Low-carbon Development in South Asia

Leapfrogging to a green future

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Photo above: Transmission and distribution losses are much higher in South Asia than other regions.
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Cover: Solar energy in Nepal has huge potential.
Photo credit: Practical Action

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Climate Action Network – South Asia (CANSA) aims to redress policy divides and insufficient systematic scientific evidence, and support collective action. It brings together 120 organisations in seven countries across South Asia.

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Abbreviations

°C	Degrees Celsius
ADB	Asian Development Bank
ADP	Adhoc Durban Platform
AEPC	Alternative Energy Promotion Centre
AR5	Fifth Assessment Report
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
CDM	Clean Development Mechanism
CER	Certified emission reduction
CFL	Compact fluorescent lamp
CIF	Climate Investment Fund
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CTF	Climate Technology Fund
ELIB	Efficient Lighting Initiative of Bangladesh
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
Gt	Gigatonne
$GtCO_2e$	Gigatonne carbon dioxide equivalent
GWh	Gigawatt hour
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kgoe	Kilograms of oil equivalent
ktoe	Kilotonnes of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
LCEDS	Low carbon economic development strategy
LDC	Local distribution company
LPG	Liquefied petroleum gas
MDGs	Millennium Development Goals
MPI	Multi-Poverty Index
Mtoe	Million tonnes oil equivalent
MW	Megawatt
MWh	Megawatt hour
NAMA	Nationally Appropriate Mitigation Action
NEC	National Environment Commission
PPA	Power Purchase Agreement
PPP	Purchasing power parity
PV	Photovoltaic
RE	Renewable energy
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
SHS	Solar home system
t	Tonne
TJ	Terajoule
TWh	Terawatt hours
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Energy Outlook
WHO	World Health Organization
WISE	World Institute of Sustainable Energy

Executive summary

The latest science is very clear – we are more than 95% certain that climate change is happening right now, that it will get much worse unless we act fast to stop it and that it is 78% due to fossil fuel combustion and industrial processes[1] – the world could be facing catastrophic events. If no action is taken, it is estimated that carbon dioxide (CO_2) emissions from the energy-supply sector will almost double or even triple by 2050. South Asia is one of the most vulnerable regions to the impacts of climate change. Rising sea levels threaten coastal cities, changes to the monsoon rain fall and significant reduction in agricultural output are among the climate risks.

To keep the Earth's temperature to below a 2 degrees Celsius (2°C) rise – the internationally agreed goal under the United Nations Framework Convention on Climate Change (UNFCCC) Cancun Agreement – will require deep decarbonisation by both developed and developing countries.

The growth rate for countries in South Asia rose over much of the past decade by an average 7.9% a year. That rate faltered slightly to just under 5% in 2013, but the prospects for 2014 and beyond look brighter. Yet South Asia, comprising India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan, remains the world's poorest region. There are more people living in poverty in eight Indian states than there are in the 26 poorest African countries. Across the region, 433 million people still have no access to electricity. For South Asia this presents a tremendous challenge because energy is key to lifting people out of poverty and creating the necessary infrastructure to provide healthcare, education, sanitation, clean water, food security and employment.

As a result of recent economic growth and increased demand for energy, South Asia's greenhouse gas (GHG) emissions are increasing annually, with India now the sixth largest emitter of GHGs in the world, even though per capita emissions are much lower than those for Europe and North America. Currently, energy production in the region is heavily dependent on fossil fuels – coal, imported oil and gas. As economies continue to grow, the region is projected to become even more fossil-fuel dependent. Replacing fossil fuels with renewable energy is therefore a priority.

The good news is that South Asia has great potential for energy efficiency and renewable energy, the two promising areas where action taken now would help ensure transition to a zero-carbon world. In terms of renewable energy, the subcontinent has vast potential to develop hydro, geothermal, wind, solar and tidal energy.

Already countries in the region are beginning to take action. These initiatives range from individual projects to comprehensive frameworks, including the regional Action Plan on Climate Change and national action plans. India has set a goal of establishing 22GW of solar capacity by 2022. Bangladesh has a target of producing 5% of its electricity from renewables by 2015. Pakistan plans to develop 3GW of wind capacity in the medium term. Nepal plans to increase the share of renewable energy from less than 1% to 10% of the total energy supply, and to increase access to electricity from alternative energy sources from 10% to 30% by 2032. Sri Lanka plans to increase the share in grid energy supply from nonconventional renewable energy sources to 20% by 2020.

Countries are focusing on energy efficiency in the manufacturing sector and on the use of energy-efficient domestic appliances. However, although a number of efforts are being made to tackle climate change, there are still huge barriers preventing a real and ambitious transition to low-carbon energy. These include: a lack of technical expertise; high initial costs in developing clean technology; a lack of adequate financing, including from developed countries and the private sector; government subsidies and policies that benefit fossil fuels over renewable energy; and a lack of intraregional cooperation and trade between South Asian countries.

These barriers will have to be overcome in order to meet two internationally agreed goals – to keep global warming to below 2°C and to provide energy for all by 2030. This will require **political will**, both internationally and from individual countries, and **practical measures** to lay the foundations for such a transformation.

Recommendations

- **Global climate deal:** Governments need to set credible and stringent clean energy targets and goals, within a fair and ambitious global climate deal.
- **Regional technology sharing and innovation:** Achieving ambitious deep cuts in emissions and accelerating green growth will require the development and diffusion of carbon-efficient technologies. Regional cooperation in knowledge sharing, energy development and trade will be essential.
- **Incentives for private sector investment:** Innovative finance mechanisms and policies are needed to reduce the risks perceived by mainstream lending institutions in cleaner technology investments and to enhance their capacity to finance low-carbon technologies and resource options.
- **Shifting subsidies from fossil fuels** to deliver sustainable energy access for all.
- **International finance:** A 'leapfrog fund' should be established from global mitigation finance to support South Asia in moving towards a low-carbon economy. The Green Climate Fund, established by the United Nations Framework Convention on Climate Change, should include a dedicated window for this purpose.

Lighting from renewable energy can help children study at night.

1. Introduction

The scientific evidence is overwhelming – climate change is happening and unless there are drastic reductions in greenhouse gas (GHG) emissions – 78% of which result from fossil fuel combustion and industrial processes[2] – the world could be facing catastrophic events.[3] If no action is taken, it is estimated that carbon dioxide (CO_2) emissions from the energy-supply sector will almost double or even triple by 2050.[4] To keep the earth's temperature to below a 2°C rise – the internationally agreed goal under the United Nations Framework on Climate Change (UNFCCC) Cancun Agreement[5] – will require deep decarbonisation by both developed and developing countries.

However, the governments of developing countries – which are most vulnerable to the effects of climate change – need energy to lift people out of poverty, both through improving the overall economy and by improving access to services such as healthcare and education. Without access to energy, billions of women, men and children will be denied the opportunity to improve their lives – to have sufficient food, earn a decent living, and have access to good-quality healthcare and education. The challenge facing the world today is how to enable developing countries, through technological and financial support, to transition to low-carbon energy options to meet increasing demand.

As a result of rapid economic growth and increased demand for energy, GHG emissions in South Asia are increasing annually, with India – now the sixth largest emitter of GHGs in the world – accounting for 75% of the region's emissions. However, the vast majority of people in the region remain energy poor, with 433 million still having no access to electricity,[6] and many relying on traditional biomass fuels (wood, charcoal and agricultural waste) for cooking.

Drawing on case study evidence from four countries (Bangladesh, India, Nepal and Pakistan), this report presents the case for a low-carbon South Asia that is able to deliver clean and sustainable energy to millions of energy-poor people and at the same time drive a productive green economic expansion to deliver a higher sustainable standard of living across the subcontinent. Renewable energy and energy efficiency have been identified as the two promising areas where actions initiated now would help to ensure transition to a zero carbon world. South Asia has huge potential for renewable energy, which is largely untapped, providing the subcontinent with the opportunity to leapfrog ahead in the journey to sustainable development.

Geothermal, small-scale hydro, solar, wind, tidal and local biomass fuels, including agricultural waste, all offer significant potential for meeting both basic needs and unlocking economic growth. Currently the region's energy supply is heavily dependent on fossil fuels. As the region's economies continue to grow (regional GDP has risen by on average 7.9% over the past 10 years and is expected to grow by 6.4% in 2014 and 6.7% in 2015),[7] countries will have to significantly expand their energy infrastructure and services. Governments will have to put in place strategies, regulations and capacity-building to stimulate low-carbon development and to attract private sector investment, innovation and markets. Energy efficiency will also be an important element of developing a low-carbon South Asia.

This report looks at the available scientific evidence on global warming and the measures that need to be taken to address climate change. It goes on to explore the current energy context in Bangladesh, India, Nepal and Pakistan, the potential for renewable energy and energy efficiency in South Asia, country initiatives and international support mechanisms that are already in place, barriers to low-carbon transition, and the benefits of low-carbon development. Finally, it proposes the establishment of a 'leapfrog fund' from global mitigation finance to support South Asia's move towards a low-carbon economy and the phasing out of fossil fuel subsidies, which in 2011 were almost seven times higher than support for renewable energy.

2. Climate change and energy – the evidence

The Intergovernmental Panel on Climate Change (IPCC) fifth assessment (AR5) Working Group (WG) 1 report,[8] based on a number of studies and scenario analysis, has concluded that global surface temperature change by the end of the 21st century is very likely to exceed 1.5°C. It assesses that if GHG emissions continue without any new measures to address them,[9] the global surface temperature rise could exceed 4°C by the end of the 21st century.

The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization and United Nations Environment Programme to provide policy makers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

IPCC assessments are written by hundreds of leading scientists who volunteer their time and expertise as coordinating lead authors and lead authors of the reports. They enlist hundreds of other experts as contributing authors to provide complementary expertise in specific areas.

The authors producing the reports are currently in three working groups – Working Group I: the Physical Science Basis; Working Group II: Impacts, Adaptation and Vulnerability; and Working Group III: Mitigation of Climate Change – and the Task Force on National Greenhouse Gas Inventories (TFI).

AR5 is the fifth assessment report of the IPCC. For more details see www.ipcc.ch/report/ar5

The increase in average global temperature has been found to be approximately linearly correlated to the cumulative total of GHG emissions. Analysis of various studies by the

Despite an increasing number of climate change mitigation policies, GHG emissions have continued to grow. Between 2000 and 2010, the annual growth was on average 2.2% per year, 0.7% higher than from 1970 to 2000.

IPCC shows that to limit global warming to less than 2°C with a probability of 66% or more will require cumulative CO_2 emissions from anthropogenic (environmental pollution and pollutants resulting from human activity) sources to stay below 3,670 gigatonnes of CO_2 ($GtCO_2$). By 2011, 1,890 $GtCO_2$ had already been consumed, leaving around 1,780 $GtCO_2$ in the available 'carbon budget'.

Despite an increasing number of climate change mitigation policies, GHG emissions have continued to grow.[10] Between 2000 and 2010, the annual growth was on average 2.2% per year, 0.7% higher than from 1970 to 2000. Total anthropogenic GHG emissions were 49 $GtCO_2e$ in 2010. Assuming that emissions stay at the 2010 level (current trends are upwards), the available carbon quota would be consumed in less than 40 years. This date will come much sooner if we aim for a higher certainty of staying below a 2°C rise, or below the safer level of a 1.5°C rise.

What the IPCC AR5 highlights is that countries will have to go down to zero emissions somewhere between 2050 and 2070, which calls for deep decarbonisation of the economies of both developed and developing countries. Two aspects of deep decarbonisation are the peaking of emissions and then reduction towards a zero carbon world. The earlier the peak, the easier would be the pathway to reducing emissions. Countries are addressing the issue under the United Nations Framework Convention on Climate Change (UNFCCC) Adhoc Durban Platform

(ADP)[11] and negotiating a new agreement to address the seriousness of the situation. The ADP covers both the enhancement reduction target pre-2020 and reduction targets post 2020. The pre-2020 reductions are key to easing the path of reductions beyond 2020.

> Based on developed country pledges currently on the table, emissions in 2020 will be 8-12 $GtCO_2e$ per year higher than the required global emission level for the world to be on track for the 2°C goal. Meeting the preferable 1.5°C 2020 target would be in the range of 10-17 $GtCO_2e$ per year.[12] According to the IPCC AR4, developed countries should reduce their emissions between 25-40% below 1990 levels, but the pledges made so far will only result in a reduction of about 16%.[13] Stricter accounting rules for developed country actions and moving to unconditional pledges would increase the reduction by 4-7 $GtCO_2e$, which is one-third of the gap identified for 2020.[14]

Renewable energy and energy efficiency

The United Nations Environment Programme Emissions Gap report 2013 identified renewable energy and energy efficiency as the two promising areas where actions initiated now would help to ensure a faster transition to a zero carbon world.[15] The potential reduction identified until 2020 is between 3 and 5 $GtCO_2e$. The IPCC AR5 has also identified energy efficiency enhancements and behavioural changes to reduce energy demand as a key mitigation strategy. Immediate reductions in energy demand provide a cost-effective mitigation strategy, as they provide more flexibility for reducing the carbon intensity[16] of the energy used to meet demand and avoid lock-in to carbon-intensive infrastructures.

Between 2000 and 2010, growing energy demand and an increase of the share of coal in the global fuel mix were key factors driving growth in energy supply-related emissions.[17] If no actions are taken, it is estimated that by 2050, direct CO_2 emissions from the energy supply sector will almost double or even triple compared to the level of 14.4 $GtCO_2$ in 2010.

Renewable energy accounted for just over half of the new electricity-generating capacity added globally in 2012, led by growth in wind, hydro and solar power. Over the past decade, new technologies have demonstrated substantial cost reductions and performance improvements and have achieved a level of technical maturity to enable deployment of renewable energy at significant scale. This is not to say that all renewable energy technologies are cost competitive with fossil fuels in all situations. Some technologies may still need direct and/or indirect support to become cost competitive in the medium to long term, and in some places technical challenges still exist in integrating renewable energy into existing energy systems. The associated costs vary according to the technology, regional circumstances, and characteristics of the existing energy supply system. International support for phasing in renewable energy, including easy and affordable access to renewable energy technologies and significant investments in technologies to integrate renewable energy systems into existing grids, could enable a faster uptake of renewable energy.

3. The growth and climate change challenge in South Asia

Current level of development

South Asia is the poorest region in the world: 52% of the world's poor live in the subcontinent (compared to 29% in sub-Saharan Africa).[18] There are more poor people in eight Indian states alone than in the 26 poorest African countries put together.[19]

South Asia is made up of Afghanistan, Bangladesh, Bhutan, India, the Maldives, Myanmar,[20] Nepal, Pakistan and Sri Lanka. As per the World Bank classification of countries,[21] Bhutan, India, Pakistan and Sri Lanka fall in the lower-middle-income group, while Bangladesh and Bhutan are classified as least developed countries. All the other countries are low-income economies.

For this report we have used case examples from four South Asian countries – Bangladesh, India, Nepal and Pakistan. For more information about the range of issues affecting these countries and their responses, see the Annex.

Although development over the past decade has dramatically reduced the number of people living in poverty in the region, the percentage of the population living on less than $2 a day is still very high: Bangladesh 76.5%; India 68.8%; Nepal 57.3% and Pakistan 59.1%. Only in Bhutan (12.6%) and Sri Lanka (23.9%) is the figure less than 50%.[22]

According to the 2014 UNDP Human Development Index report,[23] 1.56 billion people in the region live in multidimensional poverty, including 612 million in India. One billion have no access to sanitation;[24] only 39% have secondary or higher education; 40% of children are underweight; and there are only 0.6 physicians per 1,000 people. The development challenge is therefore to lift people out of poverty and create the necessary infrastructure to provide good health facilities, education, sanitation, water and other essential services.

Sri Lanka has the highest GDP per capita in the region, while Afghanistan has the lowest. India is by far the largest economy, making up almost 82% of the South Asian economy. In nominal terms, it is the world's 10th largest economy and the third largest by purchasing power parity (PPP) adjusted exchange rates. Pakistan has the next largest economy and the fifth highest GDP per capita in the region, followed by Bangladesh and Sri Lanka.

In recent years, economies in the region, led by India, have been growing at a rapid pace. During 2005-2010, regional GDP grew at an average of 7.9% per annum and per capita real GDP in purchasing power parity (PPP, at constant 2005 international $) grew at a compounded annual growth rate of 8.45%. As in other regions, South Asian countries saw mixed growth rates in the six-year period, with India taking the lead with an 8.5% growth rate in 2010.

Greenhouse gas emissions

Currently, South Asia contributes just 7% of global GHG emissions, even though it makes up approximately 22% of the world's population. Compared to the rest of the world, per capita emissions in the region are very low – 1.3 compared to 4.6 for the world as whole, 7.3 for Europeans and 17.3 for North Americans. India, by virtue of its size – it is home to 80% of South Asians – accounts for 75% of the region's emissions and by 2007 had become the sixth largest emitter in the world. Although per capita emissions in the country remain low, these are expected to grow since most planned expansion of centralised energy is based on fossil fuels. The same is true for Bangladesh and Pakistan.

The region's rapid economic growth has led to increased demand for energy and, as a result, the region's GHG emissions have risen by about 3.3% annually since 1990. Between 1990 and 2005, total GHG emissions from energy-using activities increased by 98.2% across South Asia, compared to an increase in global emissions of 30.8%.[25] Actual increases in energy demand depend a lot on GDP, population and political choices, but it is estimated that India's total primary energy supply will increase at

South Asia has been identified in the IPCC's AR5 WG II report as one of the regions most vulnerable to climate change.

a rate of 3.6% from 529 million tonnes oil equivalent[26] (Mtoe) in 2005 to 1,299Mtoe in 2030. In this prediction, the biomass share decreases but coal and oil increase.

Clearly, projections for emissions in the region are not compatible with the global urgency to stay below a 2°C temperature rise, and will not contribute to a global peak by 2020 and rapid emissions reduction thereafter. Peaking seems very unlikely unless technologies and systems based on renewable energy are developed in order to provide stable and continuous power and deeper reductions are made than those currently pledged, particularly by developed countries.

Growing sustainably

South Asia has been identified in the IPCC's AR5 WG II report as one of the regions most vulnerable to climate change. It is therefore essential that addressing climate change and working with the world community to reduce emissions is an integral part of sustainable development in the subcontinent. This presents a tremendous challenge in continuing to grow to lift the region's vast population out of poverty and providing them with basic infrastructure, while at the same time keeping the emissions from development low. However, addressing poverty and addressing climate change does not necessarily have to be an either/or choice, as subsequent chapters will demonstrate.

Traditional cook stoves have adverse effects on health, but are still widely used in Bangladesh.

4. Current energy context in South Asia

Energy demand and mix

South Asia's inefficient energy system is characterised by energy that is imported, expensive, environmentally unsustainable, and dependent on coal, oil, wood and natural gas. Regular power outages, inadequate and unreliable distribution networks and high energy costs are common to the energy sector across the region.

Countries are faced with rapidly rising energy demand coupled with increasingly insufficient energy supplies. Improving the supply of energy, particularly the supply of electricity, is therefore an important priority. Governments are looking to diversify their traditional energy supplies, promote additional foreign investment for energy infrastructure development, improve energy efficiency, reform and privatise energy sectors, and promote and expand regional energy trade and investment.

Currently there is a massive dependence on fossil fuels, which are often imported and consume a high portion of the region's export earnings. Fluctuations in oil and gas prices make the task of delivering a secure energy supply even more difficult. The focus on providing centralised conventional power from oil, gas and coal or from large-scale hydropower projects (of more than 100MW) has not effectively provided access to energy for poor people. South Asia uses far more energy for every dollar of GDP than any other region.

Currently there is a massive dependence on fossil fuels, which are often imported and consume a high portion of the region's export earnings.

Current energy sources in South Asia

Bangladesh: Biomass accounts for 68% of primary energy consumption in Bangladesh, and over 90% of household energy. Domestic natural gas accounted for 68% of the country's commercial energy consumption in 2010; imported oil and coal for another 26% and local hydropower for 5.4%. About 88% of the country's power was generated from gas and about half the commercial energy consumption was for power generation.

India: Coal and lignite, both imported as well as domestically extracted, provides 40% of India's total energy requirements. Petroleum and gas provide 31.57% of energy, of which almost two-thirds has to be imported. Non-commercial or traditional biomass sources meet almost one-quarter of the country's energy requirements. Biomass fuels are traditionally used for cooking and heating. According to the 2011 census, 67.23% of households still cook using firewood, crop residues, cow-dung cakes or coal/ coal dust.

Pakistan: Commercial energy consumption in Pakistan is met from a mix of gas (49%), oil (31%), electricity (13%) and coal (7%) – all of which cumulatively account for almost half of national GHG emissions. Almost two-thirds of the population depends on biomass fuel to meet domestic needs.

Nepal: Of the total energy consumption in 2008/9, traditional sources accounted for 87% and commercial sources for 12%, with new renewable sources accounting for just 1%. Of commercial fuels, 60% are petroleum, with coal and grid electricity (mainly hydropower) each being 13%.

Source: Country case studies in the Annex.

In most South Asian countries, fossil fuels are the main source of commercial energy (see box). In India, coal is the main fossil fuel source, whereas for other countries gas and petroleum products are the key sources. Primary energy, which includes hydro-electricity and renewable energy, accounts for a small percentage, except in Bhutan and Nepal.

Fossil fuel is a major indigenous source of energy in the region. As of 2011, proven coal reserves in South Asia were estimated at 117.3 billion tonnes, of which 97.2% are in India. Bangladesh and Bhutan have coal reserves of about 3.3 billion tons[27] and 1.96 million tons respectively.[28] The region has a total of 116,833MW coal-based electricity plants, almost all of which (116,333MW) are in India. Even though Sri Lanka has no coal resources of its own, it has built coal-based power generation plants.[29]

South Asian countries are also highly dependent on imported fuels to meet energy demand. In 2009, India imported 35% of its total energy;[30] Bangladesh met 94% of its oil and 45% of its coal demand through imports;[31] and Pakistan imported 25% of its energy.[32] Most countries in the region are dependent on imported crude oil and petroleum products, with imports ranging from 25% of commercial energy consumption in the case of Bhutan to 100% in the case of Maldives. The recent volatility and sharp increase in world oil prices has placed an unexpected and enormous burden on foreign exchange reserves, to the detriment of national economies. While countries like Sri Lanka and Maldives, which lack indigenous fossil fuel sources, are especially hard hit, even countries like India, Pakistan and Bangladesh now meet less of their demand with indigenous fuel sources and face mounting energy import bills.

While it is important to ensure sufficient resources to eradicate poverty and meet broader sustainable development ambitions, the growth in the region's GDP is also a key driver of the increase in total emissions. According to a recent study by the Asian Development Bank (ADB),[33] South Asia is projected to become more rather than less fossil-fuel dependent, with the share of coal in the energy mix increasing from 2% in 2005 to 27.6% by 2030, mainly due to the high and growing coal dependence of Bangladesh. The share of oil is expected to decline slightly (from 22.9% to 21.7%), as are the shares of biomass and natural gas, although their use in absolute terms is likely to increase between 2005 and 2030.

A challenge going forward will be to meet energy demand at an affordable cost, reduce the region's import dependence, and at the same time limit and then reduce its GHG emissions.

Energy for development – the link

As mentioned earlier, South Asia is the poorest region in the world. A key challenge for governments is therefore to lift a vast population out of poverty and provide a decent level of essential services. The correlation between energy and development is well established. Without access to energy, billions of women, men and children are denied the opportunity to improve their lives – to stay fed and healthy, participate in education and earn a living.

Energy poverty at the household level is assessed by the IEA through two major indicators: access to electricity and dependence on traditional biomass (wood, dung and charcoal) fuels for cooking. South Asian countries share these common features, with high levels of energy poverty and dependence on wood and charcoal for domestic needs. At a national level, energy poverty is aggravated by power shortages, unsustainable dependence on imported fossil fuels and lack of access to finance to invest in energy security.

The link between energy services and poverty reduction was explicitly identified by the World Summit on Sustainable Development in the Johannesburg Plan of Implementation, which called for the international community to: 'Take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the MDGs, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty.'[34]

Modern energy services help to drive economic growth by improving productivity and enabling local income generation, for example through agricultural development and non-farm employment. They also help in improving social equality. For example, modern fuels and electricity help to boost household income by providing lighting that extends livelihood activities beyond daylight hours, which increases output. By providing additional opportunities for employment, energy services also enable farmers to diversify their income sources, and thus mitigate the inherent risks associated with agriculture-dependent livelihoods. Energy is important in supporting productive activities in both formal and informal sectors. Another way modern energy services contribute to economic growth is by reducing unit costs.

Examples of how access to clean and affordable energy helps achieve the MDGs

MDG 1: Extreme poverty and hunger

- Modern fuels reduce time spent collecting fuel (such as firewood) and increase time for income-generating activities.
- Improved lighting boosts productivity by extending working hours.
- Refrigeration reduces food and crop waste.

MDG 2: Universal primary education

- Lighting allows children to study at night.
- Access to energy can help rural schools attract teachers.
- Improved cooking facilities free up time spent collecting wood for education
- Electricity enables use of information technologies in education, and access to the Internet.

MDG 4: Child mortality

- Reduction of smoke inhalation through household heating can improve child health and save lives.
- Health services are improved through lighting, heating and refrigeration.
- Improved lighting reduces deaths and injury from burns and fires.

MDG 7: Environmental sustainability

- Access to clean fuels reduces deforestation.
- Improved cooking stoves reduce greenhouse gas emissions.

Meeting the MDGs requires access to at least three types of energy services: (1) energy for cooking, (2) electricity for illumination, information and communication technology, and appliances to support household and commercial activities and the provision of social services, and (3) mechanical power to operate agricultural and food processing equipment, to carry out supplementary irrigation, to support enterprises and other productive uses, and to transport goods and people.

In recognisation of the importance of the role clean, affordable and modern energy plays in addressing poverty and wellbeing, the UN initiative on Sustainable Energy for All (SE4ALL) has adopted 'universal access to modern energy services (including electricity and clean, modern cooking solutions)' by 2030 as one of its goals. Further, as we now move towards establishing a new set of sustainable development goals (SDGs) for the post-2015 period, it is encouraging that a specific goal on energy – 'access to affordable, reliable, sustainable, and modern energy for all' – is proposed. As in the case of MDGs, sustainable energy access for all will be critical to achieve the other proposed goals.

Energy deficit

According to World Bank studies, 58% of people in rural Bangladesh are energy poor (do not have a basic level of energy consumption).[35] In rural India, the figure is 57% (more than double the number defined as income poor). In urban areas of India, the energy poverty rate is 28%, compared to 20% who are income poor.[36] A similar analysis for Pakistan indicates that energy poverty ranges from 47-66% in the four key provinces.[37]

One in four people in India and Nepal, and about one in three in Pakistan and Bangladesh, live without electricity, with much less access in rural areas than in urban areas. Approximately 433 million people in the region have no access to electricity. Although the electrification rate in South Asia is high, this does not necessarily translate into a high level of access. In India, for example, access is defined as the availability of connection to the national grid, even if houses are not actually connected. In addition, per capita consumption of electricity is very low – just 684kWh per year per person compared to the world average of 2,977kWh per year per person (and in the US, 13,246kWh per person).[38]

Statistics compiled by the IEA highlight the region as a global hotspot for energy poverty: just 68.5% of the population has access to electricity, with more than 1 billion people (69% of the total population) relying on biomass fuels for cooking (930 million in India and Pakistan alone).[39] This is compared to 695 million in sub-Saharan Africa, although the percentage there is higher (81%). In rural areas in South Asia, 87% of the population is dependent on wood and charcoal to meet their energy needs, compared to 95% in rural sub-Saharan Africa.[40]

Table 1. Electricity access in 2011 – regional aggregates

Region	Population without electricity (millions)	Electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
Developing countries	1,257	76.5	90.6	65.1
Africa	600	43	65	28
Developing Asia	615	83	95	75
India	306	75	94	67
China	3	99.8	100	99.6
South-east Asia	134	77.6	90.5	67.2
Rest of developing Asia	172	61.4	81.9	51.7
Bangladesh	61	60	90	48
Mongolia	0	88	98	67
Nepal	7	76	97	72
North Korea	18	26	36	11
Pakistan	56	69	88	57
Sri Lanka	3	85	96	84
Latin America	24	95	99	81
Middle East	19	91	99	76
Transition economies and OECD	1	99.9	100	99.7
World	1,258	81.9	93.7	69

Source: International Energy Agency, 2013

The World Health Organization (WHO) linked indoor air pollution from cooking over coal, wood and biomass stoves to 4.3 million deaths in 2012, the majority (3.3 million) in the Southeast Asia and Western Pacific regions.[41]

Future energy demand

South Asia has experienced a long period of robust economic growth, averaging 7.9% per year over the past 10 years. Regional GDP is expected to grow by 6.2% in 2014 and 6.4% in 2015,[42] driven by improvements in export demand, policy reforms in India, stronger investment activity and normal agricultural production. Based on business-as-usual growth scenarios, the ADB estimates that, in 2030, primary energy use is likely to be 2.4 times higher than in 2005.[43] Some studies have projected a business as usual 52% increase in energy consumption in Nepal, rising to 59% in a middle-growth scenario and 93% if there is high growth.[44] In Pakistan, the total energy need is expected to quadruple by 2030 compared to 2009,[45] and in Bangladesh, in order to meet projected growth, the existing capacity of 5,250MW is expected to expand to 20,000MW by 2021.[46]

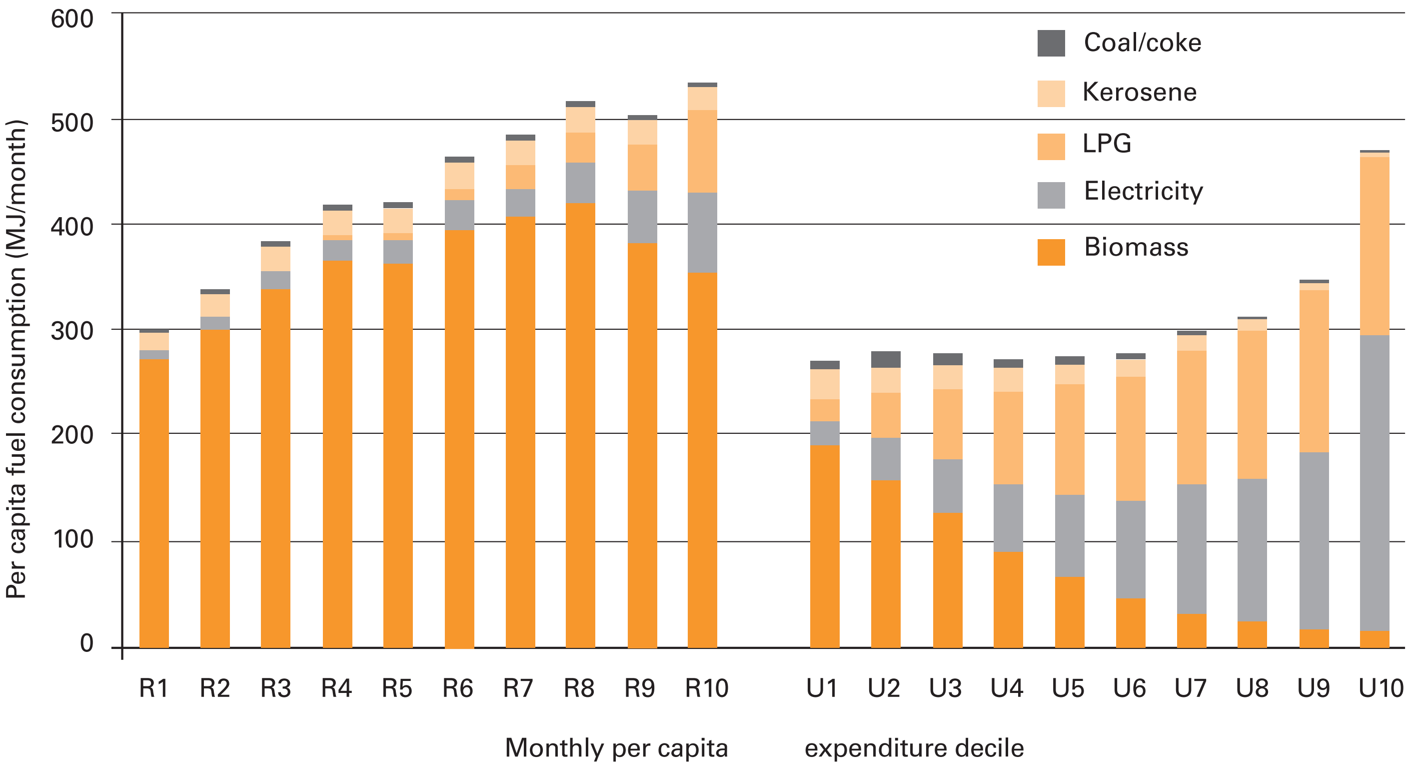
The IEA 2012 World Energy Outlook estimates that by 2030 an additional 0.85 million barrels per day of LPG will be required for cooking globally if there is 'Energy for All'.[47]

Under a business-as-usual scenario, nearly all of the new energy supplied for Asia, including India, will come from three fossil fuel sources – oil, coal, and natural gas.[48]
Oil will be the largest source of new energy supply for Southeast Asia, China, and India during the next 20 years, with nearly 700Mtoe of new supply of oil, followed by coal (about 650Mtoe) and natural gas (about 350Mtoe). India will increase its oil import dependency from just below 75% in 2007 to 94% in 2030. India's net imports of coal will increase more than five-fold, from 52Mtoe in 2008 to 281Mtoe in 2030, accounting for 37% of its primary hard-coal demand.

Table 2. Use of traditional biomass fuels in different regions of the world

Region	Population relying on traditional use of biomass (millions)	Percentage of population relying on traditional use of biomass (%)	Percentage of urban population (%)	Percentage of rural population (%)
Developing countries	**2,588**	**48.9**	**18.7**	**72.3**
Africa	698	68	44	83
North Africa	3	2	1	2
Sub-Saharan Africa	696	81	56	95
Developing Asia	1,814	51	17	72
China and East Asia	716	36	12	56
South Asia	1,098	69	27	87
Latin America	65	14	5	50
Middle East	10	5	1	14
World	**2,588**	**37.8**	**12.5**	**63.7**

Figure 1. Types of fuel used in rural and urban India by income class



Source: K Patil, A Chattopadhyay, Household Energy Use and CO2 Emission: Differentials and Determinant in India, http://iussp.org/sites/default/files/event_call_for_papers/Household%20Energy%20Use%20and%20CO2%20Emission.pdf

India's industry and manufacturing sector is energy intensive, with cement, iron and steel, fertilisers, pharmaceuticals, automobiles and household appliances being major sub-sectors. In Bangladesh, textile and garment exports are the largest source of foreign exchange earnings.

As Figure 1 shows, in India the lower income groups in urban areas continue to be highly dependent on traditional biomass fuels. However, as incomes grow, households are switching to kerosene and liquid petroleum gas, both, of which are cleaner than biomass fuels but still have an implication in terms of CO_2 emissions.

Energy-intensive industrial growth

Industry is the main driver of growth in South Asia, accounting for 15 to 40% of total GDP and 29% of total energy consumption.[49] In Bangladesh, India, Nepal, Pakistan and Sri Lanka, the iron and steel sector consumes about 30% of total energy in the manufacturing industry, contributing approximately 13% to the manufacturing value added (ie, in income generated for labour and other primary factors).[50]

In Nepal the share of energy consumption in the industrial sector in 2008/9 was 3.3%. Coal is the dominant fuel source in the industrial sector, with 58% consumption followed by 23% electricity. Coal is mainly used in the brick-making industry and in coal-fired boilers.

India's industry and manufacturing sector is energy intensive, with cement, iron and steel, fertilisers, pharmaceuticals, automobiles and household appliances being major sub-sectors. In Bangladesh, textile and garment exports are the largest source of foreign exchange earnings. Shipbuilding and the manufacture of pharmaceuticals and consumer goods are important emerging industries, while the jute sector is re-emerging with increasing global demand for green fibres. Other important export sectors include fish and seafood, ceramics, cement, fertiliser, leather and leather goods, food products, computer software and IT services. Similarly, in Pakistan, textiles, cement, mining, sugar, fertiliser and IT are the main industrial sub-sectors. South Asia is also increasingly becoming an export hub for international firms.

Industrial growth in future will therefore have implications for GHG emissions if the source of energy and energy use is not managed. As electricity makes up 60% of total energy use in the industry and manufacturing sector, replacing fossil fuels with renewable energy is a priority.

Installation of solar panels in Nepal.

5. Energy and climate change mitigation

Effects of climate change in South Asia

South Asia is extremely vulnerable to climate change:

- In the Indo-Gangetic plains of South Asia there could be a decrease of about 50% in the most favourable and high-yielding wheat area due to heat stress if CO_2 concentrations double. Sea level rise will inundate low-lying areas and will especially affect rice-growing regions.[51]
- A systematic review and meta-analysis of data in 52 original publications projected mean changes in yield by the 2050s across South Asia of 16% for maize and 11% for sorghum.[52]
- An Asia-wide study revealed that climate change scenarios would reduce rice yield over a large portion of the continent, with northern South Asia being one of the most vulnerable regions.[53]

It is therefore of crucial importance that the world cooperates in drastically cutting GHG emissions. Otherwise, the region will lose the gains it has made in addressing poverty in the last decade.

As described in the previous chapter, energy is key to development and is also currently the main source of GHG emissions worldwide. Addressing the energy deficit to provide a decent standard of living for all could therefore have a serious impact on GHG emissions and consequently on global warming. Currently, 433 million people in South Asia are without electricity. If they were provided with 100kWh per year (the IEA's recommended threshold for achieving basic MDG-level development) through the current fossil-fuel dominated mix of technologies, this would result in 28 million tonnes of GHG emissions, which is about 2% of current GHG emissions in South Asia. This is not a dramatic increase, but meeting basic household energy needs does not constitute development in any meaningful sense. To provide every citizen with a decent standard of living requires energy for production and industry to provide employment and transport (see Figure 2). Meeting this demand in South Asia, based on a global average of 3,000kWh per person per year, would imply increasing consumption by approximately 2,400kWh per person per year. This would triple South Asia's emissions if there is no move away from fossil fuel-based production of electricity.

Limiting the increase in global mean temperature to less than 2°C imposes a tough constraint on cumulative GHG emissions, including CO_2 emissions, which are the largest single source (76%) of GHG emissions. To have a likely chance – defined as a probability higher than two-thirds – of staying within this limit, the level of cumulative CO_2 emissions from land use, fossil fuels, and industry must be in the range of 550-1,300 billion tonnes (gigatonnes or Gt) by the middle of the 21st century. If one excludes a significant contribution from net negative emissions, the CO_2 budget to 2050 is 825Gt. Staying within this CO_2 budget requires very near-term peaking and a sharp reduction in CO_2 emissions thereafter, especially in energy-related CO_2 emissions. This means that countries would need to converge close to a global average of CO_2 energy emissions per capita of 1.6 tonnes in 2050, which is a sharp decrease compared to today's global average of 5.2 tonnes, especially for developed countries with current emissions per capita much higher than today's global average.

Figure 2. Energy needs ladder

Level 1

Basic human needs

- **Electricity** for lighting, health, education, communication and community services (50–100kWh per person per year)
- **Modern fuels and technologies for cooking and heating** (50–100 kgoe of modern fuel or improved biomass cook stove)

Level 2

Productive uses

- **Electricity, modern fuels and other energy services** to improve productivity, e.g:
  - Agriculture: water pumping for irrigation, fertilizer, mechanized tilling
  - Commercial: agricultural processing, cottage industry
  - Transport: fuel

Level 3

Modern society needs

- **Modern energy services** for many more domestic appliances, increased requirements for cooling and heating (space and water), private transportation (electricity usage is around 2,000kWh per person per year)

In order to meet the dual goals of development and climate change, measures to address the current energy situation in South Asia (explained in more detail later) and the rest of the developing world will have to include an accelerated deployment of renewable energy and low emissions technology. As outlined in later sections, South Asia has significant potential for renewable energy and energy efficiency, as well as the possibility of energy generation from low-carbon fossil fuels.

South Asia has significant potential for renewable energy and energy efficiency, as well as the possibility of energy generation from low-carbon fossil fuels.

Low-carbon energy options

Many analyses have made it clear that staying within a 2°C temperature rise will require deep transformations of energy and production systems, industry, agriculture, land use, and other dimensions of human development. It will require profound changes in the prevailing socio-economic development frameworks. Many of the technologies that will need to underpin these transformations are available, but many others are not ready for large-scale deployment.

Making critical low-carbon technologies commercially available and affordable, enabling countries to pursue long-term transformations, will require long-term international cooperation and trust.

The three key pillars for all countries to achieve deep decarbonisation are energy efficiency and conservation, low-carbon electricity and fuel switching (see below).

The three pillars of decarbonisation

Energy efficiency and conservation

Greatly improved energy efficiency in all energy end-use sectors, including:

- passenger and goods transportation, through improved vehicle technologies, smart urban design and optimised value chains
- residential and commercial buildings, through improved end-use equipment, architectural design, building practices and construction materials
- industry, through improved equipment, production processes, material efficiency and re-use of waste heat.

Low-carbon electricity

Decarbonisation of electricity generation through the replacement of existing fossil-fuel-based generation with renewable energy (eg hydro, wind, solar, and geothermal), nuclear power and/or fossil fuels (coal, gas) with carbon capture and storage.

Fuel switching

Switching end-use energy supplies from highly carbon-intensive fossil fuels in transportation, buildings and industry to lower carbon fuels, including low-carbon electricity, other low-carbon energy carriers synthesised from electricity generation or sustainable biomass or lower-carbon fossil fuels.

Energy efficiency in South Asia

In addition to energy savings, there is great potential for the region's manufacturing sector to achieve benefits in terms of productivity, the environment and other areas through measures to increase energy efficiency, which has been improving in South Asian countries over recent years. Energy intensity[54] is highest for India (0.147 kilograms of oil equivalent – kgoe – per unit GDP in PPP terms) and lowest for Sri Lanka (0.038kgoe). As energy intensity is calculated based on commercial fuels, the low numbers also reflect the high share of non-commercial energy (traditional biomass, etc). The intensity is also a reflection of the structure of industry. On a PPP basis, the energy intensity of South Asian countries is lower than that of the world average (0.188) as well as the US (0.26) and China (0.185).[55]

Countries in the region are focusing on energy efficiency in the industry sector, but because the related benefits are difficult to quantify, these efficiency measures are not perceived as cost-effective, which is reflected in the slow rate of uptake of energy efficiency measures.

Creating energy efficiency directly reduces the amount of energy required. A recent study highlighted that energy saving by using energy-efficient appliances in Indian households alone could result in reducing electricity consumption by 57.32TWh each year. This is equivalent to avoiding building 25,000MW of new power generation capacity.[56]

Renewable potential in South Asia

While the costs of climate change to South Asia are significant, the subcontinent has vast renewable energy resources and the potential to chart a course for sustainable low-carbon growth. Harnessing its renewable potential will bring socio-economic benefits in support of poverty reduction, economic growth and employment, as well as environmental protection.

Hydro

The total economic hydropower potential in South Asia is estimated at 152,580MW, while the total theoretical potential across three countries (Bhutan, India, and Nepal) is about 264,000MW. By 2011, India, Bangladesh and Bhutan had developed 46.7%, 29.7%, and 6.3% of their economic hydropower potentials respectively. Bhutan plans to develop another 10,000MW hydropower by 2020, most of which will be exported to India.[57] In Nepal, despite plans to develop hydropower potential in various five-year plans, the actual installed capacity of 652MW is a mere 1.6% of its economic potential. In Sri Lanka, 70% of the economic hydropower potential has been developed, but about 400MW of economy potential for small hydropower projects remained undeveloped.[58] Pakistan's water resources have rich potential for hydropower generation. It is estimated that 60,000MW of electric power can be generated economically from these resources. So far, however, only 11% of this cheap resource has been developed.

A key concern in the case of large hydro projects is the safeguards required to ensure that such projects do not result in social and environmental costs. The importance of such projects in providing stable and continuous energy is clearly understood, but at the same time such projects often end up not benefiting local communities or increasing access to energy for poor people in rural areas. Micro- and mini-hydro projects should therefore be factored into hydro projects because of their potential to minimise environmental damage while at the same time contributing to affordable access to energy.

Geothermal

Geothermal energy harnesses the underground heat that comes near the Earth's surface at geological faults. While it is a very effective source of energy, it is limited to countries with sufficient geological activity. India's Geological Survey has identified about 340 geothermal hot springs in the country,[59] and the estimated potential for geothermal energy is about 10,000MW (about 5% of current installed electricity capacity).[60]

India plans to set up its first geothermal power plant, of up to 5MW capacity at Puga in Jammu and Kashmir. In Bangladesh, a Dhaka-based private company, Anglo MGH Energy, has initiated a project to set up the country's first geothermal power plant with a capacity to produce 200MW of electricity close to Saland in Thakurgaon district.[61]

Wind

The costs of producing electricity from wind power are reducing rapidly, making it a viable alternative to conventional power for grid electricity. It can also be used off-grid for water pumping and battery charging.

Lack of reliable data is one of the big challenges in making a comprehensive assessment of wind energy potential in South Asia, except for India. Estimated potential in India is 48,561MW, of which about 36.3% had been installed (by June 2012).[62]

Estimated wind power potential in Bangladesh is about 4,614MW, but due to the limited access to grid in identified potential wind sites it is estimated that only 2% (92.3MW) of this potential can be exploited.[63] In Bhutan, further detailed studies are required to assess the wind energy potential with some level of accuracy.[64]

Pakistan has an estimated potential of 122.6 gigawatts (GW) per year but only one wind energy project producing 50MW has been set up in Thatta district, Sindh province.

Most of the potential wind power identified so far in South Asia is onshore but, with its thousands of miles of coastline, the region has significant potential for offshore wind power. For example, Pakistan – with approximately 1,000km of coastline and steady average wind speeds ranging between 5-7 metres per second – has an estimated potential of 122.6GW per year. In India, the government has taken steps towards exploiting offshore wind potential by setting up an energy committee on offshore wind. The Ministry of New and Renewable Energy published a draft national offshore wind policy in 2013 and is establishing an offshore wind authority.[65]

Solar

Most countries in South Asia have good solar power resources. Table 4 below gives the solar radiation in kWh/m²/day (amount of solar energy that strikes a square metre of the earth's surface in a single day) as well as solar-based power potential in South Asia. As can be seen from the table, there is significant potential for solar-based energy in the region, but only a small fraction of this has been tapped. India in particular has a massive opportunity.

Table 4. Solar radiation and power potential in South Asia

Country	Solar radiation (kWh/m²/day)	Potential	Installed
Bhutan[66]	4.0-5.5	58 GW	0.239MW
Bangladesh	3.2-6.1[67]		15MW[68]
India	4.0-7.0[69]	600,000GW[70]	2,600MW
Nepal[71]	3.6-6.2	2,920GWh	64,300 SHS
Pakistan[72]	4.7-6.2	1,600GW[73]	
Sri Lanka	2.0-6.0[74]		1.38MW

Tidal

In India, there is an estimated potential of tidal energy in the order of 8,000MW. The Ministry of New and Renewable Energy has sanctioned a demonstration project for setting up a 3.75MW capacity tidal energy power plant in Sunderbans region, West Bengal.[75]

Biofuels

Although traditional biomass (wood, charcoal and agricultural waste) fuels are still the most commonly used across South Asia, modern biofuel technologies are starting to replace traditional fuels, offering wide potential for power generation and transport. However, diversion of land to biofuels could reduce food production and increase prices, which would undo efforts to address poverty since poor people spend a large share of their income on food. Any efforts to create energy security through developing the potential of biofuels should therefore ensure that they do not compromise food security.

In South Asia, much of the ethanol production comes from India and Pakistan. India has huge biofuels potential and presently produces around 1,550 million litres of biofuels. The main feedstocks are sugarcane molasses and the jatropha tree. Currently, jatropha occupies only around 0.5 million hectares of wastelands across the country, of which 65-70% are new plantations of under three years. The Planning Commission on Development of Biofuels has earmarked an estimated 13.4 million hectares of marginal/wastelands as suited to growing jatropha,[76] but a recent study has shown that farmers do not have any incentive to divert their fertile lands for jatropha cultivation at present.

As Pakistan is an agricultural state and has 28.5 million hectares of available wasteland,[77] there is vast potential to promote bioenergy. Bioethanol production from molasses, a direct by-product of sugar production has grown rapidly. The country is also focusing on non-edible plant seeds as feedstock, using marginal/barren land to avoid adversely affecting food production.[78]

In both countries, the key challenge is increasing the amount of land under sugarcane production and improving the resource intensity of production.

The concept of biofuel is relatively new to Nepal. In its 2008/9 Biofuel Programme, the government focused on the production of jatropha as a biofuel feedstock. The programme has established 20 modern jatropha nurseries through 12 different organisations, and has produced and distributed 1.25 million jatropha saplings to interested farmers and organisations. Two processing plants – each with a capacity of 1,000 litres of biodiesel per day – have also been established through two private organisations.[79] Several private companies have started commercial cultivation of jatropha and have established a jatropha research centre. Biodiesel could replace up to 5% of imported diesel by 2015 in Nepal.[80] But in a country with limited accessible and arable land, large-scale cultivation of jatropha could compete with food production. Although jatropha can be grown on marginal and non-arable land, the yield could be much lower.

6. Initiatives, plans and strategies in South Asia

Both individual countries and the region as a whole have introduced initiatives to address climate change and reduce GHG emissions. In 2008, the South Asian Association for Regional Cooperation (SAARC) adopted its Action Plan on Climate Change. The plan's objectives are to: enhance south-south cooperation to regionally address climate change; use country-level plans to push forward its regional action plan; and to create common understanding of global climate change negotiations. Specifically, the plan covers: cooperation on adaptation; sharing on best practices on addressing mitigation; cooperation over technology sharing and transfer; creating a financing mechanism to support climate change actions; and creating public awareness.

These commitments were further reiterated in 2010 in the Thimphu Statement on Climate Change, in which SAARC agreed to establish an inter-governmental expert group on climate change to develop clear policy direction and guidance for regional cooperation; undertake an assessment of climate risks in the region; commission a study to explore the feasibility of establishing a SAARC mechanism to provide capital for projects that promote low-carbon technology and renewable energy; and establish a low-carbon research and development institute at a South Asian university.

This collective declaration is a reflection of individual national governments recognising climate change as an imminent challenge and committing to work towards addressing GHG emissions. However, although the intent is there, follow up has not been strong.

Country initiatives to address GHG emissions

All countries in the region have taken initiatives to address emissions from the energy sector. Key areas of focus include:

- support for projects aiming to increase efficiency of energy production and transmission, for example, through the rehabilitation of coal-fired power plants
- promotion of alternative technologies, including hydropower and small renewable power installations serving rural populations
- reducing barriers to more efficient energy use in small and medium-sized enterprises, public utilities, and agriculture
- carbon finance for transmission, hydropower, and coal rehabilitation and replacement projects, as well as for other energy projects.

These initiatives range from individual projects to comprehensive frameworks. Efforts in India especially have seen a scale change but, given the country's high volume of emissions, these efforts still need to be scaled up significantly to keep within the global 2˚C goal. The sections below provide more detail about the strategies developed by each country.

India

Internationally, the Indian Government has agreed to reduce the emissions intensity of its GDP by 20-25% from 2005 levels by 2020. Domestically, it has launched the National Action Plan on Climate Change, which includes eight missions to tackle climate change on a sector-by-sector basis. Four of these missions are focused on mitigation.

- **Jawahar Lal Nehru National Solar Mission** (JNNSM) aims to deploy an ambitious 20,000MW of grid-connected solar power by 2022. The JNNSM promotes solar power through the use of a solar-specific renewable purchase obligation, which will make it mandatory for power utilities to supply a specified share of their power from solar power plants. In addition, the JNNSM offers two types of incentives to solar projects: generation-based incentives and a capital subsidy scheme.
- **Tax on mined and imported coal** – this has been doubled from INR50 ($0.83) to INR100 ($1.67) per tonne to fund clean energy. According to the Economic Survey for 2011-12, the government expects to collect INR100bn ($1.61bn) from its Clean Energy Fund by 2015.[81]

- **Renewable purchase obligation** – in 2011, the government amended its tariff policy in line with a State Electricity Regulatory Commission requirement that a fixed percentage of energy purchase comes from renewable sources under its renewable purchase obligations. As part of the strategy to construct a solar grid under the national solar mission, a specific solar component was proposed for power utilities. The solar power purchase obligation for states may go up to 3% by 2022.
- **Feed-in tariff** – the Central Electricity Regulatory Commission has established different tariffs to promote the use of solar, biomass and wind energy.
- **Decentralised renewable-based electricity access** – as part of the National Rural Electrification Policy, the government is promoting decentralised distribution-cum-generation preferably through alternative sources of power, provided these are more cost-effective than grid-integration. As of September 2012, 284 projects based on solar photovoltaic (PV)/ biomass/small hydro, covering 682 villages/habitations and 73,904 households, with a sanctioned cost of INR2.83bn ($45.6m) were under implementation.
- **The National Mission for Enhanced Energy Efficiency** aims to address inefficient energy use and save about 5% of the country's annual energy consumption. It is the key driver for achieving energy efficiency and aims to save about 5% of the country's annual energy consumption. A number of schemes and programmes aim to save fuel in excess of 23 million tonnes of oil equivalent (Mtoe), avoid capacity addition of 19,000MW, and mitigate 98 million tonnes of CO_2 emissions per year by 2014-15.[82]
- **The Market Transformation for Energy Efficiency** initiative envisages aggregating small demand-side management projects under one roof, thereby reducing the transaction costs in obtaining Clean Development Mechanism funds. The focus is on increasing energy efficiency in agriculture, small and medium-sized enterprises, the commercial building sector and distribution transformers, and increasing the use of energy-efficient lamps. It also supports actions to reduce the costs of producing energy-efficient appliances.
- **The Energy Efficiency Financing Platform** is another complementary strategy under the National Mission for Enhanced Energy Efficiency focusing on the creation of mechanisms to help finance demand-side management programmes in all sectors by capturing future energy savings.
- **The Perform, Achieve and Trade Mechanism for Energy Efficiency** penalises or rewards 15 large energy-intensive industries for energy efficiency improvements. Overachievement is rewarded through certificates which can be sold on the market. The first three years of the scheme were expected to see savings of 9.78Mtoe and 26.21 million tonnes of GHG emissions,[83] resulting in an expected avoided capacity addition of 5,623MW.
- **The Standards and Labelling Programme** involves the mandatory energy-efficiency labelling of frost-free refrigerators, tubular fluorescent light bulbs, air conditioners and distribution transformers. Labels for direct cool refrigerators, induction motors, pump sets, ceiling fans, LPG stoves, electric geysers and colour televisions are voluntary.

The National Mission is the key driver for achieving energy efficiency and aims to save about 5% of the country's annual energy consumption.

Bangladesh

The Bangladesh Climate Change Strategy and Action Plan aims to promote climate resilient development and a low-carbon economy. A key focus is adaptation, but one of the six pillars of the strategy is 'mitigation and low-carbon development'. Within the mitigation focus the objectives are: to develop a strategic energy plan and investment portfolio to ensure national energy security and lower greenhouse gas emissions; and to promote efficient production, consumption, distribution and use of energy. Three of its six specific programmes are: improved efficiency in the production and consumption of energy; gas exploration and reservoir management; and renewable energy development.

Specific efforts include:

- Under the Efficient Lighting Initiative of Bangladesh the government has distributed 10.5 million free compact fluorescent lamps (CFLs) to 4.5 million consumers in two phases. Demand reduced by 90.14MW after the first phase of distribution in June 2010 and by 146MW after the second in October of the same year.
- A solar light-emitting diode (LED) street lighting programme in six city corporations, with a total capacity of 10MW.
- The installation of 1,000 solar mini grids in growth centres and cluster villages, with an average capacity of 25kW each, each covering 100-125 households.
- A renewable energy policy to achieve 5% of total power generation from renewable sources by 2015. A government order has been issued to ensure that a portion of electricity in government buildings is from solar photovoltaic. In the second phase this will be extended to private apartment blocks and commercial buildings.
- To make the solar home systems affordable and popular, from 2009-2014 the government exempted commercial producers of renewable energy from income tax.

Pakistan

Pakistan's 2012 National Climate Change Policy focuses on: developing environmentally safe hydropower generation; developing renewable energy resources and technologies such as solar, wind, geothermal and bioenergy; converting waste to energy; and considering the introduction of a carbon tax on the use of environmentally detrimental energy generation from fossil fuels. It also focuses on increasing the efficiency of energy generation through waste heat recovery, coal bed methane capture and combined cycle power generation.

The policy specifically recognises energy efficiency as a key focus area and outlines the following policies in addressing it: enact and enforce energy conservation legislation and audit standards; ensure high-quality management of energy production and supply, including reduction in transmission and distribution losses; improve energy efficiency in building by standardising building and construction codes and legislating/creating incentives for retrofitting; and energy labelling of appliances and equipment.

Pakistan has also made plans to develop wind resources for electricity by incentivising private sector investments through guaranteed Power Purchase Agreements (PPAs). In the medium term the plan is to develop approximately 3,000MW.

Nepal

The main goal of Nepal's 2011 Climate Change Policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low-carbon emissions socio-economic development path, and supporting and collaborating in international agreements related to climate change. Key objectives are to:

- reduce GHG emissions by promoting the use of clean energy, such as hydro-electricity and renewable and alternative energy, and by increasing energy efficiency and encouraging the use of green technology
- adopt a low-carbon development path
- establish a climate change fund from national and international sources to encourage investments in clean energy, particularly a hydropower project.

The government is also developing a low-carbon economic development strategy that supports climate-resilient socio-economic development. The strategy, which was due to be completed in June 2014, encompasses six major sectors: energy, industry, transport, agriculture and forestry, building and waste.

For several years, Nepal has been focusing on decentralised energy solutions. Renewable energy continues to be a high priority as it provides a least-cost solution to remote, sparsely populated areas unviable for grid extension. The government plans to invest $1,076m in renewable energy by 2020, and to increase the share of renewable energy from less than 1% to 10% of the total energy supply and to increase access to electricity from alternative energy sources from 10% to 30% by 2032.[84] The sources of funds envisaged include government revenue, support from development partners, loan financing from financial institutions and private equity. With support from the Netherlands, the World Bank and other international donors the government is also implementing a major biogas programme. By 2009, 93,000 biogas plants had been installed.

Sri Lanka's 2008 National Energy Policy places a strong emphasis on energy security, with reliable, affordable and clean energy available to all citizens at all times.

In Nepal donors have worked for many years in promoting RE with the focus on small and mini hydro, biogass and decentralised solar. Renewable energy development continues to be a high priority programme of government as it provides a least cost solution to remote, sparsely populated areas unviable for grid extension.

Reports of the Task Force for Generating 10,000 MW Hydropower in 10 Years (2011–2020) and 25,000 MW Hydropower in 20 Years (2011–2030): These reports contain a list of hydropower projects at various stages of development, deal with sources of investment funds, identify the barriers to hydropower development and finally suggest measures to overcome these barriers.

The Biogas Support Programme commenced in 1992 with funding from the Government of the Netherlands and technical support from the Netherlands Development Organisation. KfW also co-funded the programme from 1997, over 250,000 biogas plans have been installed to date.

By 2020, the government plans to invest $1,076m in renewable energy, of which $115m will be allocated to mini, micro and pico hydro, $333m for solar home systems and $135m for biogas.[85] The Ministry of Energy is in the process of formulating a 20-year perspective plan for RE technologies. The finalisation and approval of this document will provide more concrete information about government's plan and financial requirements.

Sri Lanka

Sri Lanka's 2008 National Energy Policy places a strong emphasis on energy security, with reliable, affordable and clean energy available to all citizens at all times. Key elements of the policy include: reducing energy losses in the transmission and distribution of electricity; energy labelling and certification of appliances; and energy benchmarking of energy-intensive industrial, transport and domestic sectors. In 2010, this policy was updated to: increase the share in grid energy supply from nonconventional renewable energy sources from 4.1% in 2007 to 8.5% by 2012, 10% by 2016, and 20% by 2020; reduce the total technical and commercial losses of the transmission and distribution network from 14.6% in 2009 to 14% by 2012, 13% by 2016, and 12% by 2020; and achieve energy savings of 4.3% in 2012, 6.4% in 2016, and 8.7% in 2020 from through energy conservation.[86] A scheme to promote the use of CFLs was introduced in 1996 and in 2000 Sri Lanka established labelling for CFLs. Presently 50% of light bulbs used are CFLs. To provide financial support for identified energy efficiency measures, Sri Lanka created an Energy Conservation Fund which was implemented in 2005.

International support

Countries in South Asia have been using the existing support mechanisms under the UNFCCC and its Protocol, such as the Global Environmental Facility (GEF) and the Clean Development Mechanism (CDM), to address their GHG emissions. GEF has financed a number of renewable energy and energy efficiency projects across all sectors, particularly through decentralised systems in rural areas. This support has mainly involved the demonstration of technologies and technical support in establishing an enabling environment (policies/laws/regulations, capacity development, etc). A total of $274m has been disbursed, leveraging investments of over $2bn, with the major share allocated to India.

The CDM has been another major source of support in reducing emissions, especially to private sector initiatives. The mechanism has generally benefited those countries with high emission reduction potential and again India has been one of the major beneficiaries. Tables 5 and 6 (see overleaf) list the CDM projects submitted by countries in South Asia and the registered projects eligible for CDM credits. In the past, the CDM has been a good incentive for private sector participation in the adoption of low-cost options, but the steep decline in the price of carbon has removed these incentives. In its analysis, Point Carbon stated that 'the volume of issued international credits is now exceeding the total demand until 2020' and forecast an oversupply of roughly 400 million international credits in the market.[87] Another concern with the CDM has been that it has followed the flow of investments, therefore countries with low investment potential or low emissions have not benefited from the mechanism.

Table 4. Registered CDM projects in South Asia

	Number	Percentage	Registered	CER (percentage)*
India	2,065	29%	1,510	16%
Pakistan	42	0.6%	33	0.4%
Sri Lanka	28	0.4%	19	0.1%
Nepal	8	0.1%	6	0.05%
Bangladesh	8	0.1%	4	0.1%
Bhutan	6	0.1%	3	0%
South Asia	7,090		6,222	

***CER (certified emission reductions) as percentage of total CERs (1,786,252) issued to South Asian projects until 2012.**

Source: UNEP DTU CDM/JI Pipeline Analysis and Database, cdmpipeline.org

NB: The last column in Table 4 lists the certified emission reductions (CERs) issued until 2012 to each country as a percentage of total CERs issued to projects registered from South Asia. Most of these projects are registered in India and focused on renewable energy and energy efficiency, as is clear from Table 5.

Nepal and India have accessed funds to implement mitigation activities from the World Bank Climate Investment Fund (CIF) and Climate Technology Fund (CTF). India has drafted an investment plan that will tap $775m from the CTF for transformative investments to improve and expand India's hydropower operations, develop untapped solar resources, and improve energy efficiency.[88] CTF financing is expected to leverage nearly $30bn in additional financing, and will focus in particular on catalysing private sector development in the low-carbon sectors. The funding in Nepal is focused on financing hydro projects. This programme is part of a joint effort by the Asian Development Bank Private Sector Operations Department and the International Finance Corporation to scale up investments in small hydropower projects. The programme seeks to contribute to market transformation by building the capacity of local financial institutions and providing appropriate financial products, thereby fostering mobilisation of private financial investment in small hydropower plants while simultaneously increasing demand through end-user knowledge management and support.

At the UNFCCC's 2010 conference in Cancun, parties agreed that developing countries would undertake Nationally Appropriate Mitigation Actions (NAMAs) in the context of sustainable development, supported by finance, technology and capacity building from developed countries. NAMAs are expected to scale up actions in developing countries and help these countries to make a transformational change to low-carbon development. Although the region has been lagging behind in preparing NAMAs, Pakistan has submitted two – one to supply energy-efficient lighting in residential, commercial, industrial and outdoor sectors and one relating to the waste sector.

NAMAs provide an opportunity for countries to translate their intent, as expressed in climate change strategies, into implementation. Developed countries have promised to scale up financing to support adaptation and mitigation actions in developing countries to $100bn by 2020. Further, the Green Climate Fund (GCF), constituted as part of the Cancun Agreement, has finally been adopted into the financing framework to support country actions. Efforts have begun to capitalise the GCF and it is expected to start funding actions by mid-2015.

Table 5. Registered projects in South Asian countries by emission-reduction activity

	Bhutan	Bangladesh	India	Nepal	Pakistan	Sri Lanka
EE industry		5				
EE own generation					9	
EE service				1		
EE supply side		1	4		4	
Fossil fuel switch			50		1	
Fugitive		1	5		1	1
HFCs	5		9			
Hydro			240	3	6	15
Biomass						5
Landfill gas		2	32		3	2
Methane avoidance			44	4	1	1
Mixed renewables						1
N_2O			8		2	
PFCs and SF6			2			
Reforestation			16			
Solar			155		1	
Transport			13			
Wind			923		7	5

EE = energy efficiency; HFCs = hydrofluorocarbons; N_2O = nitrous oxide; PFCs = perfluorocarbons; SF6 = sulphur hexafluoride

Source: UNEP DTU CDM/JI Pipeline Analysis and Database, cdmpipeline.org

7. Barriers to low-carbon transition

Although a number of efforts are being made to tackle climate change in South Asia, there are still huge barriers preventing a transition to low-carbon energy. To date, actions and support have been focused on demonstration or project-scale interventions rather than on programmatic and policy approaches. This has slowly started to change and there is now a strong desire by climate policy makers to scale up mitigation activities in developing countries. However, the current system of public and private investment is still not set up to deliver transformative change. Transformation is a process and requires roadmaps and political analysis to drive the vision for a low-carbon future, to identify critical barriers to mitigation and to predict possible adaptation challenges.

Transformative approaches typically share some key attributes. They are innovative, deliver change at a significant scale, scope and/or pace, and fundamentally change existing policy, and regulatory, market and business models. Institutions also need to learn to shift investments away from traditional partners, towards areas with high leadership, incentives and capacity. As transformation is not an easy task, it will require political leadership, the right incentives for multiple stakeholder groups, and local capacities to foster and sustain change on a local level.

Technological barriers

Countries in South Asia are still developing the technical expertise and facilities required for the successful implementation of appropriate renewable energy projects. There are not enough knowledgeable and capable personnel for the design and establishment, operation and maintenance, and promotion and dissemination of clean technology projects. This is further compounded by inadequate information and awareness programmes for technology dissemination in the relevant economic sectors. For example, in Bangladesh and India, unavailable data and information, lack of proper expertise, and limited government research and development support are cited as the main barriers to clean technology development.[89]

The transfer of technology is critical to the proliferation of renewable energy in South Asia. However, this is not simply a process of transferring technology blueprints from developed countries. Achieving the widespread dissemination of renewable energy technology requires the development of a local manufacturing base and the associated supply chains; systems for maintenance and marketing; a labour force that can build, use, and maintain the technology; and, in many cases, the adaptation of technology to local conditions. Without the capacity to absorb and use transferred knowledge, the returns on technology transfer are likely to be limited. Domestic and international policy interventions must therefore have a central role in building this capacity. Also, much more research, development and demonstration spending is required.

Figure 3 opposite highlights some of the typical technological challenges.

Other technology-related constraints in South Asia include:

- Poor and limited resource supply or availability, in particular the lack of combustion-efficient, high-quality raw materials for the development of dendrothermal (wood-burning) power stations. In Sri Lanka, for example, the development of renewable energy-based systems (eg wind- and wood-fired plants) is hindered by lack of suitable materials.
- Inadequate absorptive capacity of the power system (national grid) to accommodate renewable energy sources.[90] In India, the unavailability of transmission infrastructure and grid integration restricts the development of small hydropower and wind energy projects, especially in remote locations. While governments ought to provide the transmission infrastructure of renewable energy projects, the project developers, in reality, end up having to establish them and incur additional costs. The additional financial burden can discourage prospective developers from pursuing cleaner technology projects.

Financial barriers

As well as being technologically well proven, wind and hydro renewable energy sources have in many instances become commercially viable, while the commercial viability of solar energy technologies is still to be achieved.

Figure 3. Barriers to clean technology development

Barriers to clean technology development

Policy/regulatory

- Lack of micro-level (site specific, temporal) data to define potential resources
- Non-monetised nature of resource options
- Need to mainstream into national and regional planning
- Lack of coordination among concerned ministries/agencies for policy formulation and planning
- Lack of minimum performance standards
- Energy pricing, subsidies and other measures do not support clean technologies
- Fiscal barriers (eg, customs, duty and value added taxes
- Environmental damages not reflected in pricing of conventional options

Technology/service providers

- High project development costs
- Poor or limited (renewable energy) resource supply
- Inadequate absorptive capacity of the national power system to accommodate clean technology
- Limited demand
- Diffuse/diverse markets
- New or unfamiliar contractual mechanisms
- Limited technical, business and risk management skills
- Limited financing or equity
- Need for basic research and development for technology development and dissemination
- Need for international/ regional/subregional cooperation

End users

- Inadequate public education, information and awareness programmes
- Lack of awareness of clean technologies and high discount rates
- High project development and upfront costs
- Lack of financing or proper financing mechanism
- Ability and willingness to pay for incremental cost
- Low benefits/returns relative to costs
- Perceived risks of the new technology/system
- Mixed incentives
- Behavioural biases
- Lack of credible data

Financiers

- New technologies and contractual mechanisms
- Small sizes/widely dispersed, leading to high transaction costs
- Perceived high risks for non-traditional projects
- Other higher-return, low-risk projects are more attractive
- Behavioural biases
- Minimal private sector investment
- Investors' lack of confidence in the technologies
- Need for alternative and diversified sources of financing

Source: Adapted from World Energy Council, Renewable Energy in South Asia – Status and Prospects, 2011, and A Sarkar, J Singh, Financing energy efficiency in developing countries – lessons learned and remaining challenges, Energy Policy, 2010, 38, pp 5560–71.

Some renewable energy technologies are at an early development stage and their risks are not yet clear or fully understood. The large-scale commercialisation of some clean technologies is also hampered by the lack of minimum standards for performance, durability, reliability, and related parameters, as well as by the need for high initial capital investment.[91] In India, for example, the expected performance of solar thermal technology – yet to be developed in the country – has not been ascertained. The high initial costs of establishing solar photovoltaics and thermal manufacturing plants restrict the wider adoption of solar energy-based clean technologies.

There is also a general lack of financing and absence of proper financing mechanisms for clean technology development in South Asia. In addition, the mainstream financial institutions in the region have limited understanding of and expertise in renewable energy and energy efficiency projects and are not yet prepared to finance them. Such factors are detrimental to potential financing for individual loans to purchase or install clean energy devices, or to making investments in clean energy programmes and projects.

In Sri Lanka, for example, the lack of a consumer finance scheme is a major constraint to continued growth of solar home systems. The present loan schemes of local banks and other financial institutions in the country do not accommodate small-scale renewable energy projects, unless these are integrated with an income-generating activity (such as a rural industry), and/or providing fuel for domestic energy applications. These requirements came about from the banks' past experiences of poor loan recovery in rural areas.[92] Renewable resource-based electricity generation projects are also confronted by loan interest rates higher than those for conventional power plants and high transaction costs due to high costs of resource assessment, project planning, design and approval, and financing and power-purchase contract negotiations. In projects to promote mini and small hydropower, the omission of long-term financing to contractors to match the long payback periods of mini and village hydro projects were impediments to the development of small (< 10MW) grid-connected power projects.[93]

In Bhutan, mobilising financing is a major challenge to developing a $12bn-15bn 10,000MW hydropower programme, which is intended to generate power for export to India. Although bilateral loans from the Government of India finance the projects under the programme, several joint ventures between the Druk Green Power Corporation and Indian public sector entities require commercial financing to supplement the official bilateral financing.[94] In particular, Bhutan needs support in pursuing grid-connected renewable energy projects, including small hydropower projects below 25MW, developing follow-up public-private partnership transactions at the Dagachhu hydropower project, and increasing the focus on the environmental sustainability of large hydropower development.

In Nepal, private sector investment in renewable energy is very low because of perceived high risks and investors' lack of confidence in the technologies. To date, no commercial bank provides loans to promote renewable energy technology in the country, and available external/international donor funds are limited.[95]

In recent years, governments in South Asia have set up institutions for financing cleaner energy technologies. Examples include the Indian Renewable Energy Development Agency (IREDA), Nepal's Alternative Energy Promotion Centre (AEPC), and the Infrastructure Development Company Limited (IDCOL) in Bangladesh. These institutions play important roles in the clean energy market, but have limited funding capacity. As many clean energy projects tend to depend on uncertain or delayed national budgets, alternative and diversified sources of potential funding should be identified and developed.

One option could have been private financing. However, critical financing gaps limit private investments in clean technology. In comparison with options in other sectors, investment in early-stage clean technology innovation is hindered by longer investment periods before exit, more capital-intensive development that requires large follow-on financing, smaller investment sizes coupled with similar due diligence costs and management fees, and higher execution risks than later-stage financing. Even after commercialisation, lack of access to risk capital, project scale, and gaps in business skills remain significant barriers to investment for the widespread deployment of clean technologies.[96]

Lack of support from developed countries

While countries in the region clearly see the need to progress much faster to low-carbon green growth, they are also faced with other priorities. Budgetary allocations are largely directed at the social sector, from which spending should not be diverted. Enhancing and accelerating the transition towards lower carbon pathways would require large investments and developed countries need to play a key role in providing the additional finance.

The additional investment needs for renewable energy (compared to baseline investments in fossil fuel-based infrastructure to meet energy demand) are significant, though necessary to prevent lock-in to current high-carbon technologies. In the case of India, estimates indicate that the additional investment needs for the power sector alone are of the order of $13 trillion for 2011-2051.[97] The allocation of Official Development Assistance and loans from bilateral financial agreements for investing in the exploration and deployment of renewable energy is perceived to be an important priority.

The need for private finance

It is estimated that Asia will require over $6 trillion for new energy infrastructure by 2030.[98] Private sector financing makes up the bulk of funding for low-carbon development at the global level. Some of the difficulties in pursuing low-carbon development and technological advancement in South Asia include high upfront capital costs, the limited availability of long-term financing, regulatory uncertainty, and technological risks. For example, commercial banks financing clean energy projects in developing countries have relatively high transaction costs and lending premiums, and demand additional security and/or collateral requirements from project sponsors.

The above factors discourage private sector investment because they impose additional costs. In the absence of an efficient financial market, new approaches to low-carbon development financing such as sharing risks and costs based on performance and other similar incentive schemes are necessary to mitigate risks and to speed up

In India, most states have no defined zoning policy to guide and regulate the appropriate physical location of biomass projects. It has been reported that plants have been set up so close to each other that they were negatively affecting the availability of fuels, and eventually rendering the projects unviable.

investment. It is therefore important to accelerate capacity development activities to create an enabling policy and regulatory environment to attract private investment. At the same time, there is an urgent need to deploy innovative financing mechanisms.

Policy and regulatory barriers

Policy and regulatory barriers to clean technology development exist in various forms in South Asia. For example, direct and indirect subsidies to fossil fuels create the false impression that renewable energy-based power is much more expensive than conventional power.[99] In India, power tariffs are underpriced and subsidised, especially in rural areas and some industrial areas.[100] In Nepal, the national electricity utility has incurred a huge deficit due to the government-regulated low retail tariff, which acts as a disincentive to independent power producers. The government is also directly and indirectly subsidising the import of fossil fuels, which has encouraged the increased use of imported fuels. In addition, existing policy on hydroelectricity is aimed at larger projects which impede the development of smaller micro-hydro systems that benefit small, poor communities.[101]

Customs duty and value added tax (VAT) are additional barriers to the development of clean technologies. For example, in Nepal the government charged the electric car company REVA more than 240% customs duty when it first came to the country in 2000. While it subsequently modified the policy, electric vehicles still face 40% customs duty and 13% VAT.[102] In Bangladesh, the high import duty and VAT on all raw materials relating to solar energy (except solar panels) increase the cost of local manufacturing of solar accessories, and therefore also of solar home systems.[103]

In terms of regulatory barriers, several countries lack legal provisions requiring utilities to provide network access to renewable energy projects. Transmission or distribution access is necessary for direct third-party sales between renewable energy producers and the final consumers, especially when the renewable energy resources are located far from population centres. In the absence of regulation, utilities may not allow favourable transmission access to renewable energy producers and/or may charge high prices for transmission access.

In Bangladesh, a second form of regulatory barrier is the lack of standardised power purchase agreements for power generation from renewable energy technologies.[104] In addition, the government approval process for renewable energy projects tends to be lengthy and difficult, with various ministries, agencies and institutions involved.

In Sri Lanka, the lack of standardised agreements between the small power project developers and the Ceylon Electricity Board (CEB), a state-owned power utility, has hindered the growth of small power producers. The successful development of the Standardized Power Purchase Agreement and a non-negotiable Standardized Power Purchase Tariff with the CEB were crucial for private sector small power producers to enter the market.[105]

In India, most states have no defined zoning policy to guide and regulate the appropriate physical location of biomass projects. It has been reported that plants have been set up so close to each other that they were negatively affecting the availability of fuels, and eventually rendering the projects unviable.[106]

Another issue is that the roles and responsibilities of ministries and agencies at national and state levels are not clearly delineated, leading to a lack of coordination among institutions working in the same area. In India, for example, the Ministry of New and Renewable Energy is promoting microgrids in remote and rural areas through various schemes and incentives. These will eventually need to be connected to the national grid, which will require the Ministry of Power to resolve grid-capacity issues. Prior consultation is therefore necessary – but not always carried out – before the launch of such schemes. There needs to be an integrated approach to addressing these sector-specific issues rather than ad hoc measures based on the mandates of the respective ministries.[107]

Regulation and good governance is also vital to creating a competitive environment between private sector players. Such competition is necessary to drive forward research and development of renewable energy technologies, and improved energy efficiency measures. Primarily, electricity and modern energy services must be affordable for poor communities. They must be maintained and increased through effective government regulation that ensures cost savings from energy efficiency and that costs are shared equitably between suppliers and consumers. Reforms must also encourage the decentralised production and supply of power. Grid services are not always effective solutions, and minigrids servicing communities from renewable energy sources may be an alternative, particularly in sparsely populated or geographically hard-to-reach areas, where the costs of providing traditional grid infrastructure are prohibitively high.

Universal access to energy is more likely to be achieved if strong regulatory measures are implemented effectively, otherwise they are unnecessarily delayed. Unfortunately, lack of capacity among regulators, ill-defined social and environmental standards, and lack of awareness among non-energy specialists as to the role energy can play across sectors are still preventing the supply and affordability of reliable energy services to poor people.

Lack of knowledge sharing and intra-regional cooperation and trade

In South Asia, existing intraregional energy trade is limited to a trade in petroleum products between India and Bangladesh, Bhutan, Nepal and Sri Lanka, and in electricity between India and Bhutan, and India and Nepal. The petroleum trade is based on India importing and refining crude oil and exporting petroleum products to the other countries. India also exports diesel fuel to Bangladesh. The electricity traded is based on indigenous hydropower resources. India and Nepal have an active agreement to exchange power up to 50MW. Due to lack of transmission capacity, however, it has not been possible to increase this power trade significantly. With the targeted completion of a new transmission line by 2015, Nepal has agreed to purchase 150MW of power from India.[108]

Despite the abundance of clean resources in some South Asian countries, development and utilisation of these resources is low. For instance, only 28% (about 43,078MW) of the region's estimated 152,580MW total economic hydropower potential have been installed (ADB, 2013). Nepal, Bhutan, and India have so far installed and exploited only 1.5%, 5%, and 46% of their respective total economic hydropower potentials.[109, 110]

Much greater sharing of knowledge and experience is required across the region. Platforms are needed to share learning and experiences across developed and developing countries. Developing countries share many similarities in terms of the requirements, challenges and possible solutions to providing sustainable energy. Knowledge sharing with regard to the adoption and adaptation of new technologies, as well as new ways of handling difficult reform processes and minimising mitigation costs, could bring about rapid scale-ups of successful models across the region.

8. Phasing out coal – long-term benefits outweigh costs

Addressing dependence on coal and moving towards renewable energy-based systems is imperative for cleaner development and to address climate change. This is especially true in the case of India, which – although its per capita emissions are low – is a major contributor to the region's emissions.

However, despite the urgency of climate change, huge investments are still being channelled into fossil fuels, including coal. According to IEA estimates for global energy development up to 2035, if current global policy and investment commitments on climate and energy are carried out (this is termed the IEA New Policies Scenario), fossil fuel consumption and carbon emissions will continue to grow. The estimates show that cumulative investment in coal mining over this period will amount to $735bn, with a further $300bn in transportation infrastructure (mainly railways). This excludes the investment that would be required to convert coal to electricity.

In line with this, growth projections by the governments of Bangladesh, India, Pakistan and Sri Lanka reveal a continuing, and in some cases increasing, dependence on coal to meet energy needs. A low-carbon inclusive growth study in India indicates that 60% of electricity is still produced from coal-powered plants.[111] Indeed, an Asian Development Bank (ADB) analysis shows that South Asia is projected to become more fossil fuel dependent.

As energy security and each country's balance of payments is a key issue, coal – which is a domestic resource in most South Asian countries – is seen as an essential part of the mix. Since there are limited resources of gas and oil in the region, a shift to these would increase import dependency and have a negative impact on balance of payments. Thus, the share of coal in the energy mix of the region is estimated to increase from 2% in 2005 to 27.6% by 2030, mainly due to the high and growing coal dependence of Bangladesh and Pakistan.[112]

Investments made in coal today will last for 25-30 years, but if the world is to limit the rise in temperature to below 2°C, coal-based electricity will have to be a very small part of the energy supply mix in 2050. This presents a real challenge to countries in South Asia in the short to medium term as some renewable energy sources are not yet mature enough to completely replace fossil fuel-based energy[113] and most of the infrastructure still has to be created.

While existing renewable energy sources could provide enough energy to meet the minimum energy requirements of people who are energy poor, these constitute only a small fraction of total energy demand. Most of the increase in demand is from industry and other commercial activities that require continuous and reliable power. While it makes sense to increase investments in renewable energy sources, the technical difficulty and cost involved in phasing out coal and shifting to 100% renewable energy will require international cooperation and greater support from developed countries.

Renewable energy potential

As has been seen in previous chapters, South Asia has significant renewable energy resources, especially solar. A rapid deployment of solar-based decentralised systems would enable the quick roll-out of energy to meet the basic needs of rural poor people, especially those living in remote areas and where the extension of grid-based electricity is costly. Such systems could include electricity for irrigation purposes in rural areas as well as solar roof panel programmes in urban areas.

In terms of hydropower, some South Asian countries have significant potential. Dams can be multipurpose, and used to regulate water flow and manage floods and irrigation, as well as to generate energy. However, drought and fluctuating rainfall mean that hydro can be unreliable as a main source of energy. States such as Kenya and Ghana that currently rely heavily on large hydro plants have experienced significant power shortages in drought years.

Given the long gestation periods of fossil fuels and the significant environmental costs attached to them, and given the decreasing prices of renewable energy, coal would not appear to be the best long-term solution to meeting energy demand. The World Institute of Sustainable Energy

(WISE) makes the case against locking investments in coal, especially when these investments will have to be undone in the near future.[114] It estimates, for example, that solar power may achieve grid parity in terms of cost by 2017. Others estimate that this will happen as early as 2015.

Decentralised renewable energy is key to the rapid eradication of poverty in South Asia. It enables jobs to be created and provides opportunities for productive activities in rural areas, where most poor people live. The WISE report identifies a number of benefits from green transformation compared to coal, especially those of decentralised solar power (see box).

Benefits of renewable energy sources

Renewable energy projects:

- do not permanently destroy land, even though they require the same amount of land
- generally have low displacement and rehabilitation impacts
- use less water than coal-powered plants
- help improve air quality
- in India, can generate up to 1.6 million jobs by 2020 and 25 million jobs by 2050.
- could lead to significant reductions in investments in infrastructure currently needed to extract/import and transport coal.

The immediate to medium-term strategy must be to minimise the creation of fossil fuel-based energy infrastructure and include the following elements:

- Energy efficiency efforts should be accelerated across all sectors, especially in the residential and commercial sector, as this helps the use of renewable energy to be more cost effective.
- Renewable energy, eg from biomass fuels and biodiesel, should be accelerated as it is a good replacement for fossil fuels in terms of continuous availability and reliability. Sustainable biodiesel also helps reduce fossil fuel dependence in the transport sector. A key challenge in this strategy, however, is to ensure that efforts to increase biodiesel do not adversely affect food security.
- Regional cooperation to maximise the use of environmentally safe medium and large hydro projects will enable reduced dependence on fossil fuel-based electricity.
- Renewable energy sources such as solar and wind should be used to gain the maximum technically possible to feed into the grid without destabilising it.

Solar street lights installed on a busy road in Lahore, Pakistan.

9. Benefits and costs of low-carbon development

Access for all by 2030

As discussed in previous chapters, for countries in South Asia the shift to low-carbon energy has to be integrally linked to providing sustainable and affordable energy to people who are poor and energy poor. However, although tackling energy poverty will not make a significant impact on GHG emissions, it is likely to require substantial resources, especially if it is based on clean and renewable energy sources.

An MDG Energy Vision (developed as part of the Millennium Development Project) provides a schematic view of the energy required to meet the MDGs by 2015:[115]

- 100% of the world's urban and 50% of its rural populations use modern liquid and gaseous fuels for cooking
- 50% of the world's rural population use improved biomass stoves
- 100% of the biomass used for cooking is produced in a sustainable way
- 100% of the world's urban populations have a basic electricity supply to meet lighting and communication needs
- 100% of the world's health facilities and schools have an electricity supply and use modern liquid and gaseous fuels to meet cooking and heating needs
- 100% of all communities have access to mechanised power.

In 2011, the UN initiative on Sustainable Energy for All (SE4ALL) adopted 'universal access to modern energy services (including electricity and clean, modern cooking solutions)' by 2030 as one of its goals. A new set of Sustainable Development Goals (SDGs) are also being developed for the post-2015 period. These include a specific goal on 'access to affordable, reliable, sustainable, and modern energy for all'. The SDGs further extend the MDGs to move beyond addressing basic needs.

In its most recent report, the IEA estimates that delivering Energy for All by 2030 would require $48bn a year. Although the study does not present analysis for South Asia, the investment required for providing 100% electrification to everyone in India alone would be $135bn during the period 2010-2030, with another $107bn needed for the rest of developing Asia.[116, 117] In terms of access to clean cooking facilities, under the SE4ALL scenario, an additional investment of $74bn is required. Of this, $25bn would be required between 2010 and 2030 to achieve universal access to clean cooking facilities in developing Asia.

The IEA is clear that 70% of rural areas are best provided with energy either through mini-grids (65% of this share) or through small, stand-alone off-grid solutions (the remaining 35%). Countries where a high proportion of people in rural areas lack access to electricity are particularly dependent on mini-grids and isolated off-grid solutions.

Investment costs

According to IEA estimates, the total amount of investment required globally to avoid dangerous climate change is more than $1 trillion per annum. Half of this amount could be redirected from business-as-usual investment in conventional technologies to low-carbon alternatives. World Bank estimates suggest that around $400bn of additional investment per annum will be required for mitigation initiatives in developing countries.

In terms of the costs to reduce energy intensity through energy efficiency improvements, the UNDP estimates that on average an additional $30bn-35bn of capital is required for low-income countries – which are mostly in sub-Saharan Africa – and $140bn-170bn for middle-income countries per year until 2030, over and above investments required under the IEA's New Policy Scenario.[118]

There are few estimates available on the cost of investment needs for low-carbon development in South Asia. A recent study by the Government of India highlighted that an additional $834bn was needed over the period 2010-2030 to reduce its emission intensity in relation to its GDP by 42% over 2007 levels.[119] This would require an increase in the installed wind and solar power capacities of 118GW and 110GW respectively. Despite this significant renewable energy capacity, in this scenario 60% of electricity in India will continue to be produced from coal-powered plants in 2030. The scenario assumes that growth in energy demand comes from the residential and commercial sectors, which have grown rapidly due to both increasing population and income levels. Lighting and appliances in households (such as refrigerators, air conditioners, water heaters, fans, etc) account for 10%, while residential and commercial sectors together account for 29% of total electricity consumption. Other significant demand for electricity comes from industry, to meet the growth required to tackle poverty. The study assumes an 8% annual growth rate over the period. An estimate of finance needs to support India's eight climate missions (mentioned in Chapter 6) has been estimated at $84.65bn over the period 2010-2020.[120]

The Asian Development Bank's 2013 study[121] estimated that even a 9% reduction in emissions below a business-as-usual scenario for South Asian countries, excluding India, would cost $1.4bn at constant 2005 prices during 2005-2030. Although these costs appear low, they need to be seen in the context of limited budgetary resources and the many competing demands to meet the basic needs of a vast population.

Although the costs of low-carbon investments are not low, the positive news is that globally investments in renewable energy have continued to be significant. Total investment in renewable power and fuels (excluding large hydro-electric projects) was $214bn worldwide in 2013. This is lower than the previous year, but in part reflects a sharp fall in the price of solar systems. The greatly reduced cost of solar PV systems meant that a record amount of PV capacity (some 39GW) was constructed in 2013, and for less money than the 2012 total of 31GW.

In 2013, cost reductions and improvements in efficiency enabled onshore wind and PV projects to be built in a growing number of locations around the world without subsidy support. Wind and PV may be able to out-compete fossil-fuel options as long as there are plentiful local sun or wind resources, low capital costs, and no cheap, indigenous coal or gas stocks. Renewable energy, excluding that produced by large hydropower projects, made up 43.6% of the new power capacity added in all technologies in 2013, and raised its share of total generation worldwide to 8.5% from 7.8%[122]. Global energy-related CO_2 emissions would have been some 1.2 billion tonnes higher if delivered by fossil fuels.

10. Leapfrogging to a green future

The adoption of low-carbon growth and human development strategies will put enormous demands on developing countries' resources, capacities and skills. It will require aligning investment and spending decisions with financing sources, and short-term growth promotion with long-term strategic decisions regarding sector development and technology choices, including within the energy, transport and agriculture sectors. Such choices, in turn, will need to be aligned with broader development policies, including those aimed at improving education and health, stimulating job creation, enhancing skills in the labour market, strengthening productivity growth, and ensuring food security and universal access to drinking water and basic sanitation.

Policy makers will have to carefully weigh the adaptability of the technological options available to them for scaling up alternative sources of renewable energy generation, and assess the effectiveness of the policy instruments that provide incentives for the use of renewable energy and greater energy efficiency, while at the same time finding ways to provide affordable access to clean energy for poor communities. As analysed in depth in the World Economic and Social Surveys of 2009 and 2011,[123] low-carbon growth and human development strategies will require sizeable upfront investments. Making such investments while trying to fulfil other development objectives may create macroeconomic trade-offs, as it will put pressure on government budgets, external balances and debt sustainability. It may also create economic and social repercussions as price levels, wages, and employment change. These multiple and complex effects will need to be carefully assessed to ensure virtuous sustainable development outcomes. Policy coherence is thus of fundamental importance in the transition to low-carbon growth and human development pathways.

A number of developing countries have adopted or are in the process of adopting measures to reduce emissions. Potential benefits, costs, and economy-wide trade-offs need to be considered to inform both the design and evaluation of measures aimed at low-carbon growth and human development. However, there are gaps in countries' capacity to formulate policies and establish legal and regulatory frameworks to smooth the transition to a low-carbon economy. There are also gaps in the capacity of countries to acquire the necessary skills and expertise that will enable them to build and take advantage of integrated energy and economic modelling for policy formulation.

Policy makers will have to carefully weigh up the technology options available for scaling up alternative sources of renewable energy and energy efficiency, while at the same time funding ways to provide affordable access to clean energy for poor communities.

South Asia, although at a low level of development and facing a huge development deficit, contributes, primarily due to large emissions from India, around 7% of global GHG emissions. Anticipated growth to meet the development deficit, especially to eradicate poverty and provide modern energy services to those who are energy poor, will significantly increase emissions. Policy makers will therefore have to carefully weigh the adaptability of the technological options available for scaling up alternative sources of renewable energy generation, and assess the effectiveness of policy instruments that provide incentives for the use of renewable energy and greater energy efficiency, while at the same time finding ways to provide affordable access to clean energy for poor communities.

Policy frameworks and incentives

Governments need to set stringent and credible clean energy targets and goals. With the new global climate agreement to be agreed in Paris in December 2015, countries will have to make their own pledges to deliver carbon reductions at a national level. Policies underpinning these targets must be transparent and predictable in order to address and alleviate the financial risks associated with new technologies. Strong policies and markets that encourage flexibility and mitigate risks for investors in these technologies are vital. Ensuring that the true price of energy – including costs and benefits – is reflected in what consumers pay must be a top priority for achieving a low-carbon future at the lowest possible cost. Putting a meaningful price on carbon would send a vital price signal to consumers and technology developers. Phasing out fossil fuel subsidies – which in 2011 were almost seven times higher than support for renewable energy – is critical to level the playing field across all fuels and technologies.[124] Temporary transitional economic incentives can help to create markets, attract investments and trigger deployment. They will be even more effective if combined with other measures to overcome non-economic barriers, such as access to networks, the granting of permits, and social acceptance issues. Promoting social acceptance of new infrastructure development should be a priority.

Promoting a national dialogue and launching a process for public consultation on the long-term goal of decarbonisation is important to ensure buy-in of all stakeholders. This should involve representatives of rural and poor communities, business, civil society, and various expert communities (eg engineers, geologists, climatologists, economists and social scientists) to debate the best options for decarbonisation, identify bottlenecks, and propose new approaches.

Each country in the region can benefit from a government-led, multi-pronged clean energy programme aimed at improving access to energy, especially for poor communities; increasing energy efficiency; and scaling up the use of renewable energy sources. It is important that these programmes are integrated into national development efforts and reflected in long-term energy policies and development planning processes. These in turn should be supported by various policy options that may include, among others: strategic development planning and management of energy and energy-related sectors; appropriate market and structural reforms, including clean energy pricing and subsidy policies; mechanisms for transboundary or regional energy cooperation and trade; and favourable financial support and innovative financing mechanisms for clean energy technologies.

A transition to low-carbon energy will require political will from within countries and practical measures to lay a foundation to accept such a transformation. India has to continue playing a leading role in South Asia by phasing out coal and moving away from fossil fuel-based growth.

Carbon-efficient technologies

Achieving ambitious deep cuts in emissions and accelerating green growth will require the development and diffusion of carbon-efficient technologies – not only in niche markets but across all sectors. South Asia has good reason to implement ideas from scratch as many of its factories, infrastructures and buildings are yet to be constructed, and the market potential for the deployment of innovative technological systems is high. However, the wrong policy choices can lead to a misguided preference – for instance by subsidising the use of inefficient technologies or by postponing action to later years in the hope that new technologies will be freely transferred – which would lock South Asia into a high-carbon future. To foster the development and deployment of currently available technologies, the green innovation machine must be turned on.

A key focus in the immediate future should be on energy efficiency, which has the co-benefits of reducing emissions, diverting investment away from traditional to sustainable energy options, and providing communities with economic opportunities. Quick gains are possible through the development and use of energy-efficient home appliances, electric cooking stoves in residential and commercial sectors, and energy-efficient electric engines. Other technological approaches that bring immediate development gains and are relatively cheap to install are roof-top solar panels in urban areas and energy-efficient irrigation pumps in rural areas.

Given the availability of biomass and the possibility of biofuels in the region, countries should also focus on investments in biomass and biofuel-based energy, especially since investments in these two areas have significant development benefits by creating jobs and income in rural areas.

Finance and investments

The urgent need to address GHG emissions and climate change concerns in South Asia requires significant new investment in the development and deployment of clean energy technologies. Sources of financing for clean energy technology may include mainstream financing institutions (ie, commercial banks), government institutions established for the promotion of such technologies, NGOs and private organisations, and international financial mechanisms. In most South Asian countries, however, mainstream financing institutions are not prepared to support renewable energy projects or provide loans to purchase cleaner technology devices. For example, the cost of high interest financing adds 25% to the cost of solar power in India.[125] Some innovative mechanisms and policies are needed to reduce the risks perceived by mainstream lending institutions in cleaner technology investments and to enhance their capacity to finance low-carbon technologies and resource options.

Some examples of public agencies in South Asia that can provide financing for renewable energy projects are the Indian Renewable Energy Development Agency, Nepal's Alternative Energy Promotion Centre, and Bangladesh's Infrastructure Development Company Limited. However, they have limited resources and depend either on donor agencies or government for funds. In some cases, NGOs play an active role in promoting clean energy technologies using innovative financing and other schemes. Bilateral funding sources, private financing, and other international climate funds and funding mechanisms are also available for larger-scale clean energy development in developing countries, including South Asia.

As the public sector alone will not be able to cope with the volume of investments required, the private sector will be crucial in bringing about transformational change. Since the private sector will seek to maximise profits, one of the main tasks will be to alter the risk-reward profiles of renewable energy so as to move investment in renewable energy from a corporate social responsibility niche, and into main stream investment. Not only banks, but also local investors and a wide range of equity and debt investors have to be brought on board in order to successfully finance transformative approaches, such as through the GET FiT programme.[126]

Developed countries therefore need to deliver sufficient financing to developing countries through a dedicated window under the Green Climate Fund, with democratic and equitable governance.

The Climate Investment Readiness Index from the International Bank for Reconstruction and Development and the World Bank is an effective tool for evaluating a country's climate investment situation and the reform necessary to enable greater investment in clean energy technologies.[127]

Regional cooperation

Regional cooperation in knowledge sharing, energy development and trade provides a major opportunity for South Asian countries to achieve energy security through the large-scale development of clean energy resources. Successful cooperation in pursuing sound energy policies can be found across the world, particularly in sharing electricity generation through cross-border transmission interconnections. In Europe, electricity system interconnection has resulted in a 7-10% reduction in generation capacity costs. Similar cooperation within the Greater Mekong subregion in Southeast Asia has been estimated to potentially reduce energy costs by nearly 20%, with a saving of $200bn during 2005-2025.[128]

Areas in which regional cooperation could be strengthened to overcome the problems faced by clean energy technology development in South Asia include:

- sharing of human resources and technological know-how
- technology training programmes
- sharing of environmental monitoring and information (especially relating to renewable energy resources
- sharing renewable energy resources (trade)
- a regional renewable fund.[129]

International support

An international, science-based, and equitable climate change agreement is needed along the lines agreed in the Durban Platform for Enhanced Action (ADP)[130] of the UNFCCC. A fast transformation change to phase out coal and fossil fuels would require substantial financial and technical support to South Asian countries. Countries in the region lack sufficient resources to invest in the social sectors necessary for equitable growth. Further, South Asia is highly vulnerable to climate change and will need to re-direct some of its already stressed financial resources to undertake adaptation measures. Thus without adequate financial support it would be difficult to accelerate the transformation process. Availability of technologies is also key to creating an affordable energy infrastructure.

Developed countries therefore need to deliver sufficient financing to developing countries through a dedicated window under the Green Climate Fund, with democratic and equitable governance. This will enable South Asian and other developing countries to pursue energy access and sustainable development through a clean development model and leapfrog to a green future.

Recommendations

- **Global climate deal:** Governments need to set credible and stringent clean energy targets and goals, within a fair and ambitious global climate deal.
- **Regional technology sharing and innovation:** Achieving ambitious deep cuts in emissions and accelerating green growth will require the development and diffusion of carbon-efficient technologies. Regional cooperation in knowledge sharing, energy development and trade will be essential.
- **Incentivise private sector investment:** Innovative finance mechanisms and policies are needed to reduce the risks perceived by mainstream lending institutions in cleaner technology investments and to enhance their capacity to finance low-carbon technologies and resource options.
- **Shift subsidies from fossil fuels to energy access:** Fossil fuel subsidies should be phased out. Instead support should be given to deliver to deliver sustainable energy access for all.
- **International finance:** A 'leapfrog fund' should be established from global mitigation finance to support South Asia in moving towards a low-carbon economy. The Green Climate Fund, established by the United Nations Framework Convention on Climate Change should include a dedicated window for this purpose.

In Bangladesh, the use of LPG for cooking has been encouraged to reduce the dependence on imported oil.

Annex:
Country case studies
Bangladesh

Bangladesh, the third biggest economy in South Asia, has a population of approximately 152.5 million people,[131] and is among the most densely populated countries in the world. Annual GDP growth has averaged 6.5% in recent years and per capita income was $700.[132] Agriculture contributes less than 20% of GDP, but employs 47% of the working population, and a large portion of the broader service sector remains dependent on agricultural outputs. Remittance inflows are a large source of income, amounting to more than 10% of GDP. In 2010, 31.5% of the population was living in poverty, with 17.6% in extreme poverty.[133]

Current energy situation

Presently, 62% of the total population has access to electricity (including off-grid renewable energy). Biomass supply/demand accounts for 68% of primary energy consumption, and over 90% of household energy needs, and 84% of households depend on fuel wood for cooking.[134] The primary energy sources are gas and coal. Domestic natural gas accounted for 68% of Bangladesh's commercial energy consumption in 2010; imported oil and coal accounted for another 26% and local hydropower for 5.4%. Coal consumption was mainly limited to power generation and brick kilns. Gas production capacity is expected to increase to about 2,353 million standard cubic feet per day by December 2015. Bangladesh imports about 1.3 million metric tons of crude oil annually to meet commercial energy demand. In addition, about another 2.7 million metric tons of refined petroleum products is imported per annum. Coal reserves are approximately 3.3 billion tons.

Power generation accounted for about half the commercial energy consumption. Table 1 gives sources of electricity generation. The major consumer of liquid fuel is the transport sector, followed by agriculture, industry and commercial sector; most liquid fuel is imported.

Table 1. Sources of electricity generation in Bangladesh and globally (2010)

Energy	Bangladesh	Global
Gas	87.5%	18%
Oil	6%	10%
Coal	3.7%	37%
Hydro	2.7%	17%
Nuclear	0%	17%
Renewable	0.5%	1%

Renewable potential

Renewable energy (RE) sources include biomass (combustible renewable and waste), hydropower, solar, wind, ocean, and geothermal energy. Solar energy, for both small and large-scale electricity generation, has good prospects in Bangladesh. Bangladesh receives an average daily solar radiation of 4-6.5kWh/m^2. Solar photovoltaic (PV) is gaining acceptance – about 264,000 households use solar energy.

The abundance of biomass makes it a potential source for biodiesel. The most common forms of available biomass are rice husk, crop residue, wood, jute stick and sugarcane bagasse.

Biogas is another promising renewable energy resource. There are about 50,000 household and village biogas plants throughout the country.

Micro hydro and mini hydro have limited potential in Bangladesh, with the exception of Chittagong Hill Tracts. Hydropower assessments have identified some possible sites which could supply 10kW to 5MW.

Table 2. Potentials of different types of renewable energy resource

Resources	Potential	Entities involved
Solar	Enormous	Public and private sector
Wind	Resource mapping required	Public sector/public-private partnership
Hydro	Limited potential for micro or mini	Mainly public entities
Domestic biogas system	8.6m^3	Public and private sector
Rice husk-based biomass	300MW considering 2kg of husk	Mainly private sector
Cattle waste-based biogas	350MW considering 0.752m^3	Mainly private sector

Source: www.powerdivision.gov.bd

Table 3. IDCOL's target of power generation from renewable energy sources

	Average unit capacity	Target	Total capacity
Solar home system	50W	3 million	150MW
Biogas plant for cooking gas	2.6m^3	100,000	40MW
Solar mini grid	50kW	10	1MW
Solar irrigation pump	8kW	750	6MW
Biogas-based power plant	20kW	300	6MW
Biomass-based power plant	200kW	15	3MW
Total			206MW

Wind energy has a limited potential mostly in coastal areas. Other renewable energy sources include bio-fuels, gasohol, geothermal, river current, wave and tidal energy. The potential of these resources is yet to be explored.

Low carbon plan

The government has taken a number of initiatives from three distinct approaches towards universal energy access – energy efficiency, renewable energy and energy conservation. In 2008, a renewable energy policy was adopted by the government. This envisions 5% of total generation from renewable sources by 2015 and 10% by 2020. The government has also laid emphasis on sector-wide measures to create public awareness and wider promotion of energy efficiency and conservation practices.

The government plans to establish the Sustainable and Renewable Energy Development Authority as a focal point for the promotion and development of sustainable energy as part of an attempt to establish an institutional mechanism to implement the renewable energy policy and the draft rules.

The Bangladesh government has also adopted a Bangladesh Climate Change Strategy and Action Plan (BCCSAP); mitigation and low-carbon development is one of the key pillars. The implementation of BCCSAP is supported by a multi-donor trust fund, Bangladesh Climate Change Resilience Fund. Infrastructure Development Company Limited (IDCOL) targets for RE are given in Table 3. The government has a target to generate more than 200MW power from diverse renewable energy sources through IDCOL. The government has recently initiated a 500MW solar power programme with the support of Asian Development Bank.

The Efficient Lighting Initiatives of Bangladesh (ELIB) project aims to replace approximately 30 million household incandescent lamps, with CFLs. Conservative estimates show that the project saved nearly 146MW of power during its first phase.

Access to finance is a key challenge. To address this, Bangladesh Bank opened a new department to promote green financing and corporate social responsibility activities. The green refinancing scheme for a new renewable energy and industrial effluent treatment plant is in the process of being transferred to the new department. Lenders to environmentally friendly projects (such as solar home systems, solar mini grid, solar powered irrigation, solar panel assembly, biofuel, effluent treatment, replacement of polluting brick baking kilns with energy efficient ones, organic compost, pico, micro and mini scale hydropower, PET bottle recycling, solar battery recycling, and LED bulb manufacturing) can access refinancing support if and when needed from Bangladesh Bank.

Leapfrogging potential

Bangladesh remains energy poor, especially the rural community, and addressing this is key to addressing poverty. The financing and financing models to provide access to sustainable, modern and affordable energy are an important element for leapfrogging to green energy future. Communal use, including use of energy in education and health services is not explored enough, and neither is the energy use in rural livelihoods, including irrigation, cold storage, rice husking, saw mills and flour mills. Support for poor and isolated poor communities living in off-grid areas is essential, which promotes a move to modern energy forms using isolated stand-alone mini, micro or nano grids, targeting mainly isolated poor households, and educational, health institutions and agricultural activities, including irrigation.

Energy efficiency and renewable energy are central to leapfrogging in Bangladesh. A large untapped potential for energy efficiency exists – transportation, agriculture (irrigation), brick kiln and industry are dependent on high carbon fuel and inefficient technologies. In terms of diversification of energy sources, introducing new technology such as power generation from municipal waste can be considered for large-scale government investment in urban areas.

The challenge with RE is inadequate investment in identification of potential renewable resources for grid and off-grid areas, appropriate energy cost assessment to develop commercially viable sustainable models, assessment of economic cost benefit to replace diesel or other high carbon fuel based systems by RE, especially in cases more likely to be used by rural communities. Access to capital for private companies to implement RE has to be addressed. Low carbon development linked to energy access is usually expensive, and when considering subsidised conventional energy, it becomes even more expensive. So, along with leapfrog funds additional subsidy or cross subsidy will be needed for longer periods of time to promote RE or efficient technology especially in grid areas.

Sustaining the change would require funding and creating institutional mechanisms and enhancing policy capacity. Training in green technology and industries can help position countries to take advantage of any new low-carbon growth opportunities and markets. Technology progression and diffusion requires support. Research support should be available for technology development, product development, innovative distribution and business model development.

Low carbon examples		
Efficient Lighting Initiative of Bangladesh	**IDCOL solar energy programme**	**Solar irrigation pumps**
The Efficient Lighting Initiative of Bangladesh (ELIB) was launched in 2010 by the government as a demand-side management measure. **Project objectives** • Replace incandescent bulbs with compact fluorescent lamps (CFLs) • Create long term availability of low-cost, high-quality CFLs.	**Project objective** Scale up renewable energy to improve off-grid electricity supply in rural areas through solar home systems (SHS) for affordable lighting. **Project detail** IDCOL has devised a credit scheme for marketing solar home system units and making these an affordable alternative to grid electricity for poor people in remote areas.	To address irrigation need and reduce dependence on petroleum, the government explored alternative solutions like solar irrigation pumps. **Project objective** To install 1,300 solar-powered irrigation pumps covering over 65,000 bighas (1 bigha ~ 33 decimals).

Continued on page 44

Continued

Low carbon examples		
Efficient Lighting Initiative of Bangladesh	**IDCOL solar energy programme**	**Solar irrigation pumps**
Project detail ELIB aimed to deploy 27.5 million CFLs among residential consumers in cities. The programme included procuring better quality CFLs, supporting a systematic distribution system, conducting a comprehensive consumer awareness scheme, and monitoring and evaluation. The CFLs were distributed by Rural Electricity Corporation and other utility agencies in their respective service territories. IDCOL acted as the coordinating entity (bundling agent) for the associated CDM transaction. **Development benefit and impact** • Savings of 146MW of power. • Increase in manufacturers from 9 to 19 with a production capacity of over 30.64 million bulbs. • Creation of demand among urban consumers. • Opportunities and risks • Lack of quality control could affect the sustainability of demand. • Safe disposal of CFLs is important to address mercury content. A national guideline is being developed. **Types of investment needed** In 2009, $15m was spent to implement the first phase of ELIB. The financial internal rate of return and economic internal rate of return of the programme were calculated to be 44% and 52% respectively.	**Project detail** IDCOL manages the funds to support the programme. Besides financial support, it provides technical support to develop the capacity of partner organisations. Equipment used was according to approved specifications. **Opportunities and risks** The negative environmental impacts of this project can stem from improper disposal and recycling of lead acid batteries. Upfront investment costs are too high for the targeted consumers. **Development benefits and impact** By 2013, more than 2.5 million SHS has been installed throughout the country. Educational attainment, women's empowerment and quality of life have increased among SHS households. Boys and girls from such households have a higher school completion rates than those who do not have access to lighting. Women's mobility has increased. Households began using electric fans, television sets, refrigerators, cassette players, irons and mobile phone chargers. Rural electrification increases household income by 21% and expenditure by 11%. Users of SHS use 66% less kerosene per month than households without SHS. There are more than 30 SHS component suppliers from 20 countries and seven local manufacturers of batteries, charge controllers and inverters.	**Project detail** The project is implemented by IDCOL through NGOs, microfinance institutions or private entities, who have the experience and capacity to implement the programme. IDCOL provides necessary technical, financial and promotional support. IDCOL assesses the proposals submitted by partner organisations, approves them based on strict guidelines and disburses grants and soft loans. **Opportunities and risks** Farmers at present rely on 266,000 electric water pumps which consume around 1,300MW and 1.3 million diesel-run pumps, using up to 900,000 tons of fuel. The grant per pump is quite high to make it viable. Thus finding ways of reducing price is important. **Types of investment needed** The total grant provided for the project is $10m, with a total commitment of $24.5m in grant financing; 50% of financing is in grants, 30% as concessional finance and 20% as equity by implementers.

India

Current energy situation

India is a country of great energy hunger and deprivation – 32.7% of Indian households do not have access to electricity. Furthermore, many of the households that do have access to electricity are often supplied electricity for a very short period of time and thus continue to rely upon kerosene for lighting their homes. In addition, only around 30% of Indian households have access to modern, clean sources of energy for cooking such as LPG or electricity. The majority rely upon traditional and inefficient sources of energy such as firewood, crop residues or cow dung for cooking. Income poverty is highly correlated with, and even exceeded by, energy poverty. Thus, especially in rural areas, energy poverty persists even in those households whose incomes are above the poverty line.

Due to these factors, India's energy use per capita is only 613.72 kilotonnes of oil equivalent (ktoe), well below the world average, far behind advanced OECD economies, and closer to countries in sub-Saharan Africa such as Angola, Zambia and Côte d'Ivoire. Moreover, service delivery of various social services is compromised due to the paucity of electricity. Thus, for example, only 35.7% government-run primary health centres, and only 47.11% of government-run schools are electrified.

In terms of supplies of energy, coal and lignite, both imported and domestically extracted, provide 40% or 3,335.48 terawatt hours (TWh) of India's total energy requirements. Almost a third (31.57%) of energy requirements are met by petroleum and gas, of which almost two-thirds (63.45%) needs to be imported to supplement inadequate domestic production. Non-commercial or traditional biomass sources provide almost a quarter (2,025.94TWh) of the country's energy requirement. Biomass is traditionally used for cooking and heating. According to the 2011 census, 67.23% of households still cook using firewood, crop residues, cow dung or coal/coal dust (in areas near coal mines).

India's fossil fuel resources, with the possible exception of coal, are fairly limited. Thus, India has a high level of dependence on imports that form almost a quarter (27.69%) of its energy supplies. Dependence in the case of petroleum and natural gas is especially high, with almost two-thirds (63.45%) of the supply imported. Oil is the single biggest import into India, accounting for 34.6% of all imports, causing a huge drain on foreign reserves and making the Indian economy vulnerable to price shocks when oil prices become volatile. Of late, India has been forced to import coal to feed the growing number of its thermal power plants.

Renewable potential

The current share of renewables in the primary energy supply is only around 1%. However, the government is beginning to accept that renewable energy could supply up to 3,700TWh/year by 2047, from the extremely low 61.05TWh/year under the minimum emissions scenario. The official estimates for renewable energy, primarily electricity generation, are shown in Table 1.

Thus, much of the renewable energy potential in India is as yet unrealised even when considering the government's official, conservative estimates. There are, however, other estimates that are much more optimistic.

Table 1. Official estimates of renewable energy

Resource	Estimated potential (GW)	Installed capacity (GW)
Wind	102.8	19.1
Small hydro	19.7	3.6
Biopower	22.5	3.6
Solar power (billion GWh)	6	1.7

For example, a recent report produced jointly by The Energy and Resources Institute and World Wide Fund for Nature-India estimates that by utilising 1% of India's landmass, and adopting solar PV technology alone, there is a potential to generate 1,460GW of electricity, equivalent to around 379TWh/year. This means that by aggressively deploying solar PV technology alone, India could theoretically meet around 10% of its targeted renewable energy supply under the minimum emissions scenario in 2050, by using only 1% of its land mass. This further implies that by using 10% of its landmass, India could theoretically meet its projected renewable energy supplies under the minimum emissions scenario by 2047 by using only one of the many technologies available for deployment immediately, without considering wind and biomass, as well as concentrating solar power. The key point here is that while official estimates of renewable energy potential in India are perhaps overly conservative, even with the existing state of technological maturity of renewable energy, the potential for renewable energy deployment and utilisation is much higher than recognised.

Low carbon plan

In 2009, the government voluntarily committed to reducing its carbon intensity (CO_2 emissions per unit of GDP) by 20 to 25% below 2005 level by 2020. To achieve these goals, the government has the following targets for the deployment of renewables and energy efficiency:

- The Jawaharlal Nehru National Solar Mission (JNNSM) has a target of deploying 20,000MW of grid-connected solar power by 2022. It aims to reduce the cost of solar power generation through long-term policy; large-scale deployment goals; aggressive R&D; and domestic production of critical raw materials, components and products. As a result, JNNSM hopes to achieve grid tariff parity of solar power by 2022.
- The National Mission on Enhanced Energy Efficiency seeks to achieve 23Mtoe of fuel savings, GHG emission savings of 98.96 million tonnes and avoid capacity addition of 19,958MW.
- In continuation of its efforts to address climate change, the newly elected government announced the following measures to promote low carbon energy resources and options in its recent budget:
- Approximately $83.33m provided for Ultra Mega Solar Power Projects in Rajasthan, Gujarat, Tamil Nadu, Andhra Pradesh and Ladakh.
- Approximately $66.66m provided for a scheme for solar powered agricultural pump sets and water pumping stations.
- Approximately $16.66m provided for the development of 1MW solar parks on the banks of canals.
- A green energy corridor project is being implemented to facilitate evacuation of renewable energy across the country.

The short-term barriers of accelerated deployment of renewable energy need to be overcome. In this regard, India's domestic efforts need to be scaled up through meaningful deployment of finance as well as an enabling policy framework.

Leapfrogging potential

While the official outlook for deployment of renewables is not overly bullish, there are projections that India could shake off its dependence on fossil fuels, particularly coal and petroleum and meet a bulk of its energy requirements from renewable energy. Thus, it has been projected that by 2051, solar, wind and biofuels could meet around 84% of India's primary energy needs. If India continues with business as usual, however, around 90% of India's primary energy supplies will be provided by coal, oil and natural gas in 2051. Clearly, the business as usual scenario is frightening both from the perspective of India's longer term energy security, as well as from the perspective of sustainability and the imperative to ensure that the rise of temperatures remains below 2°C by 2050.

The short-term barriers of accelerated deployment of renewable energy need to be overcome. In this regard, India's domestic efforts need to be scaled up through meaningful deployment of finance as well as an enabling policy framework. However, there is also a case for meaningful and substantial international transfers of finance and technology to India. India and the international community can and must work together to achieve effective cooperation on facilitating a green future leapfrog for the country to enable the fulfilment of both domestic and international sustainable development goals.

Low carbon examples

Village-based solar micro grid in Indira Nagar, Rajasthan

An initiative by Minda NexGenTech Ltd led to the setting up of a solar power-based micro grid in the village of Indira Nagar. Prior to installation of the solar plant, kerosene lamps were used for lighting. Activities such as cooking, washing, sewing, and fertilizer mixing were not possible after sunset. However, the 240W solar power plant installed by Minda NextGenTech Ltd provides basic lighting to all the village's houses. The arrival of power has also sparked an entrepreneurial spirit among women. Evening hours are now spent under energy-efficient LED bulbs grinding pulses and sewing to supplement family incomes. Access to energy has increased the hours children can spend studying, facilitated women's education initiatives and brought about a social revolution in the village.

The solar power plant is based on the BOM (built, operate, and maintain) working model, with each household contributing INR150 ($2.50) as the monthly charge for usage, along with an initial connection charge. This has resulted in a minimal financial impact on the villagers, as they had paid about the same amount each month for three litres of kerosene and charging mobile phones.

Objective of the activities initiated through the solar power plant were:

- Basic lighting and mobile phone charging
- Generation of additional income and better standard of living
- Removal of kerosene lamps
- Better health, safety and education.

Pulse grinding
Women from 12 households are using extra productive hours during the evening to grind pulses. Each woman collects 5kg of pulses from the distribution centre every second day.

Lalpur's tryst with biogas

Lalpur is a remote village in Jharkhand's Madhupur district. The main source of income is agriculture, and the villagers depended upon kerosene and firewood to meet their energy needs. The negative health impacts of smoke emitted from burning kerosene and firewood for cooking was severely affecting the health of local women. In addition, firewood collection was a very time-consuming activity since the women had to travel long distances on foot.

The village consists of about 52 houses with approximately 89 cows, 75 bulls, 4 buffaloes, 110 goats and 76 sheep. About 4kg of dung is collected from each cow, bull and buffalo each day, so the village gets about 670-700kg of dung daily. The average number of people per household is six, and each household cooks and consume 1.5kg of rice, 1kg of vegetables and 200g of pulses per meal.

To ensure that all the households in Lalpur get access to quality biogas for meeting their heating and cooking requirements, it has been estimated that a biogas plant measuring 35m^3, capable of supplying 1,500 cubic feet of gas per day, would be required. An assessment of cooking and heating requirements showed that the average consumption of gas would be approximately 30 cubic feet per family per day for cooking three meals.

However, a community biogas plant would be fairly labour intensive and would also require a regular and sustained supply chain process to be put in place to ensure that the plant is run round the clock.

Therefore, in order to acclimatise people in operating a biogas plant, it was decided to install two small pilot plants, which would supply gas to four households. The idea was to

The Perform, Achieve and Trade scheme and its implementation

The National Action Plan on Climate Change has eight missions, which include the National Mission on Enhanced Energy Efficiency (NMEEE). This has the objective of enhancing energy efficiency in the country. One of the initiatives under NMEEE is the development of a market-based mechanism to drive delivery of additional energy savings cost-effectively.

Following on from this, the Ministry of Power designed the Perform, Achieve and Trade (PAT) scheme for mandatory trading in energy saving certificates for energy intensive industries.

Eight intensive industrial sectors (thermal electric power generation, fertilisers, iron and steel, cement, pulp and paper, aluminium, chloralkali and textiles) were identified for the initial implementation of the PAT scheme.

The scheme became operational in 2010, after parliament approved the Energy Conservation (Amendment) Bill 2010, and was finally notified on 30 March 2012, covering 478 industrial plants. The categories of industrial plants covered under the scheme included thermal power plants (144), large iron and steel (67 plants), and cement (85 plants).

The scheme will eventually lead to total energy savings of 9.78Mtoe by 478 designated consumers or heavy industrial energy consuming units.

The scheme was, until recently, identifying baselines as well as designing monitoring, reviewing and reporting protocols. The scheme is now into its first implementation phase where energy efficiency targets have been allocated for the various industrial units. It is one of the most ambitious initiatives of the government on energy efficiency,

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Low carbon examples		
Village-based solar micro grid in Indira Nagar, Rajasthan	**Lalpur's tryst with biogas**	**The Perform, Achieve and Trade scheme and its implementation**
Sewing centre The sewing centre involves girls from Indira Nagar who are aged 10-18 years. A local representative conducts regular training sessions, enabling them to learn a new trade and generate additional income to support their families. **Education centre** During the evenings, women are learning to read and write under energy-efficient LED lamps powered by the solar plant. **Enabling village-level entrepreneurs** Minda NexGenTech Ltd has adopted an approach to combine energy access in rural areas with sustainable rural development. It is envisaged that village-level entrepreneurs will invest and operate micro grids to provide basic lighting facilities to rural households for a monthly rental. **Conclusion** The use of solar power along with the various initiatives and innovations has provided numerous opportunities to the villagers to use the available natural resources for their benefit. The overall impact has been an opportunity to build the future of the villagers, and to provide not only light, but sustainable, all round rural development.	use this as a training pilot, and to put systems in place before a community biogas plant is built in the village. The two pilot plants that were installed require a total of 40kg of dung and 40 litres of water every day (20kg of dung and 20 litres of water per plant) and supplies close to 60 cubic feet of gas, which is sufficient to meet the cooking and heating requirements of about 20 people, covering four households. A system to ensure daily collection of dung has been put in place, with responsibilities assigned in rotation to designated family members from the four beneficiary households. A system of monthly cleaning operation has also been put in place. The pilot plants have now been in operation for nearly two years and in that time the plant was inoperative only for about four days, due to a pipe leak, which required the replacement of the pipe and some coupling accessories. Furthermore, the two plants also release slurry of 20kg (dried weight), which is used in an organic farm that the local community organisation has set up as a pilot in Lalpur.	as well as one of the first market-based mechanisms devised in the developing world for emissions reductions.

Nepal

Nepal is a landlocked country with an area of 147,181 km^2 and population of 26.49 million. Rich in biodiversity, Nepal has three distinct geographical regions, tropical south, temperate mid-hills and alpine northern Himalayan range extending from east to west. About 83% of people live in rural areas. The agriculture sector contributes more than a third of GDP, remittance 23% (the main source of household cash income for many), and tourism is the third major contributor. Nepal's per capita income in 2012 was $700 and 25.2% of people were living below the poverty line (less than $1 per day) in 2010.

Current energy situation

Traditional biomass is the main source of energy in Nepal, mostly consumed in the residential sector where fuel wood is the dominant energy source used for cooking. Traditional sources consist of fuel wood, agriculture residue and animal dung cakes. Commercial sources consists of petroleum products, coal and grid electricity. New renewable sources consist of biogas, solar, wind and off-grid micro and mini hydro. The second largest energy consumption is petroleum products, largely used in the transport sector.

Based on the Energy Synopsis Report (WECS, 2010), the total energy consumption in 2008/9 was 400,506TJ, of which energy consumption from traditional sources was 87% (348,869TJ), commercial sources 12% (48,902TJ) and new renewable 1% (2,734TJ). Table 1 gives trends of energy consumption by fuel type. The annual average increase in total energy consumption is 2.46%. This shows the annual average increase of traditional energy consumption is 2.4%, commercial energy 1.6%, new and renewable energy 15.6%.

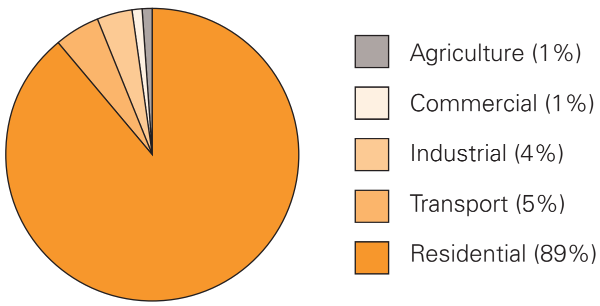
Figure 1 gives the energy consumption by sector. About 96% of residential energy consumption is from traditional energy sources, mainly fuel wood (87%), with only 3% from modern energy sources. Coal is the main source of energy in the industrial sector. Petroleum fuels are the primary source of energy for the transport sector and diesel is main source for agriculture.

Table 1. Trends in energy consumption by fuel type

Fuel type	2000/1	2008/9
Traditional	86.71%	87.10%
Commercial	12.92%	12.21%
Renewable	0.36%	0.68%

Source: WECS, 2010

Figure 1. Energy consumption by sector



Source: WECS, 2010

Total electricity supply in 2012/13 was 719.6MW while the annual estimated peak demand was 1,094.6MW Hydropower contributed 607MW, 102.5MW was imported from India and 10MW was from thermal generation. Capacity of the captive generating sets by industries for their own use in Nepal in 2010 is about 600MW. Main consumers of electricity are the residential sector (43.4%);

industrial sector (38.2%); commercial sector (6.9%); agriculture (2.1%); transport sector (0.2%) and others (9.1%).

Nepal has a high level of energy dependence. It imports all of its petroleum products, spending significant share of its foreign exchange earnings. In 2011/12, the expenditure on petroleum imports increased to 126% of export earnings (NPC, 2013). Nepal faces a massive shortfall in electricity supply which has affected the entire economy despite an increase in capacity.

Renewable potential

Hydropower holds the highest potential for use of renewable energy, with an economic potential of 42,000MW. Small hydro also has significant potential in Nepal. A combined 18.1MW of micro hydro projects (including improved water mill electrification projects) have been installed. The target is to support installation of additional 25MW to electrify 150,000 households by 2017.

Biogas is another major source of energy. Based on its domestic cattle population, Nepal has technical potential in the range of 1.3 million-1.9 million biogas plants. The economic potential is estimated to be 600,000 plants. There are 290,510 household biogas plants in Nepal as at 2012.

Nepal has 300 days of sunshine in about 70% of land area, with average solar radiation in the range of 3.6-6.2kWh/m^2/day (NPC, 2013). The Solar and Wind Energy Resource Assessment in Nepal shows commercial potential of 2,100 MW grid-connected solar power. There is a huge potential for solar thermal devices such as water heaters, dryers and cookers. Solar water heaters have been commercialised for decades and there are more than 185,000 installations in the country.

A study by WECS, Department of Hydrology and Meteorology and AEPC in 1999-2002 showed that wind energy potential in Nepal is limited to a few places in high mountainous regions like Thakmarpha, Khumbu and Kanjiroba, which have little infrastructure development. AEPC's most recent study in 2008 showed a potential 3,000MW of commercial wind power.

Low carbon plan

Nepal is a signatory to United Nations Framework Convention on Climate Change. Nepal's global GHG contribution is 0.025%, one of lowest in the world. However, Nepal ranks as the fourth most vulnerable country affected by climate change according to the Climate Change Vulnerability Index.

The government formed a task force in 2009 with a vision of generating 25,000MW of electricity over 20 years, of which hydro power would be about 18,034MW. Some of the mitigation measures taken after the Rio 2012 climate conference are:

- High priority given to renewable energy technologies to reduce poverty in rural areas through establishing AEPC.
- Energy efficiency measures introduced in industrial boilers and lighting.
- Control in vehicular emissions by introducing a mandatory requirement for vehicles to comply with EURO-I standard.
- Incentives for electric vehicles, via customs and VAT subsidies.

A climate change policy was prepared and approved by the government in January 2011. The main goal of the Climate Change Policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low carbon emissions socio-economic development path and supporting and collaborating in the spirits of country's commitments to national and international agreements related to climate change.

AEPC is the lead organisation for the preparation of the low carbon economic development strategy (LCEDS) which began in July 2012. The first phase was completed in October 2013. The main activity in the first phase is data collection and analysis. The LCEDS is expected to complete in June 2014. LCEDS encompasses six major sectors – energy, industry, transport, agriculture, forestry, building and waste. Representatives from six ministries, the National Planning Commission and technical experts are engaged in the formulation process with an intensive stakeholder consultation. Not much information is currently available as the study is in progress.

Leapfrogging potential

The biggest challenge for Nepal is to provide modern energy access to the residential sector. It has an abundance of biogas (as well as extensive experience in use of biogas), solar, and micro and mini hydro to the meet majority of its energy needs.

Nepal's hydropower resource potential far exceeds domestic electricity consumption demand for many decades to come. The priority for the government's 25,000MW hydropower development vision is to meet domestic demand and then export surplus generation to India. Construction of transmission line infrastructure for cross-border power trading is also being planned. This is a win-win situation for Nepal and India as well as for climate change. The challenge is to ensure that large hydro projects meet all the social and environmental safeguards.

Hydro electricity could also be the source of energy for the transportation sector, which is heavily dependent on imported on petroleum products. The other possibility is biodiesel.

The key challenge in leapfrogging to green future is availability of finance. Huge capital outlay is required for investment in medium and large hydropower projects. Foreign direct investment, bilateral agreements, credit from multilateral agencies and other financing institutions in mutually favourable terms are pre-requisite for increasing investment in hydropower as Nepal's own investment capacity is inadequate.

Fossil fuel is subsidised. A policy to gradually reduce subsidy and bring prices up to the real cost is required in favour of policy to promote electric vehicle and mass electric transport systems. Technical capacity building is required for the introduction of electric transport systems.

There is no rationalised energy pricing due to the lack of an independent regulatory body in the energy sector. The energy sector falls under the purview of number of ministries, causing delays in the policy and regulatory reform process, not to mention delays in administrative processes for project implementation.

Low carbon examples		
Biogas partnership programme	**Community electricity programme**	**Grid-connected hydropower by independent power producers**
Biogas Support Partnership Nepal (BSP-N) promotes biogas, clean energy produced from animal waste. Biogas drastically reduces firewood consumption in households, which saves many hours spent collecting wood by women and children. Biogas replaces traditional cook stoves which are a health hazard due to the smoke. The slurry, a by-product of biogas, is used as manure for agriculture. On average, 7.4 tons of GHG emission is reduced per household per year. The most commonly used size of biogas plant is 4m^3, sufficient for a family of five. There are over 100 pre-qualified installation companies in Nepal who supply and install biogas. There are 17 biogas appliance manufacturing workshop, 264 micro finance organisations which received loans from AEPC's Biogas Credit Fund to provide loans to farmers for purchase biogas plants. BSP-N is the first Clean Development Mechanism project in Nepal. The revenue from carbon finance partly supports the operation of Biogas Support Partnership Programme in Nepal. Biogas sector provides direct and indirect employment to 9,000 people.	Nepal has a great potential for micro hydropower projects which are more cost effective for electrification of remote and scattered communities in the mountains. Projects up to 5kW are called pico hydro and those up to 100kW are micro hydro. There were 1,480 pico hydro plants with a combined generation capacity of 3.18MW and 999 micro hydro plants (total generation capacity 18.65MW) installed in Nepal as at July 2011 under the community electrification programme. The turbine is locally manufactured and controller locally assembled. Pico hydro is used for lighting about 10 to 40 households, depending on the size of the system. They are owned by a group of individuals. They can be built easily within a period of few months. They cost about $2,500-3500/kW. AEPC provides a subsidy of about $1,400-1,700/kW (*Himalayan Time*, 2 April 2014). Micro hydropower plants generally operate agro-processing mills during the day and provide lighting at night. Other applications include powering computers, TVs, health clinics, saw mills, handmade paper making, bakeries, photo studios, photocopying, printing presses and metal workshops.	The government is encouraging the private sector to invest in hydropower through incentives like feed-in tariffs. In 2005, Sanima Hydropower Pvt. Ltd developed Sunkoshi Hydropower Project as a commercial venture. It is a run-of-river grid connect project. The project has two turgo turbine units of 1,250kW each, imported from China. The project provided employment to local people, and built the engineering design and construction capability of local engineers. As a model of a commercially successful venture, it has attracted other private sector developers to invest in small hydropower projects. There are 24 projects below 5MW with a combined capacity of about 58.7MW built by independent power producers in operation, 15 projects with a combined capacity of 45.6MW are under construction, over 44 projects with combined capacity of 93MW have signed PPA with NEA (NEA, 2013). Besides these, there are numerous projects in this range with generation licences for construction. These numbers reflect that the private sector sees investment in small hydropower as a good opportunity.

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Low carbon examples		
Biogas partnership programme	**Community electricity programme**	**Grid-connected hydropower by independent power producers**
As at July 2011, 258,642 household biogas plants had been installed in Nepal (AEPC, 2011). The technical potential of biogas in Nepal is estimated to be over 1.3 million plants and the economic potential to be 0.6 million. More than 25,000 household biogas plants are installed each year in Nepal. A $4m^3$ biogas plant costs about $400-500, about half of which is subsidised by AEPC. By July 2011, 111 institutional biogas plants had been installed. Institutional biogas plants are $10m^3$ or higher. Support is required for scaling up of institutional biogas.	In most cases, they are owned by a community or cooperative in a village. The investment needed is in the range $3,000-5,000/kW. AEPC provides a subsidy of $2,000-2,650/kW. Some of the risks in pico and micro hydro plant are reduction in generation capacity during the dry season due to low flows, lack of safety both to the plant and people from lightning during the monsoon and lack of technical skills for operation and maintenance. When the grid reaches a village with micro hydropower, the micro hydro plant ceases operation, making the investment redundant. Technical and institutional support is needed for grid connection of micro hydro power plants when the grid reaches them. This will ensure long-term sustainability of micro hydropower projects.	There are technical, social and financial risks associated with investment in small hydropower for independent power producers. Technical risks include low flow due to changes in flow regime, unexpected ground conditions during construction and financial risk due to cost escalation in the market prices of construction material, while social risk arises from local communities' over expectation. The capital investment required to develop small hydropower projects is $2,000-2,500/kW. Technical assistance for quality feasibility studies and design is required to minimise the risk at the early stage of project preparation. The assistance could be on a cost-sharing basis, and the cost could be recouped from the revenue generated from operating the projects. Establishment of a line of credit for a long-term soft loan and expansion of transmission line network are other supports required in this sector.

Pakistan

Pakistan is the second largest economy in South Asia. The population is 179.72 million people, about two-thirds of whom reside in rural areas. Though agriculture only contributes 24% of total GDP, it employs half the workforce and is the largest source of foreign exchange earnings. The estimated per capita GDP is around $2,891. Pakistan is facing an acute energy crisis which has immense implications for its struggling economy as well as its volatile security situation.

Current energy situation

The primary energy mix (commercial resources) of the country is dominated by oil and gas with their collective contribution of 81%. The contribution of non-commercial energy resources in total energy mix is substantial especially in the rural areas of the country. Traditional fuels like firewood, dung and crop residues currently contribute a major share in meeting the everyday energy requirements of rural and low-income urban households in Pakistan.

Total primary energy consumption in Pakistan in 2012 was 66,015ktoe, with 68.5% indigenously produced and 31.5% imported. The primary energy supplies were consumed in three ways – 32.5% was used in transformation (gas processing plants, petroleum refineries and electric power stations); 62% was consumed by different sectors; and 5.5% was consumed by non-energy uses. Figure 1 gives the share of various energy sources in primary energy supply.

Table 1. Cooking fuel used in Pakistan

Cooking fuel	Urban areas (%)	Rural areas (%)
Wood	19.55	68.71
Oil/natural gas	77.84	7.41
Electricity	0.05	0.07
Other*	2.56	23.81

Source: Bhutto et al, 2011

*Other consists of dung cake and any other material used as fuel for cooking other than electricity, gas, oil, wood and charcoal.

Industry and transport are the biggest consumers of energy supplies in Pakistan (Figure 1). Natural gas is heavily consumed for power production, while industry, fertilizer and household are also sizable consumers of natural gas. Its use in the transport sector is also growing. Petroleum products are mainly consumed in the transport and power sectors, which jointly have almost 90% share of the total consumption. Though Pakistan has huge coal resources, estimated at over 186 billion tonnes, this source is not yet tapped and is of low quality, so coal is imported. During 2012, about 58% of total coal was consumed by cement while 41% was consumed by the brick kiln industry, and now it is beginning to be used in the power sector.

In Pakistan, 96.6% of rural households face an energy shortfall. The rural population uses a variety of energy, including firewood, plant waste, kerosene oil and animal waste.

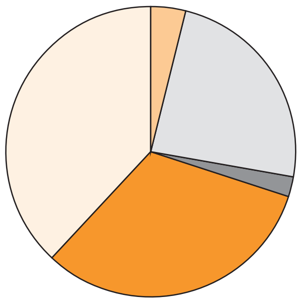
The big challenge Pakistan faces is that future demand from energy will increasingly come from coal, as use of petroleum products decline.

Renewable potential

Farooq and Kumar (2013) have estimated the current and future potential of renewable energy in generating electricity (Table 2).[135] The potential increases from 168GW in 2010 to 194GW in 2050.

Pakistan has a large biomass potential, which can be utilised very effectively for addressing energy demand in rural areas, as well as supplementing urban power houses. It is currently the fastest growing RE technology in Pakistan, with more than 4,000 biogas plants are in operation and several biogas power plants (57MW capacity in total) are either already operational or are in the pipeline.

Figure 1. Energy consumption by sector



Source: Hydrocarbon Development Institute of Pakistan, 2013

The major sources of biomass energy are crop residues (25%), animal manure (50%) and municipal solid waste (25%).[136]

According to the Water and Power Development Authority, the total installed capacity in Pakistan is 22,477MW, of which 30% are hydroelectric plants. Pakistan has three large hydropower plants – Terbela (3,500MW), Ghazi Brotha (1,450MW), and Mangla (1,000MW); the other hydropower plants are below 250MW. The remaining hydro potential is 35GW, with the possibility to develop 8,000MW in the midterm.[137]

Low carbon plan

Though there is no specific legislation on low carbon or GHG reduction in Pakistan,[138] the country has adopted a climate change policy document (2010), which emphasises addressing Pakistan's own GHG emissions by shifting to a low carbon economy.

The National Economic Council has approved the framework for economic growth, which includes promotion of green growth through investment in low carbon technologies, supported by necessary finances. Recently, the government has approved a national policy for installation of co-generation plants for power production from bagasse.[139] This may be helpful to add more than 2,000MW power to the national grid in the near future by efficiently utilising bagasse. According to estimates, the sugar industry is generating 700MW electricity.

Pakistan has a specific policy on alternate renewable energy. This policy was limited to wind, solar and hydropower at a small scale. In early 2011, the government

Table 2. Estimated electricity capacity from renewable energy sources 2010-2050 (GW)

	2010	2020	2030	2040	2050
Wind (grid connected)	12.8	12.8	12.8	12.8	12.8
Solar PV (decentralised)	9.9	14.1	19.1	24.5	29.9
Solar PV (centralised)	116.2	116.2	116.2	116.2	116.2
Solar thermal (centralised)	22.6	22.6	22.6	22.6	22.6
Biomass (field residues)	1.7	2	2.5	3	3.7
Biomass (animal waste)	1.6	2.3	2.8	3.4	4.1
Biomass (municipal solid waste)	0.2	0.4	0.7	1.1	1.9
Small hydro	2.7	2.7	2.7	2.7	2.7
Total	**167.7**	**173**	**179.3**	**186.1**	**193.9**

Source: Farooq and Kumar, 2013

enacted the Alternate Energy Development Board (AEDB) Act, which empowers the AEDB to develop national strategies, policies and plans to utilise RE projects. The ARE medium term policy encourages the utilisation of all ARE sources; not only to generate electricity but also to utilise ARE technology-based applications by commercial and domestic consumers.[140]

The strategy in Pakistan to address its energy needs and transition to low carbon growth focuses on energy efficiency in the short run, and increasing RE based power production in the medium to long-term. The medium-term strategy is to exploit run-of-river and biomass projects and the long-term focuses on generation of electricity from hydel resources.

Leapfrogging potential

The challenges for Pakistan are similar to other countries in the region, but its resource potential for RE is quite significant. Apart from solar, which is abundant in the region, Pakistan has significant hydro and wind resources.

A key pillar of leapfrogging has to be reducing the energy needed to produce a unit of GDP. In the short term, energy efficiency can help address the energy shortage, avoid moving into using coal, and reduce import dependence. Most energy efficiency options, as seen in various studies, are highly financial viable and in context of Pakistan's energy crisis, highly economically viable. Technical assistance to Pakistan in developing a comprehensive policy and regulatory framework for energy efficiency in all sectors should be an immediate step. The policy/regulatory framework should be supported by fiscal incentives and enforcement mechanisms. A key challenge often faced is perceived risk to banks and financial institutions in financing energy efficiency projects despite their profitability. Thus a financial mechanism to refinance loans and concessional loans for undertaking energy efficiency measures is required.

RE has the potential for addressing energy, especially biomass and biogas use in rural areas. The government organizations dealing with renewable energy generally lack in financial, technical and skilled human resources to imagine any breakthrough in near future. Furthermore, the involvement of private sector in renewable energy projects is negligible. However, the public-private partnership (PPP) is proving very beneficial in developing hydropower projects at macro level. Therefore, substantial potential for leapfrog funding exists especially in institutional capacity building to promote technology in private sector and in PPP projects.

Renewable energy projects can be successfully implemented in the rural and the remote areas by providing financial assistance. Micro hydropower projects in remote hilly areas have the potential to fulfil their energy demand for electricity and heating which will help to save the forests. The biogas development projects in rural areas also have potential to meet the energy demand for cooking. This can be helpful in decreasing GHG emissions. But the public sector alone cannot meet this task due to limited funds. Therefore, fiscal incentives for private sector through leapfrog funding can help access renewable energy technologies at community level.

To effectively pursue low-carbon green growth, the government should provide a comprehensive and coherent policy package and funds for long-term development. Leapfrog funds can significantly facilitate access to renewable energy in the country by creating funding opportunities for RE projects at local, community and macro levels and encouraging PPP. Steps would have to be taken to attract and encourage private investors (local and foreign). Tax rebates, financial leasing and soft loans may be helpful in this regard. Capacity building programmes in existing organisations dealing with renewable energy (such as the AEDB, Pakistan Council of Renewable Energy Technology, and National Engineering and Science Commission) should be introduced to develop the staff skills required for better business management and efficient technology transfer.

Low carbon examples		
Household – biogas/solar home system	**Community and SME – micro hydropower/agro-processing mills**	**Macro – grid connected hydropower (IPP)**
Project objective The project aims to facilitate construction of domestic biogas plants at the household level to fulfil the energy demand for cooking though setting up 14,000 biogas plants. **Development benefits and impact** Biogas reduces indoor air pollution, improving health. Reduced biomass consumption contributes towards forest conservation. It creates employment at local level and contributes towards private sector development. Most importantly, biogas reduces GHG emissions. **Opportunities/risks** Total potential is 21.35 million m^3 biogas and 36 million tonnes of biofertilizer per day. Lack of properly skilled manpower to construct and service plants is a big risk. Infrastructure for implementation and logistics for maintenance of domestic biogas technology is not available. Availability of funds is also a key risk. **Types of investment needed** The provision of funds for technology dissemination and providing subsidies to farmers can enhance the capacity of the sector to promote biogas technology. Farmers' contribution remains about 40% per plant. Therefore, funding from other sources is required in the form of farmer investment support. **Other types of support to the project** Capacity building at both individual and institutional level will be required to enhance the existing knowledge and skills and to promote the technology in rural areas.	**Project objective** The project, Dissemination of Micro-hydel Technology in the Northern Areas, installed 476 micro hydropower plants in the northern areas of Pakistan, electrifying 56,000 households. **Development benefits and impact** This technology has the potential to electrify 250,000 rural houses without break of supply. The project created job opportunities for more than 1,000 local inhabitants, and PKR45 million ($455,000) of income will be generated per year. It promoted small-scale industrial activities in rural areas. **Opportunities/risks** There is significant potential in northern areas and Kashmir as well as arid and semi-arid regions. **Types of investment needed** The provision of funds for skill enhancement and technology dissemination in the public sector; improve skills in private sector for the installation of micro hydel plants. Investment is required to enhance the ability of local manufacturers to produce more efficient turbines with increased capacity. **Other types of support to the project** Renewable energy research, development and implementation in Pakistan have been hampered by a lack of institutional support, especially clear roles and mandates. Enhancement of micro hydel technology will require capacity building at national, district and community level.	**Project objective** Install a run-of-river hydropower project to provide power and promote renewable energy, using an independent power producer (IPP). **Development benefits and impact** • Framework for hydro IPPs developed. • Encouraged economic growth by reducing the level of very costly electricity and compensating incremental demand for power. • GHG emissions reduced by 218,000 tons CO_2e per year. • Produced 300-500 job opportunities for skilled and unskilled people during the project construction phase and around 90 jobs now the plant is operational. **Opportunities/risks** • High costs of capital due to perceived risk and general scarcity of financial resources. • Low head hydropower projects based on bulb turbines are relatively expensive due to large size of plant. • Geological risks may arise during construction, such as dewatering of the powerhouse. **Types of investment needed** The allocation of funds for new power projects surpasses the cumulative allocation for health, education, housing and agriculture. In order to save governmental funding for these vital sectors, private sector investment has been sought. A combination of policy reforms, institutional support, incentives and financing modalities is required to encourage private-sector participation in financing, constructing and managing macro level hydropower projects (Sufi et al, 2009).

Endnotes

1 IPCC 5th Assessment Working Group 1, www.climatechange2013.org/

2 US Environmental Protection Agency, State Energy CO_2 Emissions, http://epa.gov/statelocalclimate/resources/state_energyco2inv.html

3 Other sources of GHG emissions are methane (16%), nitrous oxide (6.2%), and gases used in refrigerators, foams, etc (2%).

4 International Panel on Climate Change Fifth Assessment Report.

5 UNFCCC, *Report of the Conference of the Parties on its sixteenth session*, Decision 1/CP.16, UNFCCC, 2011, p2.

6 IEA, *World Energy Outlook*, 2012, www.worldenergyoutlook.org/publications/weo-2012

7 Asian Development Bank, *Asian Development Outlook 2013*, www.adb.org/publications/asian-development-outlook-2013-asias-energy-challenge

8 IPCC AR5 WG1, www.ipcc.ch/report/ar5/wg1/

9 Business-as-usual scenario is the future scenario of GHG emissions and fossil fuel consumption if countries undertake no specific actions to address climate change other than current policies and programmes – ie a continuation of past practices.

10 IPCC AR5 WGIII, www.ipcc.ch/report/ar5/wg3/

11 Ad Hoc Working Group on the Durban Platform for Enhanced Action, http://unfccc.int/bodies/body/6645.php

12 United Nations Energy Programme, *The Emissions Gap Report 2013*, www.unep.org/pdf/UNEPEmissionsGapReport2013.pdf

13 Zou Ji, Fu Sha, Chai Qimin, *Closing the Gap in the Context of WS2 of ADP*, http://unfccc4.meta-fusion.com/kongresse/sb38/pdf/closing_the_gap_in_the_WS2_context_China.pdf

14 See note 12.

15 See note 12.

16 Carbon intensity in energy supply is the amount of carbon produced per unit of energy. It is measured as CO_2 emissions per unit of energy supplied to the economy. The carbon intensity of energy supply depends on the sources of energy used to meet the demand. A higher percentage of fossil fuels in the energy supply implies higher carbon intensity and a higher percentage of coal would imply higher carbon intensity than if petroleum or natural gas is used in the energy supply.

17 See note 10.

18 S Alkire, A Conconi, S Seth, et al, *Global Multidimensional Poverty Index 2014*, Oxford Poverty and Human Development Initiative, 2014, www.ophi.org.uk/wp-content/uploads/Global-MPI-2014-in-brief.pdf

19 Ibid

20 Myanmar is not a member of the South Asian Association for Regional Cooperation.

21 The World Bank has classified countries into low-income, middle-income (low and high) and high-income countries based on per capita GDP. Low income – $1,035 or less; lower middle-income – $1,036-$4,085; upper middle-income: $4,086-$12,615; high income: $12,616 or more (as of 1 July 2013).

22 S Alkire, M Chatterjee, A Conconi, et al, *Global Multidimensional Poverty Index 2014*, Oxford Poverty and Human Development Initiative, 2014, www.ophi.org.uk/wp-content/uploads/Global-MPI-2014-an-overview.pdf

23 UNDP, *Human Development Report 2014*, UNDP, 2014.

24 World Bank, 40 percent of world population do not use improved sanitation facilities, http://data.worldbank.org/news/40prct-wrld-pop-dont-use-imprvd-sanitation

25 RM Shrestha, M Ahmed, S Suphachalasai,et al, *Economics of Reducing Greenhouse Gas Emissions in South Asia: Options and Costs*, Asian Development Bank, 2012, www.adb.org/sites/default/files/pub/2013/economics-reducing-ghg-emissions-south-asia.pdf

26 Tonne oil equivalent is the energy equal to that in one tonne of oil.

27 Ministry of Power, Energy and Mineral Resources, 500MW Solar Power Programme, www.powerdivision.gov.bd/user/brec/50/91

28 Royal Government of Bhutan, National Environment Commission, *Initial National Communication to the UNFCCC*.

29 Democratic Socialist Republic of Sri Lanka, Ministry of Power and Energy, Puttalam Coal Power Project.

30 Sun-Joo Ahn, Dagmar Graczyk, *Understanding Energy Challenges in India*, IEA, 2012, www.iea.org/publications/freepublications/publication/India_study_FINAL_WEB.pdf

31 Reegle, Bangladesh, www.reegle.info/policy-and-regulatory-overviews/bd

32 Reegle, Pakistan, www.reegle.info/policy-and-regulatory-overviews/pk

33 See note 25.

34 UN Secretary General, Ban Ki Moon: 'Universal energy access is a key priority on the global development agenda. It is a foundation for all the Millennium Development Goals.'

35 DF Barnes, SR Khandker, HA Samad, *Energy Access, Efficiency, and Poverty: How Many Households Are Energy Poor in Bangladesh?*, World Bank, 2010, http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-5332

36 DF Barnes, SR Khandker, HA Samad, *Energy Poverty in Rural and Urban India: Are the Energy Poor Also Income Poor?* World Bank, 2010, http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-5463

37 F Sher, A Abbas, RU Awan, An investigation of multidimensional energy poverty in Pakistan: A province level analysis, *International Journal of Energy Economics and Policy*, 2014, 4, pp65-75.

38 World Bank, Electric power consumption (kWh per capita), http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

39 IEA, Energy access database, www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase

40 See note 6.

41 WHO, 7 million premature deaths annually linked to air pollution, www.who.int/mediacentre/news/releases/2014/air-pollution

42 ADB Sees Steady Growth for Developing Asia, ADB, 2014, www.adb.org/news/adb-sees-steady-growth-developing-asia

43 See note 25.

44 Nepal Country Report (see Appendix).

45 Z Aslam, A Khan, *Country Paper: Pakistan*, Asian Development Bank Institute, www.adbi.org/files/2009.09.16.cpp.day2.sess4.7.country.ppr.pakistan.pdf

46 Government of the People's Republic of Bangladesh General Economics Division Planning Commission, Outline Perspective Plan of Bangladesh 2010–2021, Making Vision 2021 a Reality, 2010

47 See note 6.

48 USAID, *Energy Trends in Developing Asia: Priorities for a Low-Carbon Future*, USAID, 2011.

49 See note 25.

50 T Sarker, R Corradetti, M Zahan, Energy sources and carbon emissions in the iron and steel industry sector in south Asia, *International Journal of Energy Economics and Policy*, 2013, 3, pp30-42.

51 J Knox, T Hess, A Daccache, et al, 2012, Climate change impacts on crop productivity in Africa and South Asia. *Environmental Research Letters* ,7 (3).

52 Ibid.

53 Y Masutomi, K Takahashia, H Harasawab, et al, Impact assessment of climate change on rice production in Asia in comprehensive consideration of process/parameter uncertainty in general circulation models. *Agriculture, Ecosystems & Environment*, 2009, 131, pp281-91.

54 Energy intensity is a measure of the energy efficiency of a nation's economy calculated as units of energy per unit of GDP.

55 Energy Information Agency, eia.gov/cfapps/ipdbproject/iedindex3

56 A Boegle, D Singh, G Sant, *Energy Saving Potential in Indian Households From Improved Appliance Efficiency,* Prayas Energy Group, www.prayaspune.org/peg/media/k2/attachments/energy_saving_potential_from_indian_households_from_appliance_efficiency_108A01.pdf

57 Kingdom of Bhutan, Second National Communication to the UNFCCC, 2011, http://unfccc.int/resource/docs/natc/bhunc2.pdf?bcsi_scan_97e98328e2b67804=0&bcsi_scan_filena"e=bhunc2.pdf

58 Sri Lanka Sustainable Energy Authority, Hydro Potential, www.energy.gov.lk/sub_pgs/energy_renewable_hydro_potential.html

59 OP Sharm, P Trikha, Geothermal energy and its potential in India, *Akshay Urja*, 2013, 7, p14-18, http://mnre.gov.in/file-manager/akshay-urja/july-august-2013/EN/14-18.pdf

60 India Energy Portal, Geothermal, www.indiaenergyportal.org/subthemes_link.php?text=geothermal&themeid=13

61 Power Engineering, Anglo MGH Energy Plans to set up Bangladesh's first geothermal power plant, 2011, www.power-eng.com/articles/2011/03/anglo-mgh-energy-plans.html

62 Ministry of New and Renewable Energy, *Annual Report 2011-12*, Government of India, 2012.

63 AH Mondal, *Implications of Renewable Energy Technologies in the Bangladesh Power Sector: Long-Term Planning Strategies*, Dissertation, 2010.

64 P Gilman, S Cowlin, D Heimiller, *Potential for Development of Solar and Wind Resource in Bhutan*, National Renewable Energy Laboratory, 2009, www.nrel.gov/docs/fy09osti/46547.pdf

65 Big ambitions ahead for Asian offshore wind, *Offshore Wind*, 2013, 4, pp12-17, www.gwec.net/wp-content/uploads/2013/08/Big-Ambitions-Ahead-for-Asian-Offshore_GWEC_July-2013.pdf

66 See note 64.

67 SK Nandi, MN Hoque, H Ranjan, et al, Potential of wind and solar electricity generation in Bangladesh, *ISRN Renewable Energy*, 2012.

68 EcoSeed, Solar energy and the future of Bangladesh, 2012, www.ecoseed.org/business/asia/15750-solar-energy-and-the-future-of-bangladesh

69 Reegle, Bhutan, www.reegle.info/policy-and-regulatory-overviews/bt

70 Ministry of New and Renewable Energy, Solar, www.mnre.gov.in/schemes/grid-connected/solar

71 Alternative Energy Promotion Centre, *Annual Progress Report July 2010-June 2011*, AEPC, 2012.

72 Pakistan Engineering Council, Solar Radiation in Pakistan, www.pec.org.pk

73 Reegle, Energy profile Pakistan, www.reegle.info/countries/pakistan-energy-profile/PK

74 K Dissanayake, I Vithanage, *Solar Energy Development in Sri Lanka*, www.sari-energy.org/PageFiles/What_We_Do/activities/SOLAR_2011/Presentations/SOLAR_Sri_Lanka.pdf

75 Government of India, Tidal Energy, 2011, http://pib.nic.in/newsite/erelease.aspx?relid=70685

76 SS Raju, S Parappurathu, R Chand, et al, *Biofuels in India: Potential, Policy and Emerging Paradigms*, NCAP, 2012, www.ncap.res.in/upload_files/policy_paper/pp27.pdf

77 A Naureen, *Cost Benefit and Risk Analysis of Biofuel Production in Pakistan*, Thesis, 2013, http://stud.epsilon.slu.se/5241/1/Naureen_A_130129.pdf

78 SNA Zaidi, Pakistan energy scenario & PSO's initiative, www.psopk.com/products_services/pdf/alternate_energy_biodiesel.pptx

79 NR Dhakal, N Dhakal, An overview of biofuel programme, *Proceedings of International Conference on Renewable Energy Technology for Sustainable Development*, 2009. p112-8.

80 K Bhattarai, Nepalma Biodiesel ko Sambhabana ra Aabasyakata. *Sabaiko Lagi Urja Aviyan Urja Nepal*, 2010, 2, p9-12.

81 K Mandal, CR Sivapradha, *Climate Finance: Understanding India's Requirements and Opportunities*, IFMR Centre for Development Finance, 2012, http://cdf.ifmr.ac.in/wp-content/uploads/2012/07/CDF-Brief_-Climate-Finance.pdf

82 SP Garnaik, *National Mission for Enhanced Energy Efficiency*, Bureau of Energy Efficiency, 2011, http://moef.nic.in/downloads/others/Mission-SAPCC-NMEEE.pdf

83 Ibid.

84 Government of Nepal, *Scaling-up Renewable Energy Programme: Investment Plan for Nepal*, Government of Nepal, 2011.

85 Ministry of Energy, Report of the Task Force for Generating 10MW Hydropower in Ten Years, Government of Nepal, 2009.

86 *Sector Assessment: Energy*, ABD, www.adb.org/sites/default/files/cps-sri-2012-2016-ssa-02.pdf

87 Point Carbon, CER prices to 2020 to stay below issuance cost, forecast April 2014, www.pointcarbon.com

88 Climate Investment Funds, *Clean Technology Fund: India*, www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF_India.pdf

89 DM Rahman, NB Sakhawat, R Amin, et al, A study on renewable energy as a sustainable alternative for ensuring energy security in Bangladesh and related socio-economic aspects. *Engineering Journal*, 2012, 16(2), http://engj.org/index.php/ej/article/view/225/146

90 G Senanayake, *Sri Lanka Renewable Energy Report*. Asian and Pacific Centre for Transfer of Technology of the United Nations Economic and Social Commission for Asia and the Pacific, 2009.

91 Infrastructure Development Finance Company, *Barriers to Development of Renewable Energy in India & Proposed Recommendations*, 2010, www.idfc.com/pdf/publications/Discussion-paper-on-Renewable-Energy.pdf

92 See note 90.

93 *Sri Lanka Renewable Energy Program*, World Bank, http://siteresources.worldbank.org/EXTRENENERGYTK/Resources/5138246-1238175210723/Sri0Lanka0RE0Program0mini1hydro0.pdf

94 ADB, Sector Assistance Program Evaluation for the Bhutan Energy Sector, ADB, 2010, www.adb.org/documents/sector-assistance-program-evaluation-bhutan-energy-sector

95 APCTT-UNESCAP, *Nepal: Renewable Energy Report*, http://recap.apctt.org/download.php?p=Admin/Country/Report/9.pdf

96 D Nassiry, D Wheeler. *A Green Venture Fund to Finance Clean Technology for Developing Countries. March*. Center for Global Development, 2011, http://ssrn.com/abstract=1824645

97 ADB-ADBI Study on Climate Change and Green Asia, *Policies and Practices for Low-carbon Green Growth in Asia*, 2012.

98 Ibid.

99 See note 91.

100 India Solar, Barriers to Renewable Energy Development in India, www.indiasolar.com/barriers.htm

101 KC Surendra, SK Khanala, P Shresthab, et al, Current status of renewable energy in Nepal: Opportunities and challenges, *Renewable and Sustainable Energy Reviews*, 2011, 15, pp4107-17.

102 Kathmandu2day, 10 August 2012, www.ktm2day.com

103 MS Islam, AM Khan, S Nasreen, et al, Renewable energy: the key to achieving sustainable development of rural Bangladesh, *Journal of Chemical Engineering*, 2011, 26, pp9-15.

104 Reegle, Energy Profile: Bangladesh, www.reegle.info/countries/bangladesh-energy-profile/bd

105 See note 6.

106 See note 91.

107 N Pahuja, N Pandey, K Mandal, et al, *GHG Mitigation in India: An Overview of the Current Policy Landscape*, Word Resources Institute, 2014.

108 World Bank, Nepal-India Electricity Transmission and Trade Project, www.worldbank.org/projects/P115767/nepal-india-electricity-transmission-trade-project?lang=en

109 A Thapa, Harnessing of Hydropower Potential, *Kathmandu Post*, 2011, www.ekantipur.com/the-kathmandu-post/2012/08/10/money/harnessing-of-hydropower-potential/238266.html

110 D Sarkar, Work for Indo-Bhutan hydropower projects of 3500MW to begin within next one year, *The Economic Times*, 2012, http://articles.economictimes.indiatimes.com/2012-07-11/news/32632823_1_hydropower-projects-indo-bhutan-bhutan-s-government

111 Planning Commission, *The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth*, Government of India, 2014.

112 See note 7.

113 The variability of RE power, the uncertainty and location factors combined with variations in demand make grid stability management very difficult. Technologies are required to provide storage and grid stability management to go 100% RE.

114 World Institute of Sustainable Energy, *Future of Coal Electricity in India and Sustainable Alternatives*, 2013

115 J Rockström, GN Axberg, M Falkenmark, et al, *Sustainable Pathways to Attain the Millennium Development Goals: Assessing the Key Role of Water, Energy and Sanitation*, Stockholm Environment Institute, 2005.

116 IEA, *Energy for All: Financing Access for the Poor*, IEA, 2011, www.iea.org/papers/2011/weo2011_energy_for_all.pdf

117 Investments are based on the SE4ALL estimates, which are also based on IEA estimates. However, the level of energy assumed in the estimation package is not clear.

118 The IEA New Policy scenario is the energy mix and resulting emissions if all current global policy is implemented (that is current business as usual policy).

119 See note 111.

120 See note 81.

121 See note 7.

122 Frankfurt School, Bloomberg New Energy Finance, *Global Trends In Renewable Energy Investment 2014: Key Findings*, 2014. http://www.unep.org/pdf/Green_energy_2013-Key_findings.pdf

123 UN, *World Economic and Social Survey 2009,* www.un.org/en/development/desa/policy/wess/wess_archive/2009wess.pdf and UN, *World Economic and Social Survey 2011*,www.un.org/en/development/desa/policy/wess/wess_current/2011wess.pdf

124 In many developing countries the subsidies are being reduced as they are economically unsustainable.

125 *Better Growth, Better Climate*, The New Climate Economy, 2014.

126 The GET FiT programme is designed to directly support feed-in tariffs in countries that already have them in place or are considering enacting them. See https://www.deutsche-bank.de/cr/en/docs/GET_FiT_Plus.pdf more details.

127 *Assessing the Investment Climate for Climate Investments*, World Bank, 2012, www.uncclearn.org/sites/www.uncclearn.org/files/inventory/wb149.pdf

128 See note 97.

129 World Energy Council, *Renewable Energy in South Asia: Status and Prospects*, 2000.

130 See note 11.

131 Population and Housing Census, 2011.

132 World Bank, Bangladesh at a glance (2010 data).

133 Household Income and Expenditure Survey 2010.

134 Assessment of the improved stove market in Bangladesh, Winrock International and E+co for USAID, January 2012.

135 MK Farooq, S Kumar, An assessment of renewable energy potential for electricity generation in Pakistan, *Renewable and Sustainable Energy Reviews*, 2013, 20, pp240-54.

136 SZ Farooqui, Prospects of renewables penetration in the energy mix of Pakistan, *Renewable and Sustainable Energy Reviews*, 2014, 29, pp693-700.

137 I Gomes, *Natural Gas in Pakistan and Bangladesh: Current Issues and Trends*, Oxford Institute for Energy Studies, 2013.

138 HK Jeswani, W Wehrmeyer, Y Mulugetta, How warm is the corporate response to climate change? Evidence from Pakistan and UK, *Business Strategy and the Environment,* 2008,18, pp46–60.

139 Private Power and Infrastructure Board, *National Policy for Power Cogeneration by Sugar Industry and Guidelines for Investors*, Ministry of Water and Power, 2008.

140 Government of Pakistan, *Final Report of Task Force on Climate Change*, Planning Commission, 2010.

141 AB Sufi AB, ZH Kahn, J Iqbal, Genesis of power crises and its management in Pakistan: Public private partnership to mitigate power crisis, paper no. 264, in *Symposium on Genesis of Power Crisis and its Management in Pakistan*, Pakistan Engineering Congress, Lahore, 2009.

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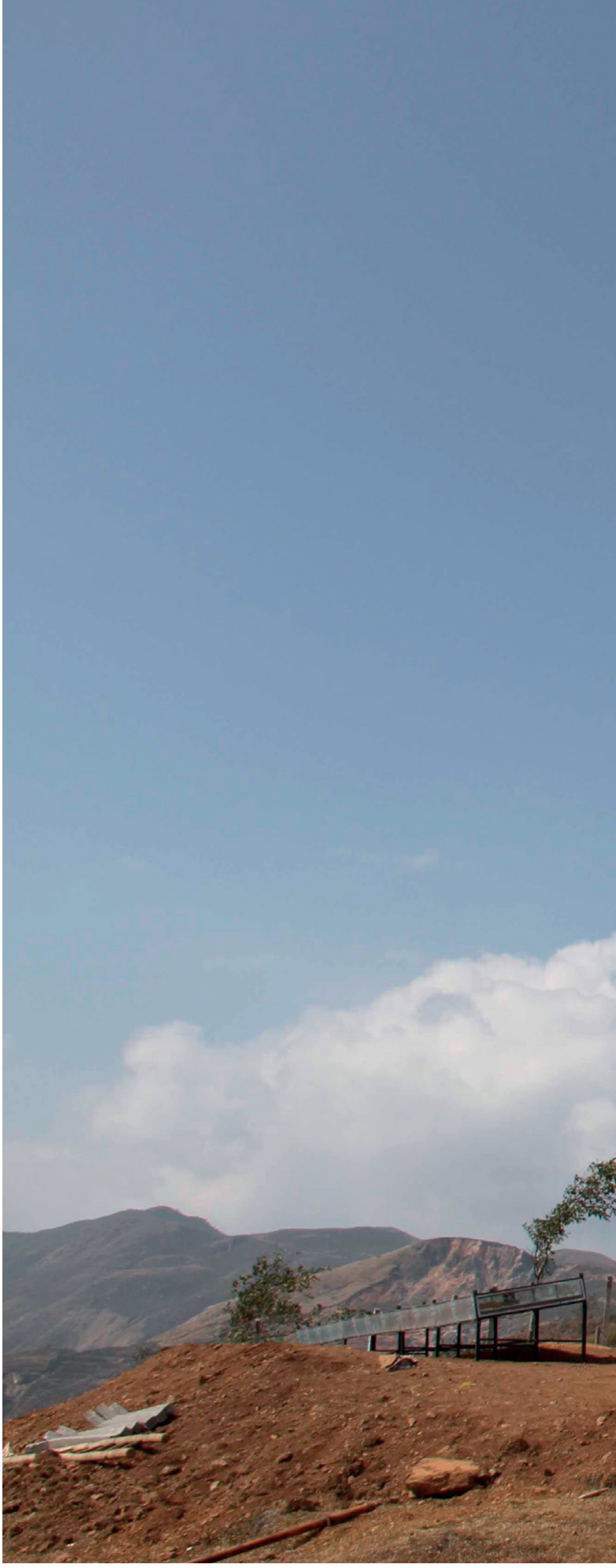

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