of climate technologies, and there is no absolute system of IPR protection in any country.

To develop appropriate and effective mechanisms for low carbon and climate resilient innovation, the incentives for private innovation and for maximising public benefit need to be balanced. To break the deadlock between developed and developing countries over intellectual property, a new agreement for IPR and licensing would provide government-to-government commitments to protect and share low carbon technologies and encourage joint-ventures and public-private partnerships. Access to international R&D funding and credit for national R&D programmes could be made conditional on implementation of agreed protect-and-share principles for IPR. Possible options are improved licensing and parallel markets, as well as "pay to play" agreements to meet the climate challenge (Tomlinson et al. 2008) Support would be made available under a fund to strengthen IPR protection measures in developing countries, consistent with their existing international commitments under World Intellectual Property Organization (WIPO) and World Trade Organization (WTO).

5. Strengthening economic conditions and incentives

How efficient policies for strengthening the national systems of innovation are depends to a considerable degree on the state of the economy in developing countries. Improving the economic conditions is key for creating a long-term viable infrastructure that absorbs low-carbon technology and accelerates development to facilitate leapfrogging into a low-carbon future. A diversified economy is also required to weather shocks from climate change and other destabilizing events, and recombine resources in new ways to adjust to a continuous process of change. In the mid to long term, new fields of economic growth need to be opened, often requiring a differently and more skilled workforce, which has implications for the education systems and related policies. Although there is already significant public and private investment in low carbon innovation in high income countries, this is often done with a view to creating national competitive advantage. Competition is a crucial factor in driving

innovation but it does not fully capture all of the global public good aspects of low carbon technologies (Tomlinson et al. 2008).

6. Incentivizing emerging low-carbon business opportunities

To move to low-carbon economies in developing countries and establish new technologies and production modes based on energy efficiency, renewable power generation and low-carbon production path new business opportunities are to be created. Due to high unit costs, difficult management, lack of markets and infrastructure, new low-carbon products and services can only develop and emerge on a sustainable basis if they are supported by *market-creation* mechanisms, even if only on a temporary basis (WIR 2010). To overcome initial hurdles, economic incentives are required to compete with existing technologies that are more advanced in their lifecycle. As production costs of new pathways decrease over time and new products become attractive to more people, the need to support emerging markets declines and should be ultimately abandoned to avoid market distortions.

To realise the social and environmental benefits of technologies that will not yet diffuse commercially, developing countries can implement policies that combine fiscal and regulatory measures by lowering costs and stimulating demand, thus steering investments into a more desirable direction. Governments can take various measures and tools to provide incentives for investments in sustainable energy technologies and become a catalyst for establishing new markets. There is a wide range of policies in place that support renewable energy around the world, including mandates and standards, innovation policies, carbon pricing, and others. These include encouraging investment in low-carbon and *energy efficient production* and transportion systems or *accelerated depreciation* of existing assets; *public procurement* of low-carbon products and technologies; energy performance standards or mandatory energy labelling schemes; *renewable portfolio standards; blending mandates for alternative fuels; taxes* for high-emission technology or tax incentives for green electricity; *tendering procedures* for green electricity or *green certificate system*s; and *feed-in tariff*s to guarantee a preferential price.

Most of these measures have already been developed and applied in developed countries, in particular in the EU which has considerable experience with several approaches and various mixes (Karakosta 2010). While developed countries will continue to take the lead in market-creation mechanisms, their experience could be fed into technology support programmes in developing countries who may wish to adopt market-creation policies in order to build local markets for certain low-carbon products and services. This could support their own export-capacity, and facilitate the introduction of technologies adapted to their development needs, such as rural electrification using renewable energy sources. Preference for the different incentive policies varies by country, sector and technology.

While governments have a special role in creating incentive structures, the specific situation of developing countries has to be taken into consideration. Instruments such as Feed-in-Tariffs have been established in developed countries where governments have the financial resources to pay the special treatment of low-carbon technologies. Most developing countries, however, have limited financial means to set up market creation programmes to match those of developed economies, which puts them in a disadvantageous position concerning the attraction of low-carbon foreign investment; it is therefore imperative for more advanced countries to take care not to undermine efforts being made in poorer countries' transition towards a low-carbon economy. Further, home countries can assist by actively promoting outward low-carbon foreign investment and by avoiding distortions of market mechanisms.

New market opportunities arising from changes in consumer behaviour in the main developed country markets should also be tapped, including for bio food, goods produced under responsible practices (fair trade, no child labour, fair treatment of workers), and low-carbon products. Appropriate policies can help protect and promote a host country's economic, social and other interests.

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