Chapter 2
Climate Change Mitigation in Developing Countries Using ICT as an Enabling Tool

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Abstract ICT is envisaged to be an important tool in the communication of climate change mitigation technologies, which are necessarily of low carbon footprint in order to reduce GHG emissions. This paper, based on literature, illustrates how new and emerging ICTs will be applied in developing countries to mitigate impacts of climate change. It highlights some smart applications, like the smart grid, mobile phone, ICT-enabled technologies for energy efficiency and management, ICT-enabled smart technologies for transportation, land use change and forestry emissions mitigation, smart motors for enhancing carbon footprint reduction in manufacturing and smart buildings technologies. Detailed review and analysis of emerging economies, notably China and Brazil, were used to identify and recommend appropriate ICT-enabled climate change mitigation technologies. It concludes that while ICTs with low carbon footprints are potentially capable of mitigating impacts of climate change, there are existing constraints that these countries must overcome, including capacity building and ICT-embedded carbon-offset project financing. It is recommended that collaboration among policymakers, academia, research and business be enhanced, and capacity building could go a long way towards the realisation of this.

Keywords GHG emission reduction · Smart transportation · Smart buildings · LUCF · Optimisation · Capacity building · Mitigation technologies

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Short Introduction

This paper illustrates the importance of computer-based applications towards offsetting climate change impacts by explaining how these technologies can be used to reduce emissions of carbon dioxide into the atmosphere, thereby contributing to the reduction of greenhouse gases in the atmosphere. It explains how modern technologies that work with the use of a computer can reduce emissions in buildings, land, transport, manufacturing, farming and forestry, among others. It gives the basis for the use of computer technologies in the least developed countries and identifies the problems that need to be overcome for successful use of these technologies.

Background

Climate change mitigation is almost entirely centred around the application of technologies and processes that reduce the carbon footprint of these technologies and processes, thereby reducing greenhouse gas (GHG) emissions into the environment. Low-carbon technologies that apply information and communication technologies (ICTs) are envisaged to contribute towards climate change mitigation in developing countries where emissions have been steadily exacerbated due to their quest to race ahead in industrial and urban development. These countries also depend on agriculture as a major economic activity, especially for people living in the rural settings. They still use high carbon footprint technologies in energy applications and transport, and it is in these countries that high-carbon fossil fuels are still used intensively.

Agriculture has the potential to degrade the environment through land reclamation from forests and wetlands. GHG emissions from land use change and forestry degradation (LUCF) are still significant in developing countries, and so are emissions from energy systems, transportation, industrial motors, buildings and manufacturing, among others. These countries' contibutions towards GFHG emissions has steadily converged with thoseof developed countries, as the latter have painstakingly deployed technologies to offset GHG emissions. In light of the existing global reality of climate change and its aggravated impact, there is a need to reverse the trend of GHG emissions in developing countries, and ICTs have been proved to provide such opportunities.

This paper, based on a comprehensive review and analysis of existing literature, aims at disseminating some of the world's smart ICTs that, if properly implemented, will contribute significantly towards climate change mitigation. It underlines the fundamental ICT applications on per sector and highlights some of the constraints likely to be faced by developing countries during project implementation.

Materials and Methods

Comprehensive literature on ICT application to climate change mitigation was reviewed and then analysed in light of its applicability to developing countries where potential ICT deployment could be used for low-carbon growth and development. The areas with opportunity for ICT-enabled climate change mitigation were identified on the basis of the carbon footprints of developing countries. Of particular consideration were the key development needs of developing countries, as well as the existing challenges facing these countries. The paper also focuses on critical development issues by evaluating how ICT-enabled climate change mitigation can be applied to poverty alleviation through industrial development and the development of pro-poor solutions such as microgrids for poor remote communities. The paper elaborates on mitigation technologies by drawing lessons from emerging economies such as China, India and Brazil. This is expected to stimulate developing countries to reinvigorate their development strategies based on low-carbon development technologies by using success stories from the advancing emerging economies which in the near-past were not much different from typical developing countries in terms of economic and industrial development and technologies. It is envisaged that ICT-enabled climate change mitigation technologies will protect the climate while promoting economic growth and development.

Climate Change Challenges for Developing Countries

Developing countries have been lately found to be experiencing rapid growth andindustrialisation, thereby becoming major sources of greenhouse gas (GHG) emissions on a global scale (Roeth and Wockek 2011). GHG emissions from developing countries are increasing, while those from developed countries are decreasing—there is some convergence between the two types of economy, as the emissions from the former have hit the 50 % mark. The major sources are fossil fuels in energy consumption and the transportation sector. This has been exacerbated by the rapid rate of development, including accelerated industrialisation, of the developing countries. Although GHG emissions per capita in the least developed countries (LDCs) are comparatively low, they are also increasing due to rapid economic development; however, these countries still remain minor contributors to global climate change with only about 0.5 % of cumulative GHG emissions between 1995 and 2008 (UN-OHRLLS 2010). The majority of LDCs have emissions of less than 2 tCO_2e per capita, with Rwanda, for instance, exhibiting per capita emissions of only 0.3 tCO_2e, while Cambodia had 1.6 tCO_2e in 2008 (World Resources Institute 2009).

The main challenges facing developing countries as regards climate change mitigation is the low potential for financing projects focused on a low carbon footprint. The other challenge is that developing countries have contributed virtually insignificantly towards global climate change, and may thus find no reason to to put effort and funding into mitigation technologies in the first place. While ICT has been found to be an enabler of climate change mitigation and development, with the carbon offset by these technologies being much higher that of the technologies themselves, thereby making them highly feasible mitigators, there is still inadequate capacity to finance and develop infrastructure for ICTs in developing countries.

Developing Countries' ICT-Enabled Climate Change Mitigation: Opportunities for Development

The main focus of this paper in this aspect is to illustrate the potential of ICTs to help move towards a more sustainable low-carbon community, thereby mitigating environmental impacts and climate change using solutions that measure, monitor, manage and enable more efficient use of resources and energy. Very high potential for the realisation of this goal has been cited in infrastructure and systems for dematerialisation, transport substitution, energy efficiency and smarter lifestyles [see e.g. Roeth and Wockek (2011)].

ICT is envisaged to tackle climate change, and subsequent solutions are expected to create enabling environments for strategic development sectors, notably transport, construction, power and industry, for greater efficiency. However, measures should be taken to keep the carbon footprint of the ICT sector below that of the potential for ICT-enabled emission reduction, thereby realising positive costbenefits.

ICT has been predicted to have the potential to reduce emissions by 7.8 $GtCO_2e$ by 2020, from an assumed total of 51.9 $GtCO_2e$ under a business-as-usual (BAU) scenario, which is much larger than the ICT sector's carbon footprint (Roeth and Wockek 2011). This assertion justifies the potential of ICTs in climate change mitigation in developing countries if the barriers to their adoption could be broken.

ICT-enabled mitigation measures include:

- Dematerialisation: by replacing physical goods and processes with 'virtual' alternatives such as videoconferencing instead of travelling for meetings and conferences, electronic mailing, e-commerce and e-procurement.
- Machine-to-Machine (M2M) communications to enable a large share of GHG emissionsto be saved using process optimisation technologies like smart grids, smart logistics, smart buildings and smart motor systems (Roeth and Wockek 2011; Vodafone and Accenture 2009).
- Systemic impacts or behavioural effects, such as better consumption patterns that contribute to GHG emission reductions as a result of ICT applications.

Prospective ICT-Enabled Climate Change Mitigation Technologies for Developing Countries

Transportation

It has been estimated that the application of ICT-driven transportation has the potential to achieve total global GHG emission reductions of up to 1.52 $GtCO_2e$ (Roeth and Wockek 2011). ICT software systems can be designed to optimise the transportation system,there by saving large amounts of energy. Specific software solutions for intervention in the rapid urbanisation and congestion problems of urban areas in LDCs include internodal shifts, ecodriving, inventory reduction and software for the design and implementation of electronic vehicles. The last intervention suggests the application of electrical energy in transportation, while reverting from fossil fuel use thereby reducing the carbon footprint of the transportation sector. Other applications of electrical energy include systems integration in road traffic through the use of smart charging systems and vehicle-to-grid systems, vehicle navigation assistance using ICTs, electronic billing systems and electronic payment systems, as well as computerised fleet monitoring systems and mobility services (Roeth and Wockek 2011).

The electronic vehicle (EV) is of particular potential as an ICT-enabled climate change mitigation innovation technology that uses sophisticated software for managing information and electricity flow between the car, the end-user, battery manufacturers, electricity distribution agencies, grid operators and government regulatory authorities. Implementation of this will necessitate the amendment of industrial and transport policies, with the objective of regulating electronic vehicle development and manufacturing [see, e.g. AltTransport (2010)].

Smart Buildings

ICT is expected to help improve the efficiency of building design, construction and operation for existing and new buildings. ICT-enabled solutions in this sector should focus on energy intensity and surface area, through operations monitoring and optimisation throughout the building's lifecycle from design through to construction, use and decommissioning, while applications in building design optimisation can be implemented through energy modelling software. Emphasis here should also be on the greening of the whole building lifecycle using green architecture and energy efficiency.

Developing countries can apply building management systems, metering technology, environmental sensors, light-control systems, energy auditing/optimisation, software services, data loggers, and building optimisation software.

With the increasing shift from rural to urban settlement, there is a need for smart city solutions, including combined Geographical Information Systems (GIS) and Global Positioning Systems (GPS) solutions, for the development of a robust operation and maintenance plan for facility management, as well as optical fibre cable networks, and telecommunications infrastructure to promote e-governance applications, such as utility services management, facility management, security enablement, on-demand services, telemedicine, e-traffic management and online communities, including social networking and video services like teleconferencing.

These may, however, require a centralised information and communication hub (Lewis 2009; LCL 2009; UKCEED, not dated).

Decarbonisation of Energy Supply and Use

The world's energy needs are expected to grow by about 45 % from 2006 to 2030, largely in developing countries, which are still using carbon-intensive fossil fuels, and this necessitates new and smart measures for decarbonising energy supply and use. ICTs can be applied in energy generation applications, such as smart grids, that enable monitoring of power consumption and use over the electricity grid, thereby enhancing energy efficiency during distribution and use, with the possibility of increasing the use of renewable and non-GHG-emitting sources of energy.

ICT applications in energy and power transmission and distribution include remote sensing to monitor and measure energy use, remote grid element management and computerised energy accounting. These technologies are expected to enhance the monitoring of energy use across the grid and the tracing of energy loss hotspots. End-use ICT-enabled technologies will accelerate the transition to low-carbon communities using smart meters to regulate consumer patterns. Decentralised energy distribution is expected to enable renewable energies, such as solar micro-hydro sources, to be integrated into the grid for fast response to local power surges and shortages, thereby enhancing energy management.

Smart Micro-Grids for Remote Areas

The UN (2010) asserts that developing countries will need to expand access to reliable and modern energy services to reduce poverty and improve the health of citizens while increasing productivity, enhancing competitiveness and promoting economic growth. That developing countries experience energy poverty, leading to health-related consequences and deterrence of economic development and inefficient combustion of solid fuels in inadequately ventilated buildings,in turn leading to indoor air pollution, are critical issues of concern to the UN [see UN (2010)]. Insufficient power supply in developing countries like Uganda has led to the emergence of novel terminologies in the energy sector, including ‘loadshedding’, and this has significantly limited opportunities for productive income-generating activities, especially in the rural communities.

Strategies for accelerating access to power in remote areas include extension of the national grid, microgrid access and off-grid access using, for example, decentralised renewable energies like solar energy systems for households. Microgrids—which are small power systems that include self-contained generation, transmission, distribution, sensors, storage and energy management software with seamless synchronised connection to a utility power system—have been suggested as possible alternatives to the high energy poverty in the developing countries (Hertzog 2010) and they can also operate independently of the utility power system. In remote areas, this operates in a sort of island mode and contributes significantly to a secure energy supply at a reduced cost, and can also integrate renewable and less carbon-intensive energy sources available locally. ICT can be used to balance between generation and demand, and to optimise transmission and distribution of distributed energy generation and storage (Roeth and Wockek 2011). This will also enable integration of large amounts of fluctuating and decentralised renewable energy sources. ICTs can be used to communicate and disseminate the technologies through outreach programmes to encourage energy efficient behaviour, such as use of electricity meters.

Export-Manufacturing Emissions

Low-carbon development paths are the shared responsibility of developed and developing countries, though the former have contributed almost entirely to the GHG emissions that have caused global climate change and its adverse impacts. There is, need to develop and transfer low-carbon technologies from advanced to developing economies in order to reduce international trade-related emissions and support those in developing countries to catch up on the road to development (Roeth and Wockek 2011). ICT-enabled climate change mitigation technologies would still include optimisation of logistics and transportation systems, electrical vehicles, monitoring and operations management, fuel efficiency management, improved design of industrial and transport facilities, flexible home delivery services, M2M technologies and electronic commerce to improve operational efficiency, including onboard telematics, loading monitoring devices and tracking systems.

Land Use Change and Forestry Emissions

Land use change and forestry (LUCF) emissions, including deforestation, logging and intensive cultivation of cropland soils are the second largestglobal anthropogenic sources of GHG emissions, estimated at 15–20 % (Roeth and Wockek

2011). Deforestation, which is the largest driver of LUCF emissions, converts forests into agricultural land in developing countries, and this makes developing countries vulnerable to forest degradation, which contributes 30 % of all their GHG emissions (Roeth and Wockek 2011). The largest emitters, as cited in the existing literature, include Indonesia, Brazil, Malaysia, Myanmar and the Democratic Republic of Congo (DRC), in that order.

Box 1: Wetland Reclamation in Uganda

In the quest for accelerated urbanisation and industrial growth, Uganda has embarked upon the reclamation of wetlands. While wetland reclamation has not been cited as a major contributor to climate change, it is implicitly evident that it contributes to the destabilisation of the water cycle, and this impacts on the energy cycle (carbon footprint) due to the close nexus of water and energy and their closely intertwined impact on climate change.

Source: Adopted from National Environmental Management Authority (NEMA) 2011

The largest and most immediate carbon stock impact in the short-term can be realised by any mitigation measures that reduce or prevent deforestation (IPCC 2007). Thus, reducing emissions by 50 % in the next century has been anticipated to help prevent 500 billion tonnes of carbon from being released into the atmosphere per year (ITU 2010).

ICT-enabled mitigation in LUCF includes systems for monitoring land use change and deforestation, thereby enhancing data collection on forest conditions and remote sensing applications by taking images through clouds at night to monitor deforestation and illegal logging, as well as forest loss from road construction, agriculture and animal grazing (Roeth and Wockek 2011). ICT makes ground data collection more efficient and cost-effective, while remote sensing applications to LUCF are expected to enhance forest monitoring and resource management (SPIDER not dated), thereby overcoming the existing challenges of understaffing in forestry management in developing countries. Remote sensing data, however, need be complemented by ground data and geolocation information to ensure accuracy.

Smart phones can be used to facilitate data collection and timely processing and dissemination globally, as well as storage in a database or server for better land use planning and more informed land use decision making (Roeth and Wockek 2011).

ICTs will also enhance capacity building by increasing public awareness of critical environmental issues, as well as enhancing opportunities for staff development, stakeholder involvement and collaboration between the public and private sectors. It also creates opportunities for fast-tracking the mainstreaming of climate change mitigation and adaptation into education and policy enforcement, thereby empowering communities and increasing support for conservation.

ICT-enabled mitigation technologies for forestry management include software for forest monitoring using Radio Frequency Identification (RFID) labels, which in turn are readable by hand-held computer devices with data capture software to record information on each tree and transfer it to a central server via the Internet or a mobile phone connection.Users can also record GIS-referenced information using touch-screen hand-held computers with databases of icon images instead of text, thereby enabling people with low literacy levels to interpret the data. ICT can also be applied to verify sourcing from sustainable legal sources of timber using supply chain software for tackling illegal logging and addressing deforestation-related GHG emissions (Youngman not dated).

Smart Motor Systems

Motor systems are key drivers of rapidly increasing energy demand in developing countries' manufacturing systems and constitute over 50 % of total industry electricity consumption in many cases (Roeth and Wockek 2011). They are, thus, energy inefficient and there is a need for ICT-enabled solutions for offsetting the proliferating carbon footprint of manufacturing systems in developing countries due to increased use of industrial motors.

Smart applications for enhancing motor efficiency include variable speed drivers (VSD) for controlling the frequency of electrical power supply to the motor, thereby adjusting angular speed to the required output and saving up to 25–30 % energy (Roeth and Wockek 2011). Other measures for enhancing motor efficiency include intelligent motor controllers (IMC) for monitoring the motor's load conditions and adjusting voltage input accordingly to extend motor lifespan and reduce the number of motors associated with GHG emission in manufacturing, though with a minor efficiency gain of less than 10 %.

Industrial motors are thus key elements in the design and implementation of energy efficiency programmes in manufacturing and the application of ICT for controlling their frequency and load conditions will enhance climate change mitigation, while improving the operational efficiency and profitability of manufacturing.

Constraints on the Implementation of ICT-Enabled Climate Change Mitigation Technologies in Developing Countries

In light of the prevailing circumstances in developing countries, such as poverty and inadequate access to project financing, some of the constraints that are likely to inhibit these countries from implementing ICT solutions in climate change mitigation are:

- diversity of the carbon footprint in the developing countries due to their diverse economic activities that range from land use for agriculture to manufacturing, with the latter often prompting reliance on unclean energies with high carbon footprints, like coal and fossil fuels. This accentuates the need for the decarbonisation of the energy supply. Since developing countries are resource-constrained, there is likely to be much laxity towards smart technology adoption, and this exacerbates GHG emissions in these countries.
- inadequate capacity of the various stakeholders along the technology uptake pathways slows promotion of ICT-enabled climate change mitigation technologies. There is frequently a lack of or low awareness and appreciation of technological developments and their potential for more carbon-and energy-efficient solutions. ICT adoption is expected to be rather slow due to insufficient knowledge on climate change mitigation applications.
- inadequate capital due to the conservative banking sector operating a system devoid of the importance of environmental conservation and climate change to economic development. This is exacerbated by the highly sector-specific venture capital and private equity sources (Carbon Trust 2008).
- highly uncertain cost of new technologies, with less or no proven commercial viability, for large scale investment in smart technologies such as smart grids and smart cities (Vodafone and Accenture 2009).
- limited or uncertain suitability of ICTs to local conditions, which often limits technology compatibility across countries or organisations. This calls for stronger linkages along the technology-uptake pathways and between the technology and telecommunications providers and affected industries in order to develop common operating standards (Vodafone and Accenture 2009).
- lack of incentives in LDCs to encourage investment in ICTs for climate change mitigation and adaptation. This has not been helped by the stringent conditions of the clean development mechanism of the UNFCC, which would otherwise encourage developing countries to invest in carbon offset projects.
- inadequate capacity to harness the potential synergies offered by the quadruple helix of linkages between and among the academia, research, policy and the private sector/non-government actors towards addressing the issues of low-carbon innovation challenges in a coordinated manner.
- the rebound effect: efficiency gains are potentially offset by a change in consumption patterns triggered by the very same technology. For instance, lower energy costs resulting from efficiency gains may lead to increased energy consumption, while e-commerce may lead to long distance delivery (increasing the carbon footprint of the consumption of delivered products) and teleworking could lead to increased household energy use and demand for electronic appliances like routers and printers.This may subsequently lead to the problem of leakage, whereby emission reductions from one locality may lead to increased emissions in another, thereby contravening the principle of additionality, which is a major requirement in carbon offset projects.

The 'paperless' office may not necessarily lead to the energy saving patterns promised by dematerialisation.

Summary and Conclusions

Energy savings may not result from the technology itself, but from how it is deployed and used—according to the rebound effect. Energy and ICT policies will play a crucial role in encouraging desired behaviour, thus mitigating anthropogenic impactson climate change. Technology transfer and financing schemes for carbon offset projects covered under UNFCCC could also be extended to incorporate the broader deployment of ICTs in developing countries. This will necessitate capacity building in project design and development (PDD), energy efficiency management and the promotion of voluntary carbon marketing prior to upgrading to CDM certifications. These will fasttrack the adoption of carbon offset projects, including those on a small scale. Developing countries could also take the voluntary carbon market path to benefit from carbon offset markets, while fast tracking opportunities for sustainable development. This is partly because CDM has more costly and more bureaucratic and time-consuming procedures, which tend to favour developed countries and seem to be infeasible for LDCs. Moreover, CDM does not incorporate conditions for sustainable development and benefit sharing, and, consequently, rural settings in LDCs are bound not to benefit from CDM. They thus need to start with voluntary carbon offset projects such as Reducing Emissions from Deforestation and Forest Degradation with sustainability and socio-economic development benefits (REDD+). This will enhance the ability and willingness of low-income, rural communities in LDCs to fast track climate mitigation projects, while harnessing the accompanying benefits.

New and alternative mechanisms to drive inclusive low-carbon growth, which utilise ICT opportunities, shall first be prototyped, before large scale uptake of the technologies. This will enhance implementation of viable projects and offset the possibility of project failure.

Recommendations

- Benchmarking could accelerate low-carbon ICT-enabled climate change mitigation technology uptake and multiplication in LDCs using lessons learned from China and other emerging economies. LDs thus need to identify appropriate technology uptake pathways that will enable the accelerated design and development of ICT-enabled carbon offset projects that will meet their investment capacity and optimise the benefits of emissions reductions, while promoting sustainable socio-economic development, especially in poor rural communities.

- There is a need to expand local lending capabilities and financial access through local commercial banks and microfinance institutions (MFIs) to accelerate the uptake of ICT-enabled carbon offset projects. These projects should be centred around energy efficiency and the application of renewable energies as substitutes for solid energy options such as biomass. The process may be very involved, as this also demands capacity building for the banking sector to create an awareness and appreciation of the socio-economic benefits of carbon offset projects.
- Small and Medium Enterprises (SMEs) in LDCs should be enabled to access ICT-enabled carbon-offset project funding. This would call for comprehensive capacity building as a prerequisite to access the funding. LDCs particularly need to take into consideration the specific development needs of these countries, while focusing on ICT-enabled low-carbon development pathways. This will translate into context-specific technology transfer, with strategies that enhance public–private partnerships for accelerated uptake and upscaling. This would be accentuated by the existing envisaged benefits oftechnology transfer to these SMEs. Once these ICT-enabled technologies are identified and proven feasible, then collaboration with financial institutions could follow to motivate the SMEs to undertake these innovative projects.
- There is a need for reducing GHG emission and providing incentives for offseting ambitious targets throughout the entire economic production value chain grid areas. This would also call for the engagement of a number of participants in a quadruple helix pattern namely policy (governments), research and academic institutions, the business sector and development agencies or non-government actors like NGOs. Research and academic institutions need to take a lead in the quest for novel ICTs that could promote climate change mitigation, and these could be incubated to tangible solutions or products through the business and non-government actor trajectory (private sector), while governments should provide conducive environments and incentives to the private sector to undertake technology incubation, through, for example, subsidies and joint investments in ICTs. Government should also help to set an agenda that focuses on carbon-intensive sectors that are crucial for economic development in developing countries, such as manufacturing, energy, transport, agriculture and forestry. It should be emphasised that technology transfer should be encouraged from local, rather than from industrialised, countries and this will necessitate the building of innovative capacity within the LDCs.
- Developing countries need to mainstream low-carbon development into industrial, energy, construction and transportation projects. This will also be achieved through enhanced capacity for innovation in ICT-enabled carbon offset projects. Once this capacity is realised, governments should set the ICT development agenda, focusing on carbon offset production and development, while prioritising thematic areas specific to the different sectors. The national planning authorities would then take and prioritise development projects that include measures for carbon offset for immediate funding. Meanwhile, policymakers

should develop carbon offset standards, or adopt existing ones from the best ones already in use in industry, for regulation, verification and certification.

- There is a need for to engage in policy advocacy to promote regulatory and policy reforms for better investment opportunities in ICT-enabled carbon offset projects. This would also be possible through the deployment of the quadruple helix highlighted above. Capacity building for non-government actors should be enhanced to enable them to act as 'watchdogs' for compliance with climate-proofed development ICTs for sustainable development.
- Since agriculture forms the main economic activity for the majority of the population of LDCs, who mainly live in rural settings, and since few studies have been conducted in ICT-enabled GHG emission reductions in the agricultural sector, there is a need for further research to explore ICT solutions in specific high-carbon sectors in LDCs. LDCs are also beset by low levels of smart energies, while they are dominated by traditional biomass as the major source of energy, with high GHG emissions and environmental degradation. In addition, electricity grids in LDCs often have poorly planned distribution networks, overloaded system components and a lack of reactive power support and regulation services, while the efficiency of metering and bill collection is low. LDCs will thus need to benchmark best practices from fast developing economies like China for energy efficiency improvement and lowcarbon development.

Finally, the business sector's capacity should be enhanced to promote a reduction in the carbon footprint of the ICT sector, and help comprehend the lifecycle impact of ICTs in developing countries. Incentives for participation in research and development ICT projects that prioritise GHG emissions reductions should be provided to private organisations once they attain adequate capacity for innovation in climate-proof ICTs.

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