

Renewable and Clean Energy

Power Sector Prospects for South Asia

SAARC CHAMBER OF COMMERCE AND INDUSTRY

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Renewable and Clean Energy

Power Sector Prospects for South Asia

SAARC CCI

In partnership with

Friedrich Naumann STIFTUNG FÜR DIE FREIHEIT

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The report observes the global as well regional developments for renewable energy options and initiatives for reducing carbon emission. Although, the South Asia is the least contributor to CO_2 emissions, given its size of population and potential for economic and industrial growth, the policy makers suggest options for the World and the Globe, necessitating for switching over from conventional resources i.e. fossil fuel to clean and renewable energy options. In this context the research work done by international organizations like World Energy Council, World Bank etc, and key players i.e. Jazz and Symphony has been widely cited in addition to information available on internet to further add value to the work done by our team of experts.

The management of SAARC CCI led by President Mr. Vikramjit Singh Sahney, assisted by team comprises of Mr. Ahmed Mujuthaba, Senior Vice President (Maldives), Mr. Md. Jashim Uddin, Vice President (Bangladesh), Mr. Thinley Palden Dorji, Vice President (Bhutan), Mr. Mahendra Parmar, Vice President (India), Mr. Pradeep Kumar Shrestha, Vice President (Nepal), MR. Iftikhar Ali Malik, Vice President (Pakistan) and Mr. Kosala Wickramanayaka, Vice President (Sri Lanka) is appreciated for its initiatives to engage Private Sector in climate change related energy options. Special thanks to Friedrich Naumann Foundation: fur die freiheit, New Delhi for their continued cooperation and partnership for this publication.

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(Muhammad Iqbal Tabish)
Secretary General
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EXECUTIVE SUMMARY

Being representative of the Private Sector of South Asia, SAARC Chamber of Commerce and Industry has realised cooperation in Clean and Renewable energy as an important area not only to deepen economic cooperation in the region but also to address environmental issues to keep South Asia, a cleaner and a greener region. As an important step forward, SAARC CCI initiated the task for creating awareness amongst the Public and the Private Sector and other stakeholders by organizing string of seminars and conferences to sensitize them about current energy scenario and emerging trends in power generation in South Asia, with an objective to quantifying benefits from commercial collaborations and partnerships amongst energy producers in South Asia. This report is based on the discussions and deliberations during this series of seminars and conferences. In addition to the findings and analysis of the experts, this report also provides global energy scenario and thereby suggests policy measures for encouragement and promotion of renewable and clean energy in South Asia in view of research done by various research organizations and energy players.

The International Energy Agency (IEA) shows a unique world energy balance in 2012 where the total consumption was 8,980 Mtoe against the total production and imports of 18,609 Mtoe. The common and major challenge is 31% power sector losses i.e. 2,784 Mtoe which is more than the leading consumption in industrial sector. The transport sector shares almost the same consumption trends as that of industrial. All other walks of life shared 35% consumption and non-energy oriented consumptions accounted for about 9%. In the framework of international environmental treaties, the developed economies are demanding that rapidly growing economies to be legally bound to reduce GHG emissions, but the developing nations opine that developed nations have already polluted the world and reaped benefits from it. The developing countries also fears that developed nations aim to decelerate the pace of their economic growth by placing carbon emission reduction as milestone around their neck.

Maldives, India and Pakistan are most vulnerable for any climate change set back, with their concurrent factors of increasing population and overexploitation of resources and global climate change, the scarcity of resources especially scarcity of water can make all other problems and disagreements irrelevant, lack of access to clean and safe water does not only poses a threat to billions of population of the subcontinent rather it can be cause of another war between the two nuclear powers.

A consensus is emerging that climate change will act as multiplier and can trigger threat for international peace and security. Moreover, no single country can control the climate risk it faces, as it is more challenging in nature, and needs profound choices that impacts broad national interest debates like energy, development and trade. Therefore, to reduce the potential onsets of climate change triggered disputes and disarrangements, state actors need to devise climate compatible development agenda and incorporate strategy in new enery sector development.

In view of the perceived impact of climate change on human and animal life, a visible shift in policies of developed as well as developing countries has been observed, necessitating adoption of environment friendly technologies to generate power from renewable and clean energy sources instead of burning fossil fuels, increasing green house gas emissions. Although, South Asian countries have enormous potential for generation of renewable and clean energy but insignificant resources have been tapped so far. Because of its multiplier effects on socio-economic development of society, energy has become an area of major concerns for policy-makers, producers, consumers as well as environmentalists who are concerned about emission of green house gases from conventional sources contributing to global warming and ultimately to climate change. The South Asian region has been reported as very vulnerable to changes in the climate. Therefore, the nexus between climate change and energy needs to be clearly understood.

The provision of low cost energy is vital for socio-economic growth, energy security and sustainability in the region. Regional cooperation for knowledge sharing and technology transfer will be required to enhance the development of the renewable and clean energy sectors. Cooperative management of water resources in the region for hydropower development and establishment of a regional grid would be one of the main steps to be taken to resolve energy crisis in many countries in the SAARC region, for which political will is the key important element which can only be brought forward through strong engagement of stakeholders within South Asian countries. The development of hydropower will not only help in improving the environment by far less emission than other sources but also provide low cost clean energy. The low cost energy, in turn will contribute to economic growth and development.

Part I

ENERGY LANDSCAPE

Future Trends in Production, Supply & Demand

Overview

The World Energy Council (WEC) has predicted that the energy landscape we expect to see in 2050 will be quite different from how it looks today. Meeting future energy demand will be a key challenge. The world's population will increase from approximately 7 billion in 2013 to approximately 9 billion in 2050, which is nearly 30% increase. The GDP per capita will also increase from slightly more than US$ 9,000 in 2010 on average globally to approximately US $ 20,000 in 2050. This represents an increase by 125% during the same period. Mobility will also increase, with car ownership in terms of cars per 1000 people increasing from 124 in 2010 to more than 200, this equates to an increase by nearly 80%.

According to the study done in JAZZ and Symphony scenarios, the WEC estimates that total primary energy supply (equal to consumption) will increase globally from 546 EJ 750 EJ in 2050. This corresponds to an increase of 61% in Jazz and 27% in Symphony. Just to compare from 1990 to 2010 – which is roughly half the time span covered in this scenario study – total global primary energy consumption rose by approximately 45%. It is expected that global primary energy consumption will continue to rise, but at a much lower rate than in previous decades. Meeting both global and regional energy demand will be a challenge. There is no one global solution to the energy supply issue. Instead, each of the individual parts of the challenge must be worked out to reach the global goal of sustainable, affordable and secure energy supply for all.

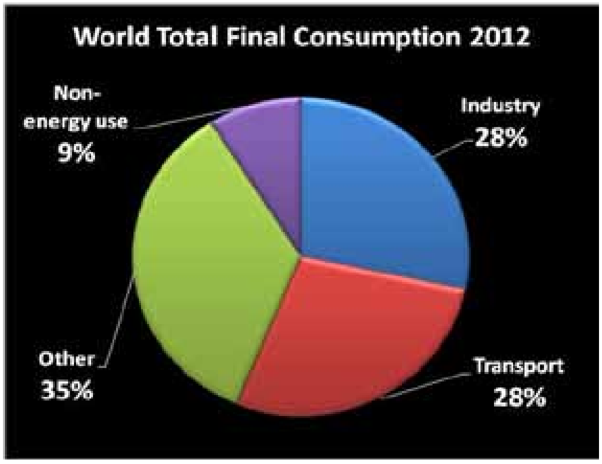
The analytical figures (as shown in figure 4) of International Energy Agency (IEA) on world energy balance 2012 shows unique trends where the total final consumption was 8,980 Mtoe against the total production and imports of 18,609 Mtoe. The common and major challenge is the 31% power sector losses i.e. 2,784 Mtoe which is also superseding figure when compared with the leading consumption in industrial sector (as shown in figure 1). The transport sector shares almost same consumption trends as that of Industrial but at number 2. All other walks of life shared 35% consumption and non-energy oriented consumptions accounted for about 9%.

The India has major share in all sectors including 87% share (as shown in figure 2) in Industrial consumption. The population and rapidly growing economic activities are key drivers of energy consumption in India. Pakistan, Nepal and Bangladesh also have same trends for industrial consumptions like Indian trends. Sri Lanka has transport sector as leading share holder in final consumption and industrial consumption comes after it.

Compared with the total final consumption in South Asian countries, power sector losses are critically important and relevant as India and Bangladesh accounts for 42% and 30% losses respectively reported in year 2012 which is a major challenge to be overcome by such a large population carrying countries. These losses share almost same figure of 13% for Pakistan and Sri Lanka whereas it found negligible for Nepal (IEA statistics, 2012).

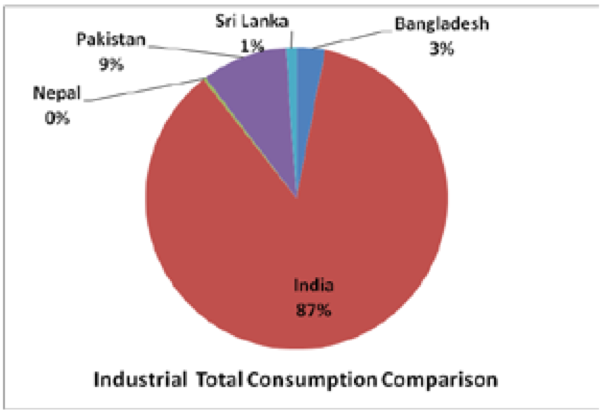
At the moment, the oil is a predominant energy sources in the form of oil production and import. But, the anticipated future primary energy mix trends in year 2050 reflect that growth rates will be highest for renewable energy sources. In absolute terms, fossil fuels (coal, oil, gas) will remain dominant, up to and including 2050. The share of fossil fuels will be around 70% compared to 79% in 2010. The share of renewable energy sources will increase from around 15% in 2010 to almost 25% in 2050. Nuclear energy will contribute approximately 7.5% of total primary energy supply globally – compared to 6% in 2010.

Figure 1: World Consumptions in Year 2012



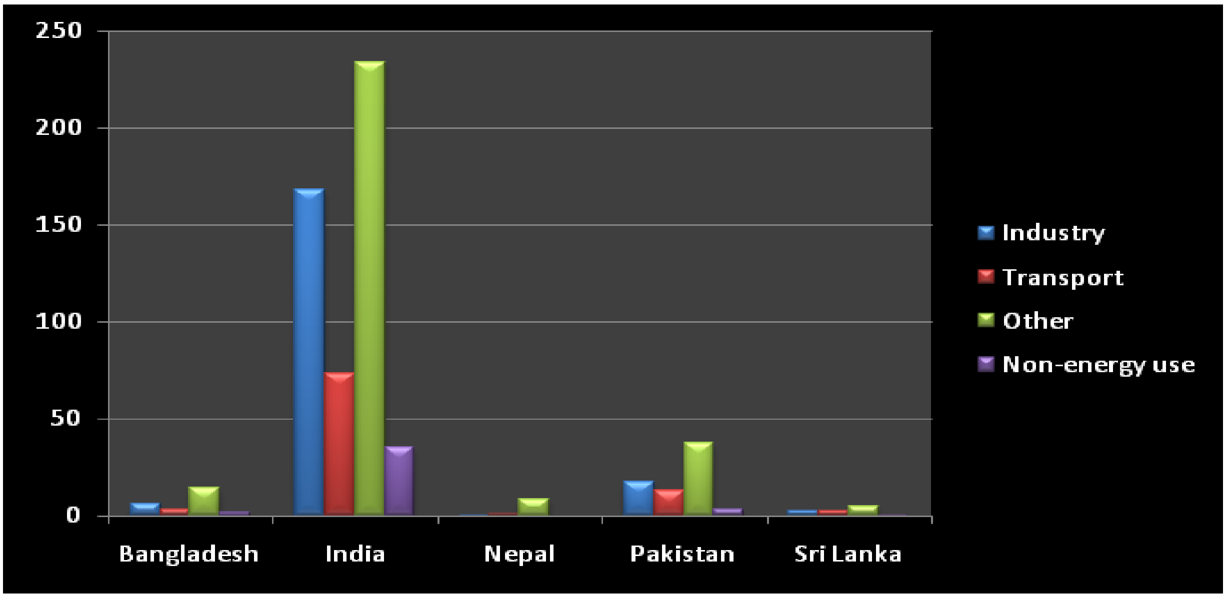
Data source: International Energy Agency

Figure 2: Industrial Consumptions in South Asian Countries (Year 2012)



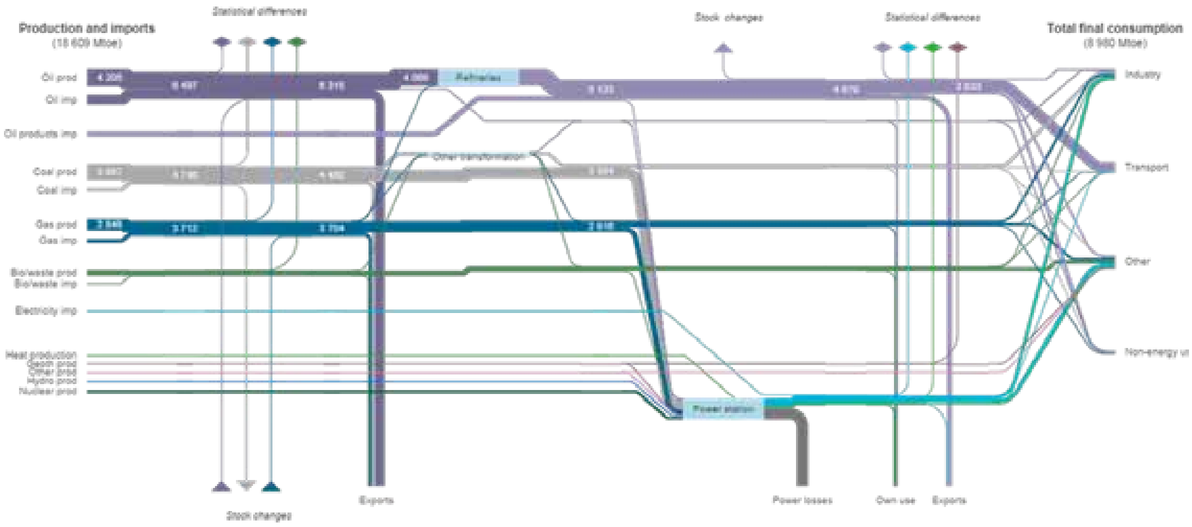
Data source: International Energy Agency

Figure 3: Sector Wise Consumptions in South Asia (Year 2012)



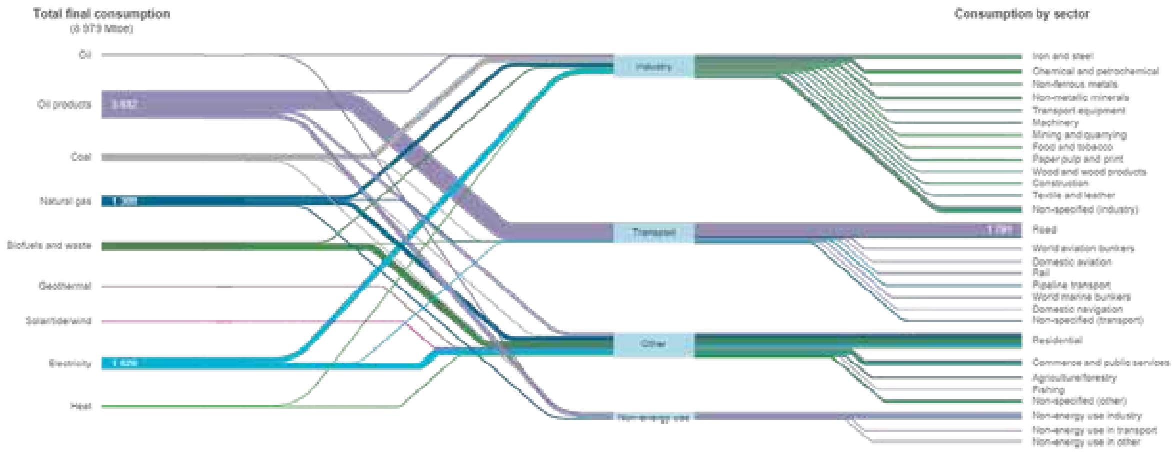
Data source: International Energy Agency

Figure 4: World Energy Balance Flows 2012



Data source: International Energy Agency

Figure 5: Sector Wise World Total Energy Consumption 2012



Data source: International Energy Agency

Global electricity generation will increase manifolds by year 2050. In year 2010, global electricity production was 21.5 billion MWh and is expected to increase to 50 billion MWh by 2050. Simply due to the sheer increase in electricity production that is needed to meet future demand, the future electricity generation mix will be subject matter to tremendous changes up to 2050.

While realizing more electricity demand, the power sector losses have now become critically important and needs serious attention for prompt strategy as part of future investments viz-a-viz environmental scenarios through efficiencies at both technological and administrative ends.

Huge investment in electricity generation is needed to meet future electricity demand. The WEC estimates that total investment needed will range from US$19 trillion to US$26 trillion (in 2010 terms) – in terms of cumulative investment in electricity generation in (2010–2050, undiscounted). Depending on each scenario, a share of 46% in Jazz and almost 70% in Symphony of this is to be invested in renewable electricity generation. Major investment requirements are in solar PV, hydro and wind electricity generation capacity. The WEC's work clearly highlights that the availability of funds for investment is one of the key clusters in scenario building terms that will shape the energy landscape until 2050.

The degree of electrification measured in terms of the share of electric energy on the final energy mix, increases up to 2050 significantly. The degree of electrification is expected to increase by almost 30% in 2050– as compared to 17% in 2010.

Electricity consumption per capita is expected to increases globally by 85% in 2050. Electricity access, measured as the share of population connected to the electricity grid will increase in both scenarios: energy access will hence improve. While in 2010, 1.267 billion people were without access to electricity globally, this reduces to 319 million in Jazz and 530 million in the Symphony scenario in 2050.

The estimate of 1.267 billion people without access to electricity for 2010 differs from that of the World Bank of 1.2 billion people due to 'differences in a relatively small number of countries, including Pakistan, Indonesia, South Africa, Thailand, and Gabon, where the International Energy Agency (IEA) uses government data (which typically report more people without access) while the World Bank uses estimates derived from various types of surveys' (World Bank, 2013).

Global Energy Scenario- Alternative Sources

Global energy scenario - the demands, alternative sources of energy and fuel prices remain in focus and fresh studies get commented upon widely. The reasons are not far to fetch, relentless hydrocarbon consumption has hiked the concern that global resources might get exhausted, leading to supplies increasingly drying up. Hence the hunt for alternatives in on: solar energy, the wing energy and host of other alternatives are being tapped. Viz-a-viz pricing, it consumes a huge chunk of budget outlays of underdeveloped and developing countries. In recent past, British Petroleum [BP] Energy Outlook 2030' has been quoted widely. It stands related in the study that demand is neither related wholly to what is the simplistic economic take of supply and demand, nor to production costs and economic conditions, but it is said to be a complex mix of so many factors. It forecast that fossil fuels–oil, gas and coal will still account for 80 percent of primary energy worldwide in 2030. Linked to it, as various studies point out is the fast growing demand or energy consumption, which is expected to rise by as much as whooping two thirds in fast growing economies like that of India and China. The conclusion could easily be drawn that these economies shall remain oil dependent and pay whatever it takes to buy oil, which as per various studies accounts for huge 35% of energy requirement worldwide. This makes a strong case for oil prices to stay up. Not only that, increased demand would necessarily entail hunt for new oil fields. As the studies point out, oil explored so far has come cheap from places, where the access was easy, hence the lower cost of production. That might not be the case any more. The new finds are expected to be the sea bed in Arctic or it might be lying trapped in tar sands in Canada and Venezuela. The argument for prices staying high is based, besides other factors, on high production cost of the expected new sites. Production runs the argument would be worthwhile, only if prices stay high and even hike further, re-enforcing the argument that this time around, there is no going back on prices, as was the case previously.

There are compelling arguments, experts opine which negate to take this that there would be no reversal, these could be listed as:

(a) unstable Middle East, hence unpredictable - a phenomenon that consumers hate, even it is conceded that there is low investment high production ratio working in favour of Middle East
(b) global warming concerns getting linked to fossil fuel burning, United states administration is reportedly pushing Environmental Protection Agency to raise the fuel efficiency standard for American-built vehicles to 35.5 miles per gal-

lon by 2016, the current average being 25 mpg, which alone will result in a 29 percent cut in American oil usage.

These concerns are prompting the hunt for alternative sources of energy, the hunt includes:

(a $600 million in research by Exxon Mobil, geared to producing a cost-effective alternative from biomass, specifically, from algae that require no agricultural land and use only waste or salt water

(b) an octane-type fuel for cars, which combines hydrogen with carbon dioxide drawn directly from the air by artificial tree

Both these alternative sources are taken to be carbon-neutral, and could be delivered through existing distribution systems and used in current vehicle engines. Either solution would be a real challenger to $100-per-barrel oil, which in other words means that it might not stay that high, opine market experts with years of experience in energy pricing. Electric-powered alternatives are beginning to appear on the market, though still they are not satisfactory for long-distance driving. Mass-produced cars burning carbon-neutral oil substitutes in internal combustion engines are probably only five to ten years away.

How does it affect us locally? In spite of living in a world where alternative energy sources and carbon neutrality is the aim and objective of leading nations, we are almost totally oblivious of the world moving ahead. That too in a situation where nature has provided us with a very rich energy source—abundance of water that could not only quench our energy thirst, but leave enough for buying whatever else might be needed for living meaningful lives. However in absence of conflict resolution, it would remain but a dream.

Part II

Towards Low-Carbon Electricity Generation

Climate Change, CO_2 Emissions and Power Sector

Climate Change, either a natural due to natural variability or due to anthropogenic activities, will inevitably have multitude of effects and causes. The responsibilities for climate impacts are presumed to be shared by a number of actors. One of the key normative decisions is the way, in which emissions are associated with particular countries bear the social and economic costs of reducing the emission, and to make efforts to respond its impacts under the Kyoto Protocol. Kyoto protocol recognizes that "developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere and places a heavier burden on developed nations under the principle of common but differentiated responsibilities.

In the framework of international environmental treaties, the developed economies are demanding that rapidly growing economies to be legally bound to reduce GHG emissions, but the developing nations opine that developed nations have already polluted the world and reaped benefits from it. The developing countries also fears that developed nations aim to decelerate the pace of their economic growth by placing carbon emission reduction as milestone around their neck.

The developing nations specially Maldives, India and Pakistan are most vulnerable for any climate change set back, with their concurrent factors of increasing population and overexploitation of resources and global climate change, the scarcity of resources especially scarcity of water can make all other problems and disagreements irrelevant, lack of access to clean and safe water does not only poses a threat to billions of population of the subcontinent rather it can be cause of another war between the two nuclear powers.

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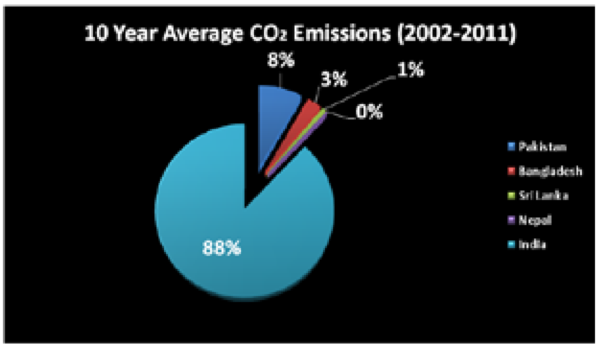
India has lead contribution towards CO_2 or GHG emissions in South Asian region. The five country data reflects alarming trends with 88% contribution of India in overall emission scenario (as shown in figure 6). The Indian high ratio of emissions is due to economic activities and population growth. The year 1971 to 2011 emission statistics of International Energy Agency (IEA) shows continuous increasing trends (as shown in figure 7). According to IEA statistics of year 2011, India shares about 51% (1745.1 Million tones of CO_2) out of total emissions of 3448 Million tones of CO_2 from Asia region (excluding China) which indicates a major challenge to be addressed (as shown in Figure 8).

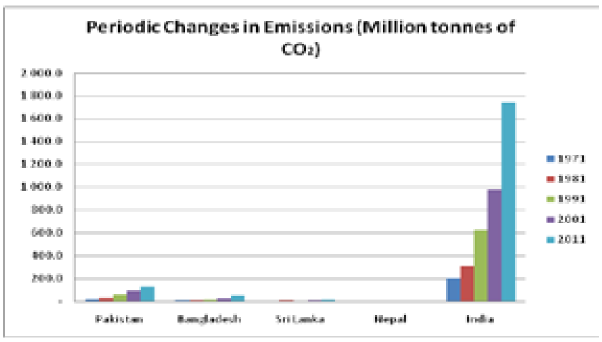
With about 89% emissions share in South Asian countries, India's power sector is the largest contributor after which other industries and then transport sector falls for emission shares. In Pakistan, the manufacturing industries are top most contributing factors towards CO_2 emissions where as the power sector is at 2nd and transport comes at 3rd level with 31%, 29% and 26% emissions respectively. So, the power sector developments in India, Pakistan and Bangladesh are important for climate compatible development agenda.

Figure 6: 10 Year Average Regional CO2 Emissions (2002-2011)



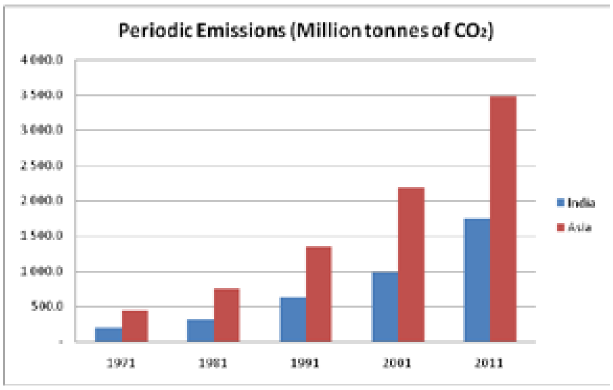
Data source: International Energy Agency statistics 2012

Figure 7: Country wise Periodic Changes in CO2 Emissions



Data source: International Energy Agency statistics 2012

Figure 8: Periodic Changes in CO2 Emissions – India VS Asia



Data source: International Energy Agency statistics 2012

CO_2 emissions will increase in both scenarios in the first half of the scenario period. In the Symphony scenario, where, by assumption, greater emphasis is placed on climate change mitigation and adaptation, a turning point will be reached by 2020. In the Jazz scenario, the turning point is only reached by 2040. As far as the total amount of CO_2 emissions are concerned, both scenarios differ substantially. In the Jazz scenario, CO_2 emissions will be more than 44 billion tonnes per annum in 2050 which is 45% higher than in 2010. In the Symphony scenario, CO_2 emissions reach 19 billion tonnes per annum

Data source: International Energy Agency statistics 2012 which is nearly 40% lower than in 2010. The WEC's World Energy Scenarios to 2050 underline that a reduction of greenhouse gas emissions is possible in the second half of the scenario period with global agreements and the implementation of cost-efficient measures like emissions trading within a cap and trade system (assumed in Symphony).

Electricity generation from renewable energy sources will increase around four to five times by 2050 in comparison to 2010. This is strongest in the Symphony scenario. In Symphony, electricity generation from hydro doubles, for biomass the increase is eight-fold, and for wind eleven-fold when comparing figures for 2010 with 2050. Solar PV has the highest increase of approximately 230 times between 2010 and 2050. By 2050, globally, almost as much electricity is produced from solar PV as from coal (coal and coal with CCUS). The share of renewable energy sources for electricity generation will increase from approximately 20 percent in 2010 to more than 30% in 2050 in Jazz and nearly 50% in Symphony. The degree to which renewable energy sources will be used and investment in CCUS technologies for coal and gas (and also biomass) will be decisive in mitigating climate change.

The WEC's commitment to climate change

At the COP 15 (Conference of Parties) meeting, the 15th session of the United Nations (UN) Framework Convention on Climate Change, the 'Copenhagen Agreement' or 'Copenhagen Accord' was ratified by delegates and they endorsed the continuation of the Kyoto Protocol. Specific emissions-reduction targets for 2020 were submitted by individual countries. At subsequent COP meetings, this was reinforced, in particular at the COP18 meeting in Doha when the 'Doha Climate Gateway' was developed – a package of deals that set out a work programme through which both rich and developing countries can deliver a new international climate agreement. The Doha Climate Gateway includes a timetable for a 2015 global climate change agreement and for increasing ambitions before 2020. At Doha, countries agreed a course for negotiating the Durban Platform for Enhanced Action, a new climate deal for all countries to be agreed by 2015 and to take effect in 2020 – the Ad Hoc Working Group on the Durban Platform for Enhanced Action (ADP). To establish a clear link between energy use and climate change objectives, the WEC has included the Doha Climate Gateway as a key differentiator between its two scenarios. The WEC assumes that in the Symphony scenario, countries pass through the Gateway and successfully negotiate a global treaty. In the Jazz scenario, these negotiations fail, and regions, countries, states and municipalities take their own sustainable development pathways.

Carbon Capture, Utilisation and Storage (CCUS) technologies are widely employed in Symphony and hence subject to higher growth rates in the Symphony scenario than in the Jazz scenario. Half of the total electricity generated based on fossil fuels will be in conjunction with CCUS in 2050 in Symphony. Combining nuclear and CCUS for gas, coal and biomass, more than 80% of all electricity generated in 2050 will be from low-carbon sources in the Symphony scenario, compared to 40% in the Jazz scenario. To compare: In 2010, only one-third of global electricity generation was CO_2 from low-carbon sources. The WEC believes that CCUS technology, solar energy and energy storage are the key uncertainties moving forward upto 2050. For CCUS to work, clear legislative frameworks are needed – combined with infrastructure investment and the right incentives. A low-carbon future is not only linked to renewable: CCUS is important and consumer behavior needs changing. Changes in consumption habits can be an effective way to de-carbonise the energy system. Voters need to balance local and global issues.

Part III

Regional Developments & South Asia

Regional Developments & South Asia

Future economic growth shifts from developed countries to developing and transition economies, in particular in Asia. Of all the eight regions considered in this scenario study, Asia will be characterised by highest economic growth both in relative and absolute terms.

By 2050, nearly half of all economic growth (measured in terms of production of GDP) will happen in Asia and its three sub-regions: Central and South Asia, East Asia and Southeast Asia and Pacific. This means that the share of Asia on total primary energy consumption will increase from 40% in 2010 to 46% in 2050. To compare: by 2050, Europe and North America (including Mexico) will make up for about 30% of total global primary energy consumption (2010: 44%).Africa, including the middle East will account for 15% to 16% (2010: 11%) and Latin America and The Caribbean from 7% to 8% (2010: 5%).

South Asia Region: Energy Outlook and Options in Selected Countries

Coal is the backbone of the Indian energy sector. India has about 38 billion tons of oil equivalent of proven coal reserves (approximately 207 years reserve life79), the third largest in the world after the United States and China. Though coal is abundant, it is of low calorie and high ash content and, therefore, highly polluting. Currently, about 70–80 percent of the country's electricity is produced from coal.

Poor-quality coal, aged legal framework, low levels of plant efficiency, and an ageing capital stock combine to make the power sector highly carbon intensive. Average emissions in Indian power plants are significantly higher than the global average. Transmission and distribution losses are a further drain on system efficiency and may exceed 20 percent in some states, well above global best practice (Government of India, Press Information Bureau 2001). Consequently, energy-efficiency opportunities exist to reduce the carbon intensity ofpower production while simultaneously increasing electricity supply. Rising energy demand is driven by urbanization, industrialization, and prosperity, all of which are parts of a broader process of development that is lifting millions out of poverty. However, increased energy consumption has been accompanied by rising greenhouse gas emissions. On average, emissions have risen by about 3.3 percent annually in the South Asia region since 1990, more rapidly than in any other region except the Middle East and North Africa. Total emissions exceed 2.5 billion tons of carbon dioxide equivalents and the region has emerged as one of the major contributors to global GHG emissions. As the region strives to meet its development goals, the potential for further growth in emissions is enormous.

More than 400 million people in the region have no access to electricity, more than in allof sub-Saharan Africa. How the region meets these demands, it will have far-reaching consequences on global greenhouse gas emissions.

Reflecting the size of its economy, population, and territory, India remains the largest contributor to GHGs in the region, accounting for about 75 percent of emissions.

Consequently, greater attention is focused on India in this chapter. Globally India is the seventh largest emitter of greenhouse gases, it has low per capita emissions and low-carbon intensity. In terms of emissions per unit of GDP, India remains an exceptionally low-intensity producer of CO2 emissions. Per capita emissions in India, and the region as a whole, are low by international standards. In India, per capita energy consumption is less than 10 percent of the average of the OE CD and about one-half the average for developing countries. Of the remaining seven South Asian countries, the following discussion mostly concerns Bangladesh, Pakistan, and Sri Lanka, where incremental emissions could be globally significant but where future emission paths can potentially be influenced.

Strategies to lower emissions by diversifying into cleaner sources of power are constrained by the country's energy resources and import possibilities. India is not well endowed with reserves of cleaner fuels such as oil, gas, and uranium.Hydropower potential is significant and large in absolute terms (150,000 megawatts) but small compared to the country's vast energy needs. In addition, there are possibilities for importing about 50,000 megawatts of hydropower from Bhutan and Nepal, and perhaps as much as 20,000 megawatts of wind power from Sri Lanka. However, even when exploitation of hydropower is technically feasible,there are social and environmental concerns to take into consideration, and there remain difficulties in establishing transboundary energy trade agreements. Hydropower development is also made more complex by glacial melting, which increases the medium- and long-term hydrological risk associated with such investments.

Under most plausible scenarios, detailed assessment by India's Planning Commission suggests that coal is expected to remain the dominant fuel used for power generation, even under the most optimistic scenarios. Renewable energy sources (including wind, solar, and hydro power) and nuclear power would play a minor role in the country's energy mix (Box 12.1). For India, transformational climate-change interventions would therefore need to increase the efficiency of coal use through migration to more efficient technologies. In parallel, other future technology options such as mass solar power should be pursued, as has been suggested in the India National Action.

India Supply Options for Lowering Emissions: Planning Commission Estimates

The Planning Commission has explored possibilities for energy diversification to meet the demands of a rapidly growing economy. The figure below presents estimates for three scenarios in 2031. The economy is assumed to grow at 8 percent on average, which in turn implies more than a tripling of energy needs. In the business as usual scenario over 60 percent of generation is coal based. In this case, by 2030, India's emissions approach those of the United States today (approximately 6,000 million tons). The forced nuclear, hydro, and natural gas scenario and the high-efficiency coal, power, and transport plus renewables scenario are the most optimistic conceivable cases and are useful in illustrating limits and possibilities. These assume that all available hydropower potential (150,000 megawatts) is exploited, nuclear capacity increases at an optimistic pace, demand-side management (DSM) reduces demand by 15 percent, and at least 11 percent of generation is from gas, irrespective of price differentials. Even in the most optimistic scenario coal remains a dominant fuel, accounting for over 40 percent of the mix, though emissions decline somewhat to about 4,000 million tons. The implication is clear: under any plausible setup, coal is likely to dominate and other fuels will play a lesser role, even under extreme assumptions that are very favorable to the growth of those alternatives. Consequently, a clean energy strategy must aim to lower emissions from coal.

Pakistan- Low carbon Initiatives

Pakistan is one of the lowest emitters of greenhouse gases (GHG) in the world: it accounts for just 0.8% of total global emissions, and ranks 135th in terms of per capita emissions. Unfortunately, Pakistan is also one of the most climate vulnerable countries in the world. Over the past 20 years, 141 extreme events have killed on average over 500 people a year, and led to annual economic losses of more than US$ 2 billion. The knock-on effects of climate change threaten food security, water security and energy security – and ultimately, national security.

International Institute of Sustainable Development (IISD) and partner Energy Research Centre of the Netherlands (ECN) have extended great deal of cooperation to Government of Pakistan for taking multiple actions. Pakistan launched its National Climate Change Policy in February 2013, and has been an active participant in global discourse on climate change. While Pakistan's priority focus is adaptation to climate change, it is cognisant of its international responsibilities under the UNFCCC and realises it must move to low carbon development pathways.

Although, Pakistan is one of lowest emitters of GHG in the world: 51% of the country's emissions come from the energy sector, and 39% from agriculture and livestock, a significant growth in emissions is expected, particularly in the energy and transport sectors as Pakistan develops.

A number of mechanisms and concepts in the UNFCCC negotiations potentially impact mitigation actions including Low Carbon Development Strategies (LCDS) and reducing Emissions from Deforestation and Forest Degradation, plus the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+); Low Carbon Development Strategies set out the priority actions needed to reduce emissions by sector and across the economy. With regard to the clean development mechanism, Pakistan has approved 67 CDM projects and gained considerable experience that could be used to inform low carbon planning and the development of NAMAs. However, reduced demand for credits from the CDM means that Pakistan will require new strategies to stay engaged in the carbon market. Finally, in relation to technology, the new Technology Mechanism established by the Cancun Agreements in 2010 promotes use of technology through, for example, public-private partnerships and joint research activities. Pakistan could position itself as an early collaborator with the Climate Technology Centre and Network that has been established to implement the Technology Mechanism.

Options for mitigation readiness in Pakistan are multiple, and include preparing a NAMA Framework, updating the GHG inventory and establishing sector emission baselines, carrying out a study of renewable energy resources, building capacity at national and provincial levels, and designing specific NAMA proposals.

With regard to the private sector, it was noted that profit is the bottom line driving force for involvement. Keeping this in mind, the private sector will need to be made aware of opportunities for involvement in adaptation and mitigation actions. Profit-making opportunities are more apparent for mitigation actions: already a number of private sector companies are trying to promote solar power in Pakistan.

Bangladesh and Nepal

Because of the cost advantage of coal and the relative security of the fuel supply streams, Bangladesh, Pakistan, and Sri Lanka will increasingly see coal emerge as the front running fuel for incremental generation of power. Bangladesh and Pakistan have substantial, unexploited coal reserves (albeit of dubious quality and difficult to extract), and Sri Lanka has unfettered access to global coal markets. The risks around investment in coal-fired capacity are perceived as being lower than those of alternative power sources, and the overall cost of the delivered power is competitive versus other options, based on prevailing market prices for coal and competing fuels. This suggests that there is a need for more active and extensive interventions to tilt the balance in favor of cleaner technologies. To the extent that these countries can delay the next generation of coal-fired plants under consideration, the carbon savings would be substantial, perhaps as much as 3 million tons per year per 1,000 megawatts of capacity, if it is assumed that the alternative to coal is natural gas.

Pakistan has created a number of incentives to attract renewable / alternative energy, including attractive ROE (17%), Tax free revenues and Duty free imports, Guaranteed purchase of energy, Grid Spill Over concept (Small Power Producer & Cogeneration), Net metering (under process), Wheeling provisions (under consideration) and Banking of electricity (concept stage). However, for Pakistan, the alternative to coal is likely to be natural gas imported from its oil-rich neighbors in the Middle East and Central Asia. Pakistan shares a land border with the world's second-largest holder of gas reserves, Iran. In Sri Lanka, the alternative source of supply would be imported liquefied natural gas. However, plans for a massive expansion of coal-fired energy are well advanced, so the prospect of reversing that decision may not be feasible, though little consideration appears to have been given to its health and environmental implications. On the other hand, Bangladesh has significant reserves of natural gas, but exploration drilling has not kept pace with demand.

Policy constraints, impediment to revitalizing exploration and production, enhancing production and reservoir management from existing fields, and reducing losses (mostly due to theft, but also to substantial amounts of leakage) from the existing gas supply network remain common challenges for South Asian countries.

Thus, the situation in Bangladesh is significantly different from that in Pakistan and Sri Lanka, as Bangladesh will not need large incentives from a global carbon market to inform investment decisions that choose between coal and natural gas. What it will need is simply more domestic gas development, and this remains firmly in the range of the possible, provided that the country's financial policy improves. Otherwise, the country will be forced to analyze the tradeoffs between coal and imported gas, much as Pakistan and Sri Lanka must do.

Part IV

Approaches for Climate Compatible Power Sector

Approaches for Reducing Emission Intensity

Options for Cleaner Coal

In the immediate future, there are three main options for lowering the emission intensity of coal that are appropriate to the Indian setting:

(i) rehabilitation of old plants,
(ii) replacement of inefficient plants, and
(iii) adoption of cleaner generation technologies that are economically justifiable.

Each of these is considered in turn:

Rehabilitation: India's state electricity boardsand their successor entities own and operate plants that represent more than 50,000 megawatts of generation capacity. Some of these are old, inefficient, and highly polluting.

Rehabilitation of these with energy efficiency as a priority can generate substantial emission reductions. For example, plant efficiency can increase to 35 percent from 30 percent or below, and as a result, the annual CO_2 emission reduction would be more than 1 million tons for every 1,000 megawatts for a power plant that was so renovated.

Replacement: Ageing coal-fired power plants with no further rehabilitation potential could be replaced by new, more efficient plants, ideally using supercritical technology, where technically and economically feasible.

Cleaner generation: A favored option in India is supercritical technology, based on based on its track record internationally, availability in India, and suitability with coal streams (domestic and imported). It is likely that many such investments will be led by private sector entities or state organizations with substantial access to market financing, such as the National Thermal Power Corporation. There is scope to expand the use of supercritical technologies to other countries in the region

South Asia: Shared Views on Development and Climate Change its track record internationally, availability in India, and suitability with coal streams (domestic and imported). It is likely that many such investments will be led by private sector entities or state organizations with substantial access to market financing, such as the National Thermal Power Corporation. There is scope to expand the use of supercritical technologies to other countries in the region.

Loss Reduction, Energy Efficiency, and Pricing

For South Asia in general and India in particular, there are large gains to be had from addressing loss reduction or efficiency gains. The energy that does not have to be generated due to loss reduction or efficiency gains is attractive from both the cost and the climate change standpoints. There are large opportunities for efficiency gains and loss reduction in South Asia as depicted in the table below. Much of the industrial output in the region is from small- and medium-scale enterprises that utilize outdated and inefficient technologies and processes. Cost-effective energy efficiency opportunities exist across the entire chain of modern energy production, distribution, and consumption in all South Asian countries. However, success in capturing these benefits has been elusive; many energy efficiency projects with positive economic returns remain unimplemented.

The classic barriers to increased energy efficiency include noneconomic pricing of energy (encouraging overconsumption), imperfect information, and institutional barriers. Additionally, weight is often given to reducing up-front costs instead of considering the lower recurring lifecycle costs typically available from installation of more cost-efficient equipment and adoption of more efficient processes.

Energy-efficiency projects can also face higher transaction costs due to their small average size.

Table 1 Energy-efficiency Opportunities and Measures in Key Consuming Sectors

Sector	Energy-Efficiency Improvement opportunities
Building unities	Integrated building design and measures such as better insulation, advanced windows, energy efficient lighting, space conditioning, water heating, and refrigeration technologies plus energy efficient brick manufacturing and wall paneling brick manufacturing and wall paneling
Industry	Industrial processes, cogeneration, waste heat recovery, preheating, efficient drives (motor, pump, compressors)
Cities and Municipalities	District heating systems, combined heat and power, efficient street lighting, efficient water supply, pumping, and sewage removal systems, solid waste management (methane capture to generate electricity)
Agriculture	Efficient irrigation pumping and efficient water use, such as drip irrigation
Power Supply	New thermal power plants: Combined cycle, supercritical boilers, integrated gasification combined cycle, etc. Existing generation facilities: Refurbishment and repowering (including hydro), improved operation and maintenance practices, and better resource utilization (higher plant load factors and availability) Reduced transmission and distribution losses: High-voltage lines, better insulated conductors, capacitors, efficient and low-loss transformers, and improved metering systems and instrumentation Intensified investigation of renewable options: Solar and wind power, hydro-electricity (including possibility of increased regional trade)
Transport	Efficient gasoline/diesel engines, urban mass transport systems, modal shifts to inter- and intra-city railand water transport, improved fleet usage, compressed natural gas (CNG) vehicles
Households	Efficient lighting, appliance efficiency, improved cook stoves, solar panels for heating and cooking.

Source: South Asia: Shared views on Climate Change and Development - WBG

Finally, capital constraints at small and medium enterprises often leads to allocation of capital toward new production capacities rather than toward investments that will reduce operating costs through energy efficiency, especially if energy costs are a small component of total production costs.

The International Energy Agency has noted that more than 60 percent of GHG reductions could come from adoption of energy-efficient policies and measures. Though contested, this conclusion highlights the importance that energy efficiency can play in reducing demand and dependence on fossil fuel use, reducing levels of power shortages by capacity-constrained electric utility companies, and improving economic competitiveness, while capturing the environmental benefits to be derived from the numerous government-led initiatives currently under way. In India, the Planning Commission estimates that improving energy efficiency in industry will have the greatest impact in reducing India's CO2 emissions. The Government of India has demonstrated its commitment to and support for improving efficiency with the passage of the Energy Conservation Act (2001) and the formation and operation of the Bureau of Energy Efficiency. Recognizing the importance of lowering demand through energy conservation and improved efficiency, the 11th Five Year Plan seeks to improve Indian efficiency by 20 percent by 2016/7, and the recently released Climate Change Action Plan of the Government of India includes a specific mission to increase efficiency through deployment of several innovative market mechanisms. Government-supported programs for efficiency have also been launched in Afghanistan, Nepal, Pakistan, and Sri Lanka.

Hydroelectricity and Regional Trade

Though India's hydropower potential is limited relative to its needs, the hydropower sector can contribute to reductions in emissions. The Bank already has a presence in the Indian hydro sector, with one project under implementation (Rampur)and two more under preparation (Vishnugad Pipalkoti and Luhri). There are also good prospects for an increased Bank involvement in financing of hydro capacity in Nepal and Pakistan.

There are significant opportunities in energy trade between the countries with a surplus of clean renewable sources of energy—hydropower in Bhutan and Nepal, and wind energy in Sri Lanka—and the energy-deficit countries of India, Pakistan, and Bangladesh. Trading this clean energy would allow climate-change-mitigation benefits to arise from reduced operation of thermal(particularly coal-fired) power plants. The improved interconnectedness and efficiency associated with this regional trade would also yield improvements in operational performance. However, given the inadequacy of existing interconnections for trading large quantities of clean energy and current shortages of power, at the present time imported power would serve mainly to reduce load shedding, and substantial benefits would materialize only over the long term.

Other Renewable Sources

The contribution of non-hydro-renewable energy in the overall mix in South Asia is likely to be small. Even if such alternatives experience vigorous growth, their contribution to mitigation of overall carbon emissions will be limited, though individual projects will be able to attract potentially significant volumes of carbon finance. More work and research will be needed to deploy viable technologies and support emerging technologies. Recognizing this need, the Government of India has recently unveiled an ambitious approach in its National Action Plan on Climate Change to raise solar power production capacity and invest heavily in research and development in this field.

Leveraging Climate-change-related Funds

Without adequate and additional funding it is unlikely that the South Asia region can achieve the transformation needed to create low-carbon economies. Ultimately, good projects will be the key, but the long delays in obtaining carbon finance (including through clean development mechanisms) are often a hurdle. The magnitude ofavailable funds is also inadequate for the scale ofthe challenges in the energy sector.

Private Sector Players

The private sector will be playing a key role across the board in investing in new, clean coal plants, gas-fired plants, and renewable energy. The Clean Development Mechanism already provides, to some extent, a signal toward future prices of carbon. However, there will still be significant risks attached to private investment in clean energy technology that is not least cost or whose potential remains unproven

Part V

Recommendations

Recommendations

There are scientific evidences on the presence of huge potential of Renewable Energy resources in SAARC region, and there is growing consensus that the sustainable harnessing of the available potential would play a significant role for socio-economic developments on sustainable grounds and climate compatible development in the region. However, such development avenues critically face many challenges in terms of technical and financial provisions in particular, and stakeholder engagement and political decision making viz-a-viz trans-boundary resources conflicts in general.

On one side, immediate provision to low cost energy is vital for economic growth and on the other side development of renewable / indigenous energy resources is the key to the energy security and sustainability. Regional cooperation for knowledge sharing and technology transfer will be required to enhance the development of the renewable and clean energy sectors. Establishment of a regional grid would be one of the main steps to be taken to resolve energy sector issues in many countries in the SAARC region, for which political will is the key important element which can only be brought forward through strong engagement of stakeholders within South Asian countries.

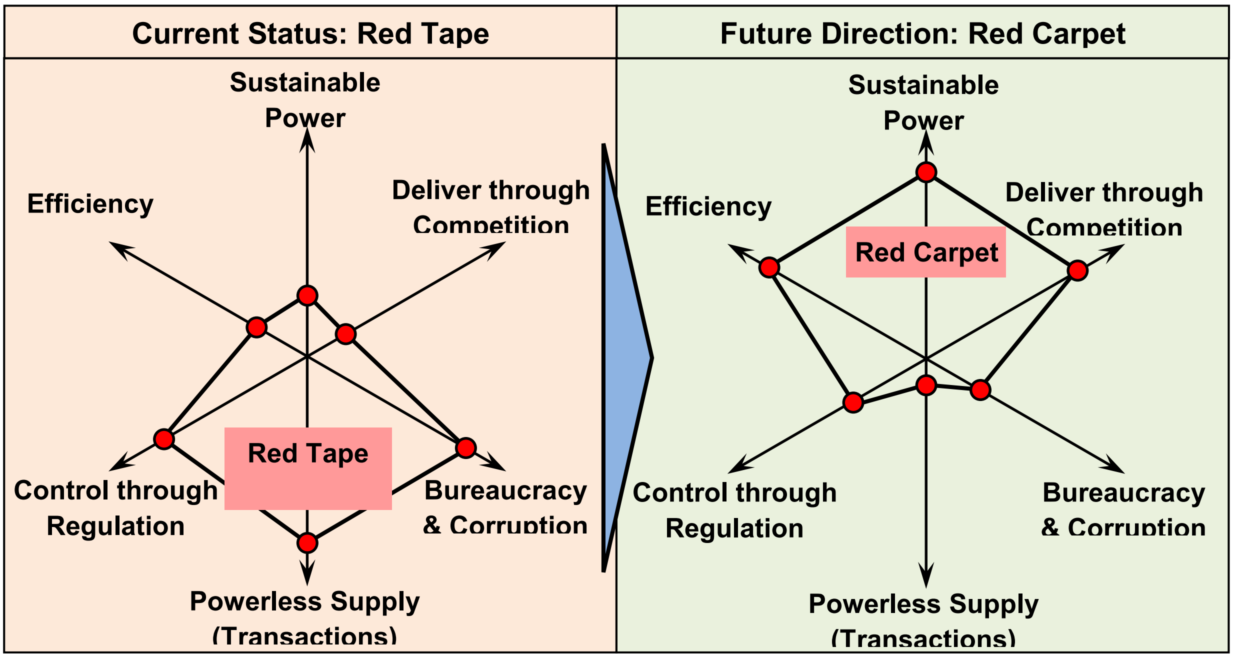
There is a dire need for creating awareness, training and capacity building for the potential entrepreneurs related to the Renewable Energy business opportunities.

Availability of perpetual supply of energy at affordable price is common demands of trade and industry to attain higher growth. If South Asia aspires to do it, necessary measures are required to eliminate the demand-supply gap, reduce the economic cost of power to single digit, and eradicate pilferage / corruption as priority concern. Some key principles and options to address the challenges are:

A- Organizational Policy Principles

South Asian countries can only achieve these aspirations by shifting the organizing policy principles from “Red Tape” to “Red Carpet”, with the proposed strategic approach illustrated in Figure 9.

Figure 9: Strategic direction for organizational policy principles



B- Promotion of Renewable / Alternative Energy

The key challenges for the development in Renewable Energy (RE) sector include attracting foreign investments, building compensatory base load capacity, raising consumer awareness, and decreasing costs through efficiency. There is need to build the base load capacity to introduce wind and solar power generation options. The SAARC region can easily accommodate 10 – 15 % of its total load as wind and solar in next few years. Following factors should be made part of overall low cost energy solution keeping in view the more or less same socio-economic features in all SAARC member countries:

a) *Tariff Rationalization and strategic control on price hike compare with the per capita economic growth and overall poverty viz-a-viz economic development scenarios. A pro-poor philosophy should be adhered in all future strategies by member states.*
b) *Fair & Level Playing Field should be provided to encourage private sector investments in renewable energy sector.*
c) *Introduction of incentives for green technological solutions encouraging environmentally sound operations, at the level of SAARC.*
d) *The cost may be reduced by employing low cost energy mix technique – a technological solution.*
e) *Investors need to scout for the most efficient wind and solar technologies to assist South Asian countries to achieve its targets of reducing cost of production and increase affordability. Renewable sources preferably water and wind resources have the potential to generate energy at lower cost as compared with Solar. The ideal situation would be availability of energy per unit at single digit i.e. 9 cents/ unit.*
f) *Encourage the development of energy cities and corridors with the application of PPP concept which would also be equally effective for development of run-of-river power projects.*
g) *Donor sponsored hydro projects should be encouraged.*

C- Efficiency Measures

Efficiency is driven by a policy of meritocracy, transparency, automation and accountability for which following measures should be adhered by SAARC member states so as to ensure sustainable and good governance with efficiency based orientation for attaining long-term results:

I- Merit Order in:

- allocations based on efficiency;
- optimized dispatch & payment;
- tariff encouraging efficiency;
- retiring high cost power as the contracts end in favour of low cost energy; and
- using high cost power only for peak demand on marginal variable cost.

II-Transparency & Automation though:

- information access with online tracking mechanism; and
- transmission system optimization.

III-Accountability of system through:

- professional hiring based on competency criteria;
- awarding performance based contracts;
- intolerance for corruption & poor performance; and
- application of stakeholders' right to information.

IV-Policy for competition

A competitive and enabling environment should be provided to encourage competition based development of energy corridors and favourable tariffs for low cost energy solutions, and creating a key client management system.

V- Policy for Sustainable Power

Power sustainability will be driven by decreasing of power cosy to single digit, creating a fair and level playing field, and aggresively promoting demand management, and relying on renewable and viable options.

VI- Demand Management though:

- application of time of the day / night metering;
- application of technology standards for energy efficiency;
- bringing energy efficiency standards for building and infrastructure development, including the domestic and industrial segments.

Part VI

Statistical Annexure

Biomass and Biogas Production Potential and Total Number of Biogas Plants Installed in South Asia

			Biomass Potential (million tons)				
Country	Reference/Source	Year	Fuelwood	Agricultural Residues	Animal Waste	Theoretical Annual Biogas Production Potential[h] (million cubic meters)	Total No. of Installed Biogas Plants
Bangladesh	Mondal (2010)		10.9[a]	44.1	40		22,549
	GPRB MPEMR PD (2012b)					8.60	
Bhutan	RGoB DoE (2007)	2005	3.9	0.366	0.3	8.86	
India	GoI MNRE (2012a)	2011	500				
	GoI MNRE (2012b, 2012c)					15,000[b]	4,404,762[d]
	Sarkar (2007)	2011		388			
The Maldives	ECN (2004a, 2004b)	2005	0.009[e]	0.015[f]	0.023[g]	n.a.	
Nepal	GoN WECS (2010)	2008/2009	12.5	19.4	14.9	1,865.3	
	AEPC (2012a)						256,662
Sri Lanka	FAO (2009)	2011	8.9				
	ADB (2004)	2011		1.96			
	SSEA (2012a)	2011			0.01		
	Nissanka and Konaris (2010)					1,168[c]	

GJ = gigajoule, kg = kilograms, kJ = kilojoule, n.a. = data not available, TJ = terajoule.

[a] Recoverable biomass, calculated considering a 100% recovery rate and unchanging production rate (Mondal 2010).

[b] Calculated from 35 million m^3/day potential.

[c] Calculated from 3.2 m^3/day potential.

[d] Cumulative physical achievements as of 31 March 2011.

[e] Net calorific value of fuelwood is considered to be 14,400 kJ/kg to convert 130 TJ to tons.

[f] Net calorific value of agricultural residue is considered to be 15 GJ/ton to convert 220 TJ to tons.

[g] Net calorific value of animal waste is considered to be 8.8 GJ/ton to convert 200 TJ to tons.

[h] Based on animal waste only.

Structure of Total Primary Energy Supply in South Asia, 2005 and 2009

	Bangladesh		Bhutan[a]		India		The Maldives[b]		Nepal		Sri Lanka		South Asia including India		South Asia excluding India	
Indicators	2005	2009	2005	2009	2005	2009	2005	2008	2005	2009	2005	2009	2005	2009	2005	2009
TPES (toe)	24.2	29.6	0.4	n.a.	537	675.8	0.2	0.3	8.6	9.9	9.0	9.3	579.5	725.0	42.4	49.1
Energy resource share in TPES (%)																
Biomass	34.3	29.8	57.6	n.a.	29.7	24.8	1.3	0.2	87.5	86.2	52.9	51.0	31.1	26.2	49.0	45.0
Coal	1.4	2.1	6.8	n.a.	39.1	42.7	0.0	0.0	2.0	1.9	0.7	0.6	36.3	39.9	1.8	2.4
Petroleum products	19.1	15.9	19.9	n.a.	24.2	23.9	98.7	99.8	8.3	9.1	43.2	44.7	24.1	23.7	22.2	20.6
Natural gas	44.7	51.8	0.0	n.a.	5.4	7.3	0.0	0.0	0.0	0.0	0.0	0.0	6.9	8.9	25.3	30.7
Hydropower	0.5	0.4	15.8	n.a.	1.6	1.3	0.0	0.0	2.2	2.7	3.2	3.6	1.6	1.3	1.6	1.3

n.a. = not available, toe = ton of oil equivalent, TPES = total primary energy supply.

Sources

IEA (International Energy Agency). 2011. *World Energy Outlook 2011*. Paris.

[a] 2005 data from RGoB DoE (Royal Government of Bhutan, Department of Energy). 2007. *Bhutan Energy Data Directory 2005*. Ministry of Trade and Industry. Thimphu.

[b] RoM MMA (Republic of the Maldives, The Maldives Monetary Authority). 2011. *Annual Economic Review 2010*. Malé. http://www.mma.gov.mv/ar/ar10.pdf?bcsi_scan_9688b637a46568db=0&bcsi_scan_filename=ar10.pdf

Theoretical and Economic Hydropower Potential in South Asia

Country	Reference/Source	Theoretical Hydropower Potential (megawatt)	Theoretical Hydropower Potential per Capita (kilowatt as of 2010)	Economic Hydropower Potential (EHP in megawatts)	Installed Hydropower Capacity (megawatts as of 2011)	Installed Hydropower Capacity (% of EHP)
Bangladesh	GPRB (2011)	n.a.	–	775	230	29.7
Bhutan	RGoB NEC (2011)	30,000	42.86	23,765	1,505.32	6.3
India	GoI MoEF (2012) GoI MPCEA (2012)	149,000	0.13	84,040[a]	39,291.40	46.8
The Maldives		n.a.	n.a.	n.a.	n.a.	n.a.
Nepal	GoN WECS (2011)	83,000	2.87	42,000	652.09	1.6
Sri Lanka	Young and Vilhauer (2003) DSRSL CBSL (2012)	n.a.	n.a.	2,000	1,399	70.0
Total		264,000[b]	0.21	152,580	43,077.8	28.2

n.a. = not available, – = no data.
[a] at 60% plant factor; [b] for four countries.

Wind Power, Solar Power, and Coal Resources in South Asia

Country	Reference/ Source	Wind Power (MW)		Technical Solar Power Potential (MW)	Coal Reserves (ton)	Installed Coal-Fired Power Plants (MW)
		Potential	Installed			
Bangladesh	Mondal (2010)	4,614	92.3	50,175		
	GPRB EMRD (2012)				3.3 billion	250
Bhutan	Gilman, Cowlin, and Heimiller (2009)	5–3,670		91 million kWh		
	RGoB NEC (2011)				1.96 million	
India	GoI MNRE (2012b)	48,561	17,644			
	GoI MoC (2011)				114 billion	116,333
The Maldives	NREL (2008)			793 MWh/year		
Nepal	AEPC (2008)	3,000	9.2 kW			
	GoN WECS (2010)			2,920 GWh		
Sri Lanka	Young and Vilhauer (2003)	24,000				
	DSRSL CBSL (2012)		3			
	DSRSL MoPE (2012)				0	300

GWh = gigawatt-hour, kWh = kilowatt-hour, MW = megawatt, MWh = megawatt-hour.

Sector Share in Total Final Energy Consumption under Base Case and Carbon Tax, South Asia (%)

	Agriculture	Commercial	Industrial	Residential	Transport	Total TFEC (PJ)
Bangladesh						
2005	4.9	1.6	29.9	47.7	15.9	855.1
2030 Base case	2.9	2.3	49.6	32.5	12.7	2,009.2
2030 Carbon tax	3.0	3.3	50.1	30.8	12.8	1,989.3
Bhutan						
2005	1.3	10.4	22.7	52.6	13.6	15.4
2030 Base case	0.6	13.4	41.9	13.2	31.1	71.1
2030 Carbon tax	0.6	13.4	41.9	13.2	31.1	71.1
India						
2005	6.3	3.3	53.7	11.9	24.8	11,304.4
2030 Base case	1.7	3.0	56.2	8.6	30.6	63,136.9
2030 Carbon tax	*	*	*	*	*	*
The Maldives						
2005	0.0	19.0	13.8	15.5	50.0	5.8
2030 Base case	0.0	9.9	7.4	11.9	70.8	35.3
2030 Carbon tax	0.0	9.9	7.7	11.9	70.7	35.2
Nepal						
2005	0.8	1.4	3.3	90.7	3.6	365.0
2030 Base case	2.1	6.4	8.3	69.8	13.7	533.0
2030 Carbon tax	2.1	6.4	8.1	70.2	13.2	530.0
Sri Lanka						
2005	0.2	4.2	25.7	48.9	20.9	311.9
2030 Base case	0.2	7.2	42.5	20.9	29.2	937.8
2030 Carbon tax	0.2	7.2	46.6	16.5	29.5	928.0
South Asia (excluding India)						
2005	2.9	2.2	22.7	58.0	14.1	1,552.3
2030 Base case	2.0	4.5	41.0	34.4	18.1	3,587.3
2030 Carbon tax	2.0	5.1	42.3	32.4	18.2	3,553.6
South Asia (including India)						
2005	5.9	3.2	50.0	17.4	23.5	12,856.7
2030 Base case	1.7	3.1	55.4	9.9	29.9	66,724.2
2030 Carbon tax	*	*	*	*	*	*

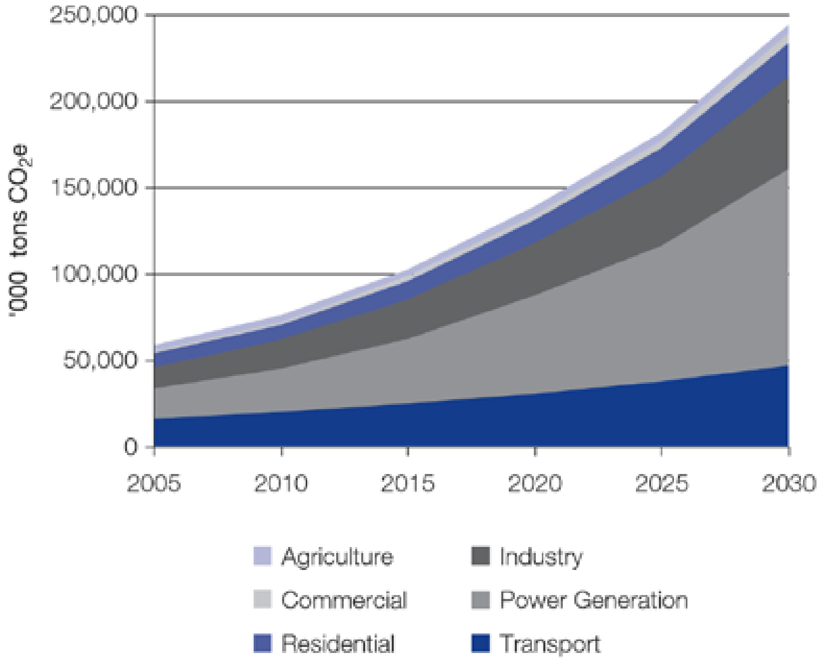
PJ = petajoule, TFEC = total final energy consumption.

* No analysis under the carbon-tax scenario was done for India.

Notes: For India, the 2005 and 2030 data refers to 2006 and 2031, respectively. The sector energy consumption for India does not include biomass energy consumption (TERI 2006).

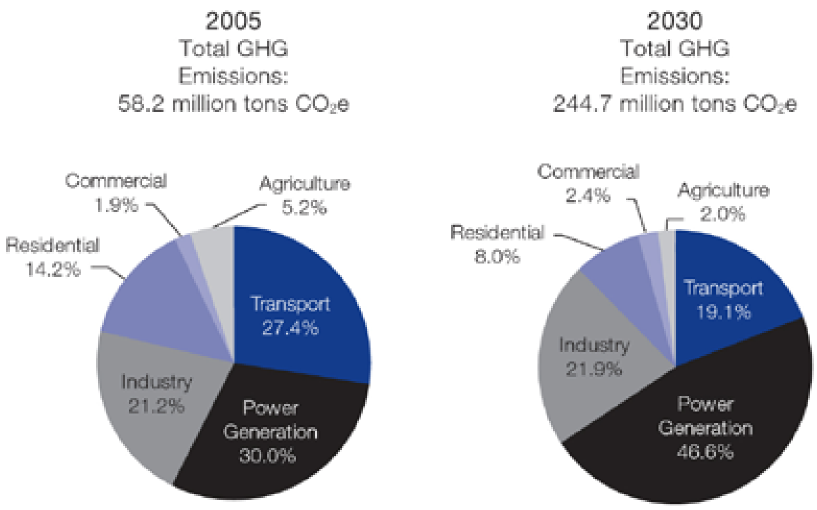
Source: RECCSA1 country reports (unpublished).

Sector GHG Emissions, South Asia (Excluding India), 2005–2030



CO_2e = carbon dioxide equivalent, GHG = greenhouse gas.
Source: RECCSA1 country studies (unpublished).

Sector Shares in GHG Emissions, South Asia (Excluding India), 2005 and 2030



CO_2e = carbon dioxide equivalent, GHG = greenhouse gas.
Source: RECCSA1 country studies (unpublished).

Contributions to Total GHG Emissions of Energy-Using Sectors under Base Case and Carbon Tax, South Asia (%)

	Agriculture	Commercial	Industrial	Power	Residential	Transport	Total GHG Emissions (million t CO_2e)
Bangladesh							
2005	6.7	1.2	23.5	33.5	11.1	24.0	41.32
2030 Base case	2.5	1.4	26.4	50.2	8.8	10.7	168.30
2030 Carbon tax	3.1	0.8	33.2	42.7	6.8	13.4	134.15
Bhutan							
2005	0.3	7.2	38.7	0.3	7.2	46.2	0.33
2030 Base case	0.1	1.6	39.4	0.2	1.2	57.5	2.86
2030 Carbon tax	0.1	1.6	39.5	0.0	1.2	57.6	2.85
India[a]							
2005	*	*	*	*	*	*	1,147.00
2030 Base case	*	*	*	*	*	*	3,314.00
2030 Carbon tax	*	*	*	*	*	*	
The Maldives							
2005	0.0	0.1	5.9	58.8	2.9	30.9	0.68
2030 Base case	0.0	0.2	4.4	31.9	2.3	61.7	2.98
2030 Carbon tax	0.0	0.2	4.4	31.9	2.4	61.4	2.95
Nepal							
2005	4.1	3.9	16.9	1.5	56.1	17.8	5.40
2030 Base case	5.0	5.5	23.3	0.5	27.6	38.1	13.53
2030 Carbon tax	5.1	5.7	23.7	0.8	28.0	36.7	13.16

Total GHG Abatement Potential and Costs from Activities Not Using Energy, South Asia (Excluding India and the Maldives), 2020

Sector/Abatement Option	Assumptions Related to the Abatement Option Used in this Study	GHG Abatement Potential (ton CO_2e) 2020	GHG Abatement Potential (ton CO_2e) Total 2005–2030[a]	Incremental Abatement Cost in 2020 ($/ton CO_2e)[b]
Agriculture	*Subtotal*	*1,369,565*	*33,054,485*	
1. Urea-molasses multi-nutrient blocks (UMMB)	10% of improved dairy cattle can be targeted for UMMB supplementation starting in 2006. The targeted number can be increased annually at the GDP growth rate until 2030 to simulate increasing coverage over time.	101,145	1,995,566	13.51–14.66
2. Urea-treated straw (UTS) feeding for local (indigenous) dairy cattle	10% of local dairy cattle can be targeted for UTS feeding starting in 2006, increasing annually at the GDP growth rate until 2030	60,258	1,431,387	43.66–45.99
3. Flood regulation through multiple aerations	10% of irrigated, intermittently flooded rice land under single aeration can be targeted for regulating flooding through multiple aerations in 2006, increasing annually at the GDP growth rate	933,120	23,133,946	3.01–25.03
4. Draining fields twice in rainfed, flood-prone, and deep water (50–100 cm water level) rice land	Draining fields twice in rainfed rice land was assumed to be a feasible abatement option, targeting 10% of land area under this water management regime in 2006 and increasing the targeted area annually at the GDP growth rate until 2030.	275,042	6,493,586	15.72
Forestry	*Subtotal*	*23,562,699*	–	
5. Conserving existing carbon pools/sinks	Deforestation rate to be reduced by 50% and plantation development to increase by 100% in Bangladesh, Nepal, and Sri Lanka. In Nepal, shrub land regeneration would increase by 50% with adequate protection. In Sri Lanka, the productive and protection plantation would increase by 5% per year. In Bhutan, the regeneration rate of modified natural forests to increase by 50% and plantation development to increase by 100% per year.	15,440,512	–	0.58–194.79
6. Expanding the amount of carbon stored (stocks)		8,122,187	–	14.71–642.96

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Sector/Abatement Option	Assumptions Related to the Abatement Option Used in this Study	GHG Abatement Potential (ton CO_2e) 2020	GHG Abatement Potential (ton CO_2e) Total 2005–2030[a]	Incremental Abatement Cost in 2020 ($/ton CO_2e)[b]
Waste Generation	*Subtotal*	*1,519,329*	–	
7. Recycling	MSW disposed assumed to decrease at 1.0% per year because of recycling. Degradable organic component also assumed to decrease at 1.5% per year because of composting.	620,263	–	1.18–5.48
8. Composting of municipal solid wastes (MSW)		899,066	–	0.42–1.98
Industrial Processes	*Subtotal*	*2,605,542*	–	
9. Post-combustion carbon capture and storage (CCS) in cement production	One new 1 million ton capacity cement plant will be built in 2015 under both business-as-usual and abatement scenarios. In the base case, the new cement plant is structured as any other integrated cement plants. Under the abatement scenario, the plant is assumed to be fitted with carbon capture and storage technology. GHG emissions can be reduced by 77% and 52% through post-combustion CCS and oxy-combustion CCS, respectively. Cost estimates for CO_2 capture are based on costs for Asia (Barker et al. 2009). Costs for CO_2 transportation and storage are based on estimated values for the Indian subcontinent in IEA (2008).	1,555,246	–	139.05–155.78
10. Oxy-combustion CCS in cement production		1,050,296	–	137.24–153.74

– = no analysis, CO_2e = carbon dioxide equivalent, GHG = greenhouse gas.

[a] This refers to cumulative GHG abatement potential for the 2005–2030 period.

[b] The range of incremental abatement cost in 2020 shows the variation across the four countries included in the analysis.

Sources: RECCSA1 country reports (unpublished).

Base Case Total GHG Emissions from Activities Not Using Energy, South Asia, 2005 and 2030 (million tons CO_2e)

	Crop Production	Livestock Raising	Forestry	Industrial Processes	Waste Generation	Total
Bangladesh						
2005	25.86	19.19	(1.34)	2.33	2.04	48.08
2020	29.25	21.05	(1.25)	5.27	3.64	57.96
2030	32.00	22.62	(1.19)	5.53	5.07	64.03
Bhutan						
2005	0.08	0.29	(12.68)	0.28	0.06	(11.97)
2020	0.11	0.54	(13.77)	1.38	0.08	(11.66)
2030	0.15	0.83	(15.44)	2.36	0.09	(12.02)
India						
2005	314.9	213.8	–	–	103.1	631.8
2020*	517.7	242.6	–	–	296.7	1,057.0
2030	730.7	264.0	–	–	600.2	1,594.9
Nepal						
2005	4.72	8.84	(18.78)	0.17	0.09	(4.95)
2020	5.68	10.94	(16.61)	0.86	0.13	1.00
2030	6.43	12.83	(15.81)	1.14	0.15	4.74
Sri Lanka						
2005	3.49	1.34	3.50	0.47	0.57	9.37
2020	4.19	1.45	6.02	2.05	0.59	14.3
2030	4.74	1.54	7.51	4.89	0.59	19.27
South Asia (including India)						
2005	349.05	243.46	(29.30)	3.25	105.86	672.33
2020	556.96	276.56	(25.60)	9.56	301.14	1,118.62
2030	774.02	301.82	(24.93)	13.92	606.10	1,671.02
South Asia (excluding India)						
2005	34.15	29.66	(29.30)	3.25	2.76	40.53
2020	39.24	33.98	25.60	9.56	4.43	61.60
2030	43.32	37.82	(24.93)	13.92	5.90	76.02

– = no analysis, ( ) = negative, CO_2e = carbon dioxide equivalent, GHG = greenhouse gas.

* For India, total figure in 2020 came from Mitra and Battacharya (2002).

Notes:

1. GHG emission from crop production refers to those from rice cultivation, field burning of agricultural residues, and agricultural soils.
2. Livestock raising refers to that of cattle, buffalo, goat, sheep, swine, and poultry. GHG emissions from this sector are those from enteric fermentation and manure management.

Source: RECCSA1 country studies (unpublished).

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