EMISSIONS REDUCTION PROFILE

Lesotho

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Contents

Brief Profile

Full name:	The Kingdom of Lesotho	Major religion:	Christianity
Population:	2 million (UN, 2010)	Life expectancy:	47 years (men), 47 years (women) (UN)
Capital:	Maseru		
Area:	30,355 sq km (11,720 sq miles)	Monetary unit:	1 loti (L) = 100 lisente
Major languages:	Sesotho, English	Main exports	Water, diamonds, clothing, wool, mohair, food, livestock

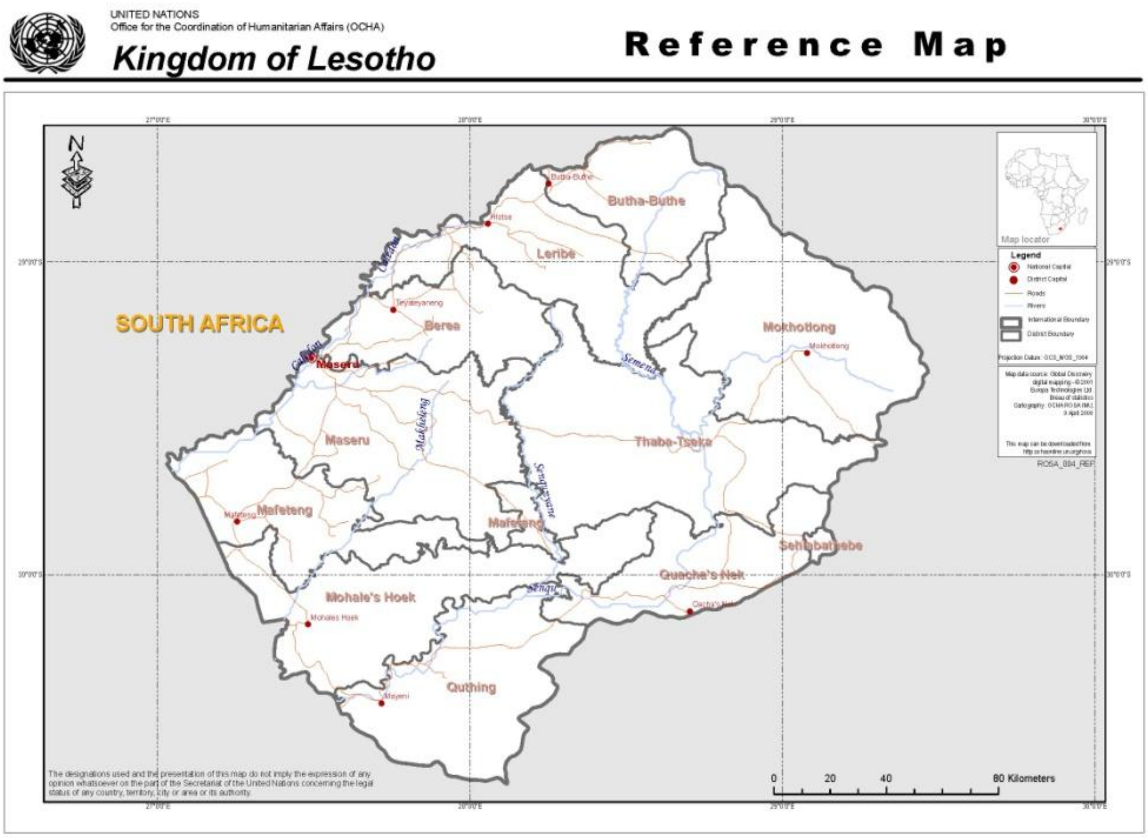

Figure 1. Map of Lesotho[1]

[1] *Office for the Coordination of Humanitarian Affairs (OCHA), UN, 2012.*

The Kingdom of Lesotho is a small, landlocked, and mountainous country, surrounded by South Africa. It gained independence from the United Kingdom in 1966, but remains a member of the Commonwealth of Nations. Lesotho's economy has been heavily dependent on neighbouring South Africa -- specifically on remittances from miners employed in that country, as well as customs duties from the Southern African Customs Union (SACU). The harsh environment of the highland plateau, and the limited agricultural space in the lowlands has left the nation scarce in resources, with the exception of water. Water is the main export of Lesotho in addition to manufacturing, agriculture and livestock. Almost half the nation relies on animal husbandry for their income, while nearly the entire other half relies on some sort of agricultural industry for their well-being. Lesotho also exports diamonds, wool, mohair, clothing, and footwear. Two major American corporations, Levis and Russell Athletics, have facilities located in Lesotho, which has become the largest exporter of garments to the US in sub-Saharan Africa. Lesotho's business is closely linked to that of South Africa, since it is geographically located inside the nation.

Lesotho has created the Lesotho Highlands Water Project (LHWP), which began in 1986. The LHWP is designed to capture, store, and transfer water from the Orange River system to South Africa's Free State and greater Johannesburg area, which features a large concentration of South African industry, population, and agriculture.

Lesotho is completely self-sufficient in electric energy production from hydropower, and exports a significant surplus of electricity production to South Africa. Lesotho has an installed capacity of 73 MW, which is complemented by imports from Eskom. Lesotho Electricity Corporation (LEC) owns and operates the main transmission system as well as small hydropower stations, of which only the Muela 73 MW plant is connected to the national grid. Other sources of energy, such as petroleum, coal and gas, are imported from South Africa.

Economy, Growth and Emissions

In the past few years, Lesotho has embarked on important reforms, mostly related to public financial management, in order to improve efficiency of resource allocation. It also adopted a strategic approach to reduce the public debt to sustainable levels, by using accumulated reserves to service the debt and build adequate levels of international reserves. In the medium-term, the rationalization of expenditures focusing mainly on the productive components, and pegging overall budget to core SACU revenues, will enhance the quality of economic growth. There are fears that the expiration of concessions on textiles, under the World Trade Organization (WTO) in 2012, will affect the country's exports to the USA and hence economic growth in the medium-term. Economic diversification with emphasis on the value chains in agriculture, industry and mining will help mitigate potential risks from the expiration of the WTO concessions, and their impact on the textile industry. These, coupled with the improvement of the business environment, should help to attract investment including FDI, which will impact positively on economic growth in the medium-term.[2]

[2] *http://www.africaneconomicoutlook.org/en/countries/southern-africa/lesotho/*

Lesotho's economy showed signs of recovery in 2009, following the global financial crisis; however, the impact of floods during early January 2011 has slowed the pace of the expected recovery (figure 2-4). Growth was estimated to have reached 3.1% in 2011 (down by 2.5 percentage points compared to 2010) due to recovery of the manufacturing sector, and high demand of diamond exports. Notwithstanding the projected higher import requirements and low Southern African Customs Union (SACU) revenue, in the medium-term, growth is forecast to average 4.8%, driven by investment in phase II of the Lesotho Highlands Water Project, and rehabilitation of infrastructure affected by the floods.[3]

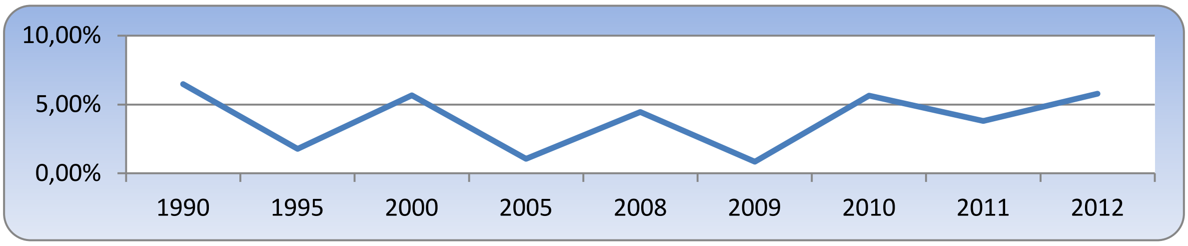

Figure 2. Economic growth since 1990 (GDP percent change)

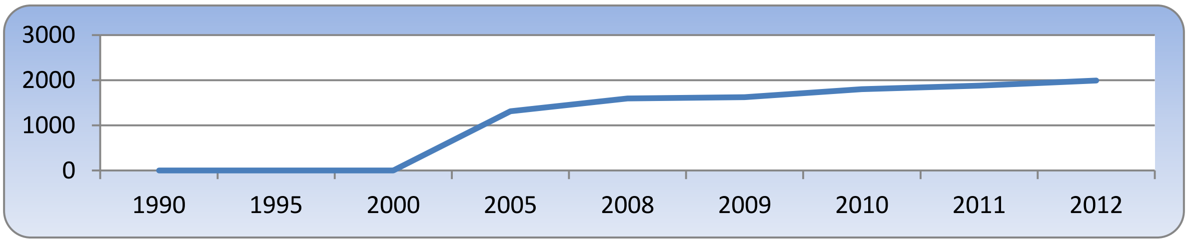

Figure 3. Economic growth since 1990 (GDP USD billions)

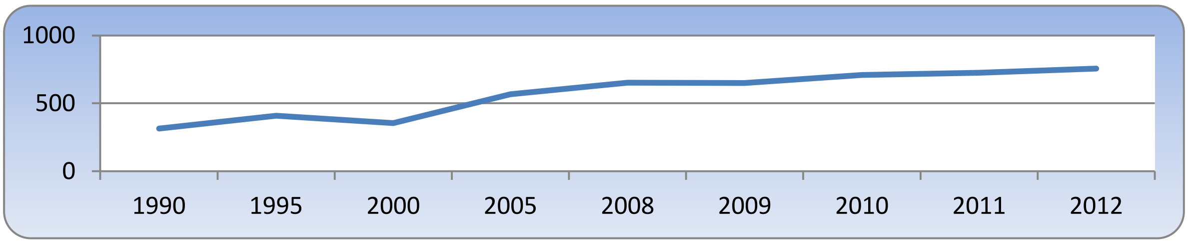

Figure 4. Economic growth since 1990 (GDP USD per capita)

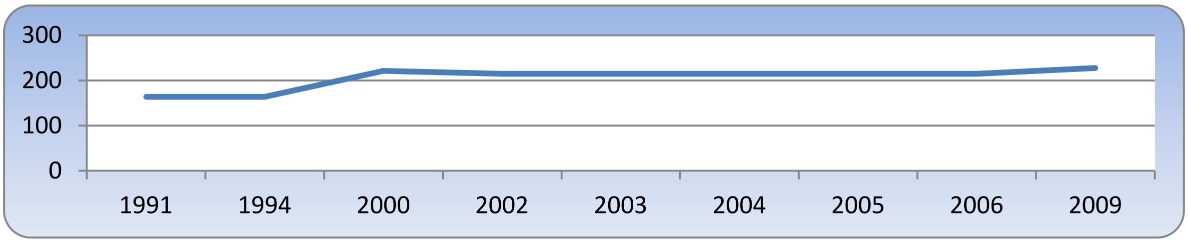

Figure 5. CO_2 emissions per year in $ktCO_2$/year

Lesotho's GHG emissions are minimal due to its predominant dependence on hydropower (Figure 5). The country's grid emission factor is 0.0038 tCO_2/GWh.[4] Other sources of emissions are related to agriculture and husbandry.

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[3] *http://www.africaneconomicoutlook.org/en/countries/southern-africa/lesotho/*

[4] *Analysis of Grid Emission Factors for the Electricity Sector in Sub-Saharan Africa, UNEP Risoe & GFA Envest, 2011.*

Status of CDM Development and Capacity Building in Lesotho

To date, there has been a single CDM project from Lesotho submitted to the CDM registry. It is an energy efficient household project, aiming at distributing efficient wood stoves, capable of reducing the quantity of fuelwood by up to 80%. A review for the project has been requested, but it is expected that the project will prevent the emission of 34,433 tons of CO_2 annually. There have been no capacity development activities for CDM programmes in Lesotho.

Title	Status	Type	tCO_2 reduction/year	Date of submission
Efficient Wood Fuel Stove-Cooking-Sets, Lesotho	Review Requested	Efficient stoves	34,433	17-11-2010

There are also five Programmes of Activities including Lesotho. All of these are currently at the validation stage, and none of the PoAs have as yet included a CPA specific for Lesotho. The overview of PoAs can be seen in the table below.

Name	**Status**	**Type**	**tCO_2 reduction/ year**	**Date of submission**
International Water Purification Programme	At Validation	Water purification	12,488	29-07-2011
Southern African Renewable Energy (SARE) Programme	At Validation	Solar, hydro, wind, geothermal, wave, or tidal power	51,444	16-09-2011
CDM Africa Small-Scale Hydro PoA for Southern Africa	At Validation	Hydro	13,200	26-10-2011
Promotion of Energy Efficient Cook Stoves within Southern African Development Community (SADC)	At Validation	Efficient cook stoves	44,869	23-03-2012
NuPlanet Small-Scale Hydropower PoA	At Validation	Hydro	18,175	04-04-2012

The DNA of Lesotho lies with the Ministry of Natural Services, more specifically at the Department of Meteorological Services.

Overview of CDM Opportunities in Lesotho

Agriculture and Forests

Land-use, land-use change, and forestry are the largest sources of GHG emissions in Lesotho. While the LULUCF sector re-absorbs a large part of its emissions, mainly from the abandonment of managed lands, emissions from the sector stem from agriculturally impacted soils, and grassland conversion. Emissions from the agricultural sector are mainly derived from enteric fermentation and the burning of rangelands. The past few decades have seen an accelerated conversion of the country's lowland grasslands and croplands into villages as a response to population growth and urbanization. Although there has been no quantitative assessment of the scale, this has had significant impact on national GHG emissions. Most of the soil in Lesotho is characterized by a light texture, shallowness, and low organic content, which are all characteristics that reduce the carbon holding capacity.

Economic activities in the agriculture and forest sectors hold significant potential in combating climate change. To begin with, forests are a source of 'negative' greenhouse gas emissions, in the sense that CO_2 is consumed in the photosynthesis process. Therefore, every tree cut effectively increases the CO_2 content in the atmosphere – while every tree planted increases the absorption of CO_2. In the CDM Pipeline there are projects on reforestation, afforestation, and mangroves protection. Forestry projects that have the purpose of reducing CO_2 through 'removals by sinks' are of two types: afforestation or reforestation. Afforestation refers to the establishing of forest on cultivated land that has not been forested in recent history, where the trees capture carbon dioxide from the atmosphere, and fix and store it in the wood tissue. According to the UNFCCC definition, the land cannot have been occupied by a forest for the past 50 years or longer, if a project is to be regarded as afforestation. If a forest has been cut down recently, and intensions are to re-establish it, in part or in full, it is regarded as reforestation. The CDM limits reforestation to areas that had been without forest from 31 December 1989, onward. Projects may also include mangroves that simultaneously serve as coastal protection.

Forest Carbon Options

Afforestation and reforestation of degraded forest lands present a significant potential for climate change mitigation in Lesotho, while generating financial flows from forest carbon activities under the CDM. However, A/R CDM activities have remained underdeveloped, compared to other CDM sectors, mainly as a result of the complexity of the A/R CDM procedure, and the limited market demand for A/R CDM credits. Moreover, CERs from these projects are not eligible in the European Emission Trading System, and only tCERs are issued to A/R CDM projects. Nonetheless, Africa holds a significant share in the global CDM forestry sector by hosting 30% of all A/R CDM activities, which represent 8% of CDM activities in Africa[5], altogether reflecting Africa's potential for abatement in the LULUCF sector.

According to the latest mapping inventory from 2009, the forested area of Lesotho is estimated to be 43,800 ha, which translates to approximately 1.3% of the country's area.[6] This makes the country one of the least forested in Africa; however, there is a clear lack of comprehensive data on the extent of Lesotho's forest cover. Lesotho has no primary forests, and the majority of the forests are naturally regenerated (76%),

[5] *UNEP Risoe CDM/JI Pipeline Analysis and Database, June 1st 2012*

[6] *http://faostat.fao.org/site/377/DesktopDefault.aspx?PageID=377#ancor*

while the remaining 24% consists of planted area. Although there is very low tree cover in the country, indigenous trees and scrubs remain a major source of energy for rural communities, as well as an important source of NTFP.
The main forest resource in Lesotho is 8,000 hectares of forest plantations, which are mostly planted with eucalyptus and pine species. These forest plantations have all been designated as State Forest Reserves, and are used for the production of fuelwood and poles. The area of private forest is not known, but is suspected to be much smaller than this. Currently, there are no forest processing plants operating in Lesotho, and all processed forest products are imported. The government manages all the organized forestry activities, and there are no private forestry companies operating in the country[7]. Lesotho's forests contain 2 million metric tons of carbon in living forest biomass.

Between 1990 and 2010, Lesotho lost an average of 200 ha, or 0.50%, per year.[8] If this trend is reversed so that 200 ha of forest are replanted each year, it could potentially produce nearly 40,000 tCO_2 of emission reductions for each area of 200 ha of tree cover. These rough calculations are based on an estimation of the amount of carbon stored in the country's forests per year to 53 tC/ha, and a conversion factor of 1 ton of biomass carbon to an equivalent of 3.67 tCO_2.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Afforestation/ Reforestation	38,902	AR-AM1, AR-AM3, AR-AM4, AR-AM5, AR-AM9, AR-AM10, AR-AMS1, AR-ACM1, AR-ACM2

Fuelwood

Wood-based biomass is the dominant source of energy for sub-Saharan Africa, and fuelwood consumption per capita is higher in Africa than any other continent. In Lesotho, the bulk of domestic energy consumption is based on fuelwood. Although there is very limited tree cover in Lesotho, the majority of people rely on wood as a source of energy. Cow dung has also been used as a source of energy for generations in Lesotho. This is gathered from the fields, for those who do not own livestock, and from kraals, for those who do.

Firewood

Biomass consumption (wood-energy and agricultural residues) remains the main source of domestic energy, and energy in small-scale commercial sectors. Reducing the demand for firewood is, therefore, an important strategy to reduce drivers of deforestation and, subsequently, the release of GHG emissions. Such strategies include improved fuel-efficient cook stoves, and alternative fuels and techniques for cooking and baking, which altogether might have a significant impact on GHG emissions.

Charcoal

Charcoal constitutes the primary urban fuel in most of Africa, and is a major source of income and environmental degradation in rural areas. The production, transport,

[7] *FAO Working paper: FSFM/WP/03*

[8] *http://rainforests.mongabay.com/deforestation/2000/Lesotho.htm*

and combustion of charcoal constitute a critical energy, and economic cycle in the economies of many developing nations.

Charcoal production releases methane – especially in the traditional open pits process. There are three phases in the carbonization process: 1) ignition, 2) carbonization, and 3) cooling. CDM projects are implemented in two different processes: 1) improving the kiln design for better temperature control and greater control of carbonization variables, which reduce methane emissions, and 2) capturing the methane released from the charcoaling plant, and combusting it to generate electricity (e.g. in a gas engine).

Since charcoal production involves tree removal from forests, sustainable wood supply is an important concern. Therefore, any introduction of efficient charcoal production technologies should only be approved if facilities have allocated dedicated woodlots for sustainable fuelwood plantations. If charcoal is sustainably produced through plantations, and methane emissions are zero, charcoal production becomes carbon neutral, since all emitted carbon would subsequently be sequestered in replanted trees.

The annual charcoal production in Lesotho for 2011 was estimated to be 96,631 t.[9] According to a recently registered CDM project, using renewable charcoal from forest plantations, shifting from traditional open kilns to efficient kilns employing methodology AM0041[10], the anticipated methane emissions reduction per ton of produced charcoal is 0.037 tons[11]. This corresponds to 0.777 tons of carbon emissions reduced per ton of produced charcoal, based on the global warming factor of 21. Assuming that project emissions are zero, and that fuelwood is supplied from sustainable plantations, transforming the country's entire charcoal production from a 100% open kiln production in the baseline would potentially result in emissions reduction of 75,082 tCO_2e/year. Such a project might be viable, but significant uncertainties are associated with this calculation, if not on the actual emissions reduction potential and project emissions, then on the current production methods and the outlook for including the entire charcoal production under one CDM activity.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Charcoal production	75,082	AMS-I.C., AMS-III.K., ACM00021, AM0041

Fuel Production

Agricultural offsets are challenging to achieve, due to: significant scientific knowledge required for project implementation, high uncertainty in emissions factors, no record of baseline data from farmers, monitoring of a vast area, and small size of farmer plots.

Planting energy crops as a biomass stock seems unrealistic for Lesotho due to the availability of agricultural land.

[9] *http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor*

[10] *http://cdm.unfccc.int/filestorage/A/P/Q/APQY8M2DU796JH10G3SKEW5ZR4TBXN/05072010_PDD_Charcole.pdf?t=V298bTZrcmtxfDCc85eDOxwk3EIdOherlYZR*

[11] *http://www.fao.org/docrep/x2740E/x2740e60.pdf*

Waste

The CDM covers a wide range of waste handling projects, from methodologies on domestic manure to methodologies for establishing large-scale incineration plans. Waste project types in the CDM are mainly divided into three categories: agricultural waste, liquid waste, and solid waste. Waste management has a great GHG emissions reduction potential. The potential for reductions lies in two different areas of waste handling: proper disposal of organic matter, that would otherwise emit methane (CH_4), or waste incineration, that can serve to replace energy (both thermal and electric) that would have been produced from fossil fuels.
Organic matter, for instance in the form of waste, emits large quantities of greenhouse gasses, primarily methane (CH_4), if not disposed of properly. The potential for the reduction of these emissions lies in various sectors.

Agricultural Waste

The total agricultural area of Lesotho is 2.304 million hectares[12]. More than 80% of the population is located in rural areas, and almost all depend, to a large extent, on agriculture for their livelihoods. However, there is not enough land to support the existing size of the rural population in agricultural activities. The Ministry of Agriculture considers less than 10% of Lesotho's 3,035,500 hectares arable, and classifies another 66% as grassland and pasture, implying an availability of less than a hectare of arable land per rural family[13]. The average area cultivated is estimated at 1.3 ha, and only 11% of households cultivate more than 3 ha. The field crops in Lesotho are dominated by maize, which accounts for 60-70% of the area planted. The other major crops grown, in order of importance, are: sorghum, wheat, peas and beans. The agricultural sector is being increasingly dominated by livestock activities. The majority of rural households, perhaps over 80%, own livestock -- mainly cattle, sheep and goats. Many also have a horse, two or more donkeys, and chickens[14]. The total amount of livestock units as of 2002 was 451,000[15]. The livestock sector is dominated by smallholders. The average amount of cattle, sheep, and goat per household is 2.5, 43, and 25, respectively [16].
Agricultural residue is biodegradable, non-fossilized organic matter—with the gas captured from its decay—originating from plants, animals, and microorganisms. It is rather costly to gather and process agricultural residues that are to be used on an industrial scale. Due to the poorly developed infrastructure, farm sizes, and their locations (both for livestock and crops), a centralized energy project seems unrealistic. Therefore, another option could be decentralized small-scale solutions, such as domestic bio-digesters.
Slightly more than 40 biogas digester systems were constructed in Lesotho from the early 1980s, with support from FAO and UNESCO, the involvement of the National University of Lesotho, and the Department of Energy. In general, application of the

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[12] *Source: FAOSTAT. Estimated, 2007.*

[13] *UNDP country assessment report : http://www.undp.org.ls/documents/CCA_Final_Document_2005_small.pdf*

[14] Special Report FAO/WFP CROP AND FOOD SUPPLY ASSESSMENT MISSION TO LESOTHO 2002.

[15] *FAO Livestock Sector Brief 2005.*

[16] *Agricultural marketing in Lesotho.*

technology has proved unsuccessful, for a number of reasons, including high initial cost, lack of water, and lack of trained people to maintain the plants. In addition, LP Gas is readily available, making production of biogas less attractive[17].

The residential sector is responsible for 81% (23,933.71 TJ) of the country's total energy consumption (Energy Balance 2000). At the household level, energy is used mostly for cooking, space and water heating, lighting, powering entertainment appliances (radios and televisions), and running small-scale income-generating activities, which are more common in urban areas, due to the relative availability of energy sources. Sources of energy used include: electricity, LPG, paraffin, candles, coal and biomass fuels (fuelwood, cow dung, crop residues, and shrubs). The extent of the usage of different energy sources differs from urban to rural households, depending on the availability of the sources, and the extent of disposable household income. According to the Lesotho Demographic Survey (2001) and the Lesotho Core Welfare Indicators Survey (CWIQ, 2002),[18] about 56% of households in the country use firewood for cooking, 39% use gas/paraffin, 1.6% use electricity, and 3.5% of households use other sources of energy.

About 56% of the total population depends on fuelwood for cooking, and it is assumed that the vast majority of these households are located in rural areas. There are approximately 310,000 households in Lesotho dependent on small-scale farming. If 20% of these rural households (approximately 60,000 households) had the sufficient number of livestock (3-5 cattle) for installing a domestic biogas digester to generate gas for cooking, the traditional use of firewood could be replaced/reduced. By using the suppressed demand method for this potential emissions reduction calculation, and assuming a daily use of 0.5 litres of kerosene for cooking, the potential reduction would be 60,000 households * 0.5 litres * 2.6 $kgCO_2$/litre * 365 days /1000 = 29,200 tCO_2/year.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Domestic biogas	28,470	AMS-I.A, AMS-I.C, AMS-I.D., AMS-III.H., AMS-III.D., AMS-III.F., AMS-III.I., AMS-III.R., ACM14, AM25, AM80

Forest Waste

An analysis by the World Bank showed that 50 MW of additional installed power capacity, or 66% of installed capacity, could be put in place using residues generated from about 2 million tons of roundwood production. Assuming that 20% of the residues that are generated from logging activities could be gathered for power production, a 10 MW biomass power plant could be built. Using the SAPP grid emission factor of 0.9176, and assuming the 10 MW plant runs for 6,000 hours per

[17] Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.

[18] *Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.*

year, there is a potential emissions reduction of 10 MW * 6,000 hours * 0.9176 tCO_2/MWh = 55,000 tCO_2/year.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Forest residues	55,000	ACM6., AMS-I.C., AMS-I.D., AMS-III.E., AM36

Landfills

There is no formal waste management in Lesotho. The waste management in Lesotho is characterized by the absence of a solid waste management system that would coordinate recycling, and an insufficient, informal collection system. Random and illegal dumpsites are used for waste disposal both in rural and urban areas. However, there are reports signifying that even though there is no formal treatment of municipal waste, there are waste recovery centres. A number of private companies are getting actively involved in some aspects of waste management, particularly in collection, sorting, and occasional exporting[19]. According to UNEP assessment, the total mass of waste generated for all residential areas sampled in Maseru city is 84.06 tons per annum[20]. The overall waste generation, by sources of waste under consideration in this study, is 244,832 tons per annum, which includes waste generated by institutions. There is one dumpsite for Maseru city, Tšosane dumpsite, but no landfills. This presents serious obstacles in developing waste-to-energy projects in Lesotho.

Liquid Waste

The centralized sewage treatment plant in Maseru is underutilized, due to the small percentage of households connected to the main sewer line. However, even these small volumes do not reach the sewage treatment plant because of technological and topographic reasons, high maintenance costs, and high operational costs. Thus, most of the households utilize a septic tank. Since 2003, bio-digester installations for households have been distributed by a local NGO (Technologies for Economic Development), with the support of GTZ.

Conventional Power Production

The Lesotho Highlands Development Authority is the main electricity producer through the operation of the Muela Hydropower Station (72 MW)[21]. The national electrification rate in 2011 was 22%, with most of the access in the urban centres – less than 6% of the areas with electricity coverage are rural[22]. The demand has been steadily growing, and in 2011 the peak demand reached 138 MW, while the generation capacity was only 72 MW. As a result, Lesotho Electricity Company, the monopoly transmitter, distributor and supplier of electricity, had to import 66 MW[23] of the needed capacity from Eskom -- a South African power utility.

[19] *Final Baseline Report on Waste Management in Maseru City, 2008.*

[20] UNEP, DTIE, Baseline Assessment of Waste Management in Maseru City.

[21] *Lesotho Electricity Authority, 2012, http://www.lea.org.ls/AboutLEA/Regulatory/Technical.php*

[22] *REEGLE, 2012, http://www.reegle.info/countries/lesotho-energy-profile/LS*

[23] *Lesotho Electricity Authority, 2012, Annual Report 2010/2011.*

Currently, there is no thermal power production planned, however, new generation capacity is severely needed. A proposed project is the Kobong 1,000 MW pumped storage plant in the Bokong area[24]. Any future power project could benefit from Lesotho being a part of the Southern African Power Pool (SAPP), and its corresponding grid emission factor.

Renewable Energy

Studies have shown that Lesotho has a hydropower potential of 450 megawatts (MW). However, only 17% of this potential is currently being exploited, 96% of which is at the Muela Hydropower Station, and the rest from mini hydropower plants at Mantsonyane, Mokhotlong, Tsoelike, and Semonkong in the mountain heartland. Since the commissioning of the 72 MW Muela Hydropower Station in 1999, the country is almost 100% self-sufficient in electricity supply. Nevertheless, as the economy expands, generation capacity will have to be expanded, otherwise the country will be compelled to depend on imports to cover the emerging deficit. Conversely, while Lesotho has 300 days of sunshine a year, current generation of solar energy is estimated to be 65 kW. Moreover, 23 photovoltaic systems are used to power national communication systems, water pumps for rural water supplies, rural clinics, and a number of household activities. Studies are currently underway to assess the country's wind energy potential[25].

In the context of the overall energy balance, renewable energy, excluding large hydropower and biomass, currently plays a small role in terms of total energy consumed. The overall rate of electrification is estimated at 11%. It is the government's view, however, that since about 90% of all households in Lesotho do not have access to grid electricity, renewable energy could play a more important role in enabling households to meet their energy requirements. It should be kept in mind that many Basotho already depend on a mixture of renewable forms of energy, such as wood, other bio-fuels, natural solar heating of buildings, and hydrocarbon fuels, for their basic energy needs[26].

Solar PV

Stand-alone PV installations could provide an electricity source for rural households, tobacco farms, and institutional buildings. Solar photovoltaic (PV) is one of the renewable energy technologies with the highest potential for success in Lesotho. The services relating to renewable energy technologies (including PV) are provided by the private sector in the country; however, there is no local manufacturing[27].

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[24] *Lesotho Electricity Authority, 2012, Annual Report 2010/2011.*

[25] Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.

[26] *Ibid.*

[27] Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.

Solar PV has application in the following areas: solar home systems (including lighting and entertainment), solar PV for clinics and schools (including refrigeration, entertainment and lighting), water pumping, and telecommunications. There are also potential applications for more productive uses, such as cottage industries and small-scale agriculture.
About 1% of total rural households currently use solar home systems. It is estimated that about 4,000 systems are installed in Lesotho. At the household level, solar PV competes with kerosene or candles for lighting, and disposable dry cell batteries or charged automotive batteries for powering radios and televisions. An analysis undertaken by the Department of Energy indicated that about 30% of rural households could afford solar PV if a financing mechanism (whereby owners buy on credit) were in place. The total market for PV installations can be estimated at around 90,000 units, which if replacing the use of kerosene lamps consuming about 0.5 litres of kerosene per day would result in an annual emissions reduction of about 42,700 tCO_2e.
The Department of Energy has developed a code of practice for the installation of solar home systems; however, local solar dealers do not always adhere to the code. There are about 150 medical clinics in the country, the majority of which are in remote rural locations not supplied with electricity. Of these, 32 clinics have been provided with solar PV, although they are in varying states of operation due to poor maintenance arrangements. Furthermore, 43 clinics are provided with diesel generators, but due to high running costs, these are generally underused. The total installed capacity of solar PV in the clinics is estimated to be 25.4 kWp.[28]

Solar PV for water pumping is widely used by the Department of Rural Water Supply for providing potable water to rural communities. There are few cases where individually-owned systems are operated. The main problem experienced by PV water pumping systems relates to theft or vandalism.
At present, there are about 35 systems installed, of which only 11 are working as a result of solar panels being stolen. The DRWS is still installing new systems, and new security measures are being developed. The total installed capacity is estimated at 132 kWp [vii]. Currently, there are about 18 solar PV telecommunication systems installed by Lesotho Telecommunications Corporation (LTC) –now known as Telecom Lesotho (TCL). As with water pumping, theft is a major problem. The total wattage installed is estimated at 67 kWp.

Solar Thermal

The major areas of application for solar thermal are solar water heaters, passive solar design of buildings, solar cookers, and solar dryers. Key users of solar water heaters are both government and private hospitals, and clinics. Nine government hospitals are provided with solar water heaters that have electrical back up. Almost all the clinics have solar water heaters, although most of them are in need of repair due to poor workmanship and lack of equipment, and maintenance standards unsuitable for local conditions. It is estimated that there are about 500 systems

[28] Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.

installed. The lack of a viable financing scheme is perceived to be one of the major obstacles for penetration of the technology. Installed capacity is estimated at 0.22 MW. The largest potential for application of the technology, at the household level, is in the urban areas where electric geysers are used for hot water requirements.

Solar Water Heating

With about 300 days of sunshine, there is significant potential in Lesotho to encourage passive solar design. Passive design was first formally introduced in the country under Thaba-Tseka Integrated Rural Development Project in 1979. Funded by USAID, the Renewable Energy Technology Project (RETP) continued to promote these concepts from 1981, onwards. The concepts are generally applicable (and fundamental) to any building designed for human habitation. Currently, the focus of the Department of Energy, in this regard, is on the residential sector. A code of practice for passive solar design and energy conservation has been developed and published; its implementation is yet to start.

There are significant opportunities in Lesotho for greater use of solar water heaters. Public and residential buildings could be the immediate large-scale rollout targets, where electric water heaters are currently the preferred source of heating. Determination of actual energy savings is contingent upon the emission factor for displaced electrical heating. In a CDM project in India (CDM project no. 3757), it is estimated that one 2 m^2 solar panel results in emissions reduction of 0.7 tCO_2e. A complete shift to solar water heating for the 6.8% of the population in Lesotho that are currently grid connected[29] - converted into number of households – results in a potential of about 27,000 installations (based on an average of 5 persons per household). This calculation assumes that households that are not grid connected do not heat their water with electricity. This is the rural average, while the urban (and grid connected) average may be smaller, resulting in a marginally higher potential number of installations. This translates into about 18,900 tCO_2e annually.

Solar Cookers

While the Appropriate Technology Section (ATS), within the Ministry of Local Government, produces solar cookers, its focus now is on investigating the viability of, and need for, research and development of the technology. The Bethel Business and Community Development Centre (BBCDC) is also involved in production of this technology. Although it has a potential for reducing the burden of fuel shortages, the penetration of the technology has been very slow. In 1993, the technology was ranked lowest on the priority list of technologies that have potential for success in the country. The technology was said to conflict with the norms of Basotho. For example, cooking at midday is at odds with the normal pattern of eating (the main meal is either in the evening or in the morning). However, there is a high potential for application of this technology in schools and institutions. Most schools in rural areas have feeding programmes. Since the meals at schools are taken around midday, the demand matches the availability of the energy source. It may, therefore, be more appropriate that application of solar cookers focus on schools and institutions, rather than on households.

[29] *World Bank, 2011.*

Solar Dryers

Solar dryers are used mainly by rural households for drying vegetables and fruits. In 1993, a socio-economic study found the solar dryer to be the most viable renewable energy technology for Lesotho. ATS, one of the manufacturers of solar dryers, produces about 70 units per annum, and the reported demand exceeds this production rate. The manufacturer now plans to transfer the production of the units to a private entrepreneur. In order to successfully affect this transfer of production, ATS is undertaking training of some individuals who are engaged in meal works business. One such training has been completed in Leribe. In addition to providing training, ATS also undertakes market assessment for the prospective manufacturers, so as to ensure there will be business on this product. There is great interest among the manufacturers on improving their skills in this line of business.

Wind

In the past, low-speed water pumping units have been installed for supplying potable water to the rural communities and individual households. The technology is losing popularity in the country since most of the existing units are neither maintained nor replaced when they are malfunctioning. Of the 43 water pumping units installed in the country, only a few are still operating. It is likely that the lack of maintenance is related to the question of ownership of the units. The possibility for exploiting the wind energy resource has been assessed, after one year of continuous measurements at three different sites, namely: Lets'eng-la-Terae, Phahameng, and Sani Top. This assessment was focused on the large-scale and isolated generation of electricity. The estimated total annual energy production (AEP) for the case study wind farm at Lets'eng-la-Terae is 37.3 GWh. The net annual energy production from the wind farm varies from 3.5 GWh to 3.95 GWh per wind turbine per year, for a wind farm of 10 wind turbines. A 17.5 MW wind farm, established at Lets'eng-la-Terae would be able to produce electricity at a cost of 45 lisente per kWh.

In 2011, Lesotho was expected to begin construction of an $87 million wind farm, the first in the mountainous African kingdom, which would add as much as 30 MW to the nation's electricity grid.

Mini- and Micro-hydropower

Mini- (or micro-) hydropower units consist of systems with capacity of up to 2 MW. At present, there are three mini-hydropower plants, unconnected to the grid, and one connected to the grid with diesel backup. The total installed capacity of these units is about 3.25 MW. An additional 22 sites have been identified for the purposes of harnessing hydropower potential. All the existing units were commissioned less than 10 years ago. LEC owns and operates them, although in most cases, the units are not operating at their full capacity because of drought and siltation. A significant organizational problem associated with the existing mini-hydropower plants is that customers must travel long distances to the LEC office, in Maseru, to pay their bills, since local revenue collection facilities are not available. The existing institutional set-up limits full utilisation of the installed capacity and expansion to increase the customer base. The electricity sector reform presents possibilities for private or community ownership of these facilities.

Other problems are the erratic seasonal flow of the rivers in the country, and serious siltation at the power plants. The problem of siltation is related to the large-scale soil erosion in the country, in that the eroded soil is washed down the rivers to accumulate at dams used for mini-hydropower plants. While soil erosion is a major challenge for the country, beyond the scope of energy policy alone, dam siltation requires regular attention.

The largest hydroelectric power project is the LHWP, which became operational in 1998. It is a partnership between the governments of Lesotho and South Africa that involves a system of several large dams and water tunnels. Prior to the construction of the LHWP, Lesotho imported all of its electricity from South Africa. The Muela Hydropower Station produces all of the electricity in Lesotho, and is capable of generating 72 MW per hour at full capacity. Lesotho is able to meet its electric needs during the summer, and export a modest amount of electricity to South Africa. However, in the winter, which is the peak period for electric demand, electricity is imported from South Africa.

Electricity is supplied by the Lesotho Electricity Company (LEC), which is a government entity that is also responsible for distributing and transmitting electricity. The electrification rate is just 16%. In urban areas, it is 44.0% and in rural areas, it is 6.0%. The government has set a target of raising the electrification rate to 25% by 2015. The electric supply is not always dependable, given the dilapidated nature of the power-generating infrastructure. There has been inadequate investment in new power stations to meet the rising demand. Plans are underway to increase the capacity of the Muela Hydropower Station, as part of the construction of the Polihali Dam. Construction is expected to start in 2011, and the projected cost is $950 million.

Technology type	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Solar PV	42,700	ACM2, AMS-I.A., AMS-I.C., AMS-I.D.
Solar Water Heaters	18,900	AMS-I.C.

Energy Consumption

Greater efficiency in the consumption of energy is commonly an attractive option for emissions reduction, due to its dual benefit of reducing both emissions and the size of the energy bill. However, despite many years of promotion, it is also the most overlooked option. In the CDM, for instance, demand-side energy efficiency projects only make up 1% of the CER generation. There are many reasons for this, including the fact that most developing countries focus on energy access rather than energy saving.

Efficient Cook Stoves

Improved energy efficiency in households is a significant potential source of GHG emission reductions. The household sector is, by far, the largest energy user in Lesotho, accounting for 81% of the country's total primary energy consumption.[30] At the household level, energy is used mostly for cooking, space and water heating, lighting, and powering entertainment appliances (radios and televisions). The

[30] *Energy Balance, 2000.*

predominant source of energy in households is firewood, used for cooking in 56% of households and 67% for heating. Most fuelwood is burned in inefficient, traditional three-stone cooking fires. There has been little adoption of improved stoves, especially in the rural areas. Adoption of improved cook stoves in the rural areas where the firewood is the main source of cooking energy is a viable option. However, it is difficult to estimate how many households are still using traditional three stone fireplaces. Thus, assuming that 25% of households, or about 100,000, are to introduce energy efficient stoves a conservative estimate of the reduction potential is about 200,000 CERs annually (based on 2 tCO_2e per stove per year). In addition, about 67% of all households in Lesotho use biomass fuels as main sources of energy for space heating (while approximately 27% use paraffin), which means that reduction potentials might be higher if the stoves are used not only for cooking, but also for heating.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Efficient stoves	200,000	AMS-I.E. AMS-II.G. AMS-I.C.

Lighting

As hydropower generates all the electricity in Lesotho, the immediate emissions reduction potential in electricity consumption is zero. However, as Lesotho is connected to the Southern African Power Pool (SAPP), and the prospective adoption of a common grid emission factor for SAPP will increase the grid emission factor to 0.92, there could be reduction options -- mainly in lighting. According to the Lesotho Demographic Survey (2001) and the Lesotho Core Welfare Indicators Survey (CWIQ, 2002)[31], only about 10% of households use electricity for lighting, while 56% use gas/oil and about 38% use candles. Reduction potentials in domestic lighting, therefore, are much more significant for individual solar PV systems, than would be the case in a CFL programme. If 40,000 households are using electricity for lighting, and each would install 2 CFLs replacing incandescent bulbs, the reduction potential in a CFL programme would only be about 3,700 tCO_2e per year based on an average saving of 50 kWh per bulb per year (using the SAPP grid emission factor of 0.92).

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
CFL distribution	3,700	AMS-II.E. AMS-II.J.

Industrial Production Processes

Industrial activities cover several industry sectors and reduction options related to energy efficiency, as well as change of processes, and substitution of materials. In

[31] *Lesotho Meteorological Service, Ministry of Natural Resources, Adaptation to Climate Change: Technology Needs in Lesotho. Energy and Land Use Change and Forestry, 2004.*

developing countries, there are many cottage industries, such as small-scale brick production or even household-based productions like textiles, which in most cases are not captured, and do not represent noteworthy emissions reduction options. In many countries, brick kilns are the exception, and may even represent considerable reduction potentials.

Water and diamonds are Lesotho's only significant natural resources. Water is being exploited through the 30-year, multi-billion dollar Lesotho Highlands Water Project (LHWP), which was initiated in 1986. The LHWP is designed to capture, store, and transfer water from the Orange River system, and send it to South Africa's Free State and greater Johannesburg area, which features a large concentration of South African industry, population and agriculture. At the completion of the project, Lesotho should be almost completely self-sufficient in the production of electricity, while also gaining income from the sale of electricity to South Africa.[32]

Diamonds are produced in Leteng, Mothae, Liqhobong and Kao mines. The sector suffered a setback in 2008 as a result of the world recession, but rebounded in 2010 and 2011. It is a major contributor to the exports of Lesotho,[33] and a significant consumer of electricity. However, energy efficiency initiatives are hampered by the current grid emission factor of zero, and would depend on the adoption of the SAPP grid emission factor of 0.92. Energy efficiency and renewable energy programmes are widely used across the diamond mining industry. Emission levels are monitored through energy and carbon emission assessments. Mines have reduced their energy use by introducing a range of schemes: installing timers on boilers, shutting off pressurised fans over weekends, running mud pumps during off-peak periods, and introducing battery-powered vehicles that do not emit harmful gases. Furthermore, solar panels and energy-saving schemes have reduced the amount of electricity used in mines.[34]

Mining company BHP Billiton has established an Energy Smart Program at their Ekati Diamond Mine in Canada's Northwest Territories. This programme has saved the equivalent of 1 million litres of diesel fuel per year, since its inception. Since 1996, the principal electrical energy source for Argyle Diamonds, in Western Australia, has been the Ord River hydroelectric power generator, which supplies up to 94% of Argyle's electricity. This initiative has reduced the emission of approximately 70,000 tCO_2e/year.[35] While the extent and relevancy of such initiatives employed at Lesotho's diamond mines are not clear, the Australian experience indicates the amount of energy used in mining, and that the sector holds reduction potentials.

In the textiles sector, Lesotho has taken advantage of the African Growth and Opportunity Act (AGOA) to become the largest exporter of garments to the US from sub-Saharan Africa, employing over 50,000, workers in mid 2004.[36] While the clothing industry is among the most polluting ones, the actual manufacturing of

[32] *http://en.wikipedia.org/wiki/Economy_of_Lesotho*

[33] *http://www.centralbank.org.ls/publications/Quart%20Review%20Jun%202011.pdf*

[34] *http://www.diamondfacts.org/pdfs/media/media_resources/fact_sheets/Diamond_Mining_Environment_Fact_Sheet.pdf*

[35] *http://www.diamondfacts.org/pdfs/media/media_resources/fact_sheets/Diamond_Mining_Environment_Fact_Sheet.pdf*

[36] *http://www.centralbank.org.ls/publications/Econo%20Review%20June%202011.pdf*

garments is among the least emitting processes in the entire production chain[37] - 10% of the total for a pair of denim jeans, which amounts to about 0.5 kg CO_2e. Therefore, 10 million pairs of jeans would lead to emissions of 5,000 tCO_2e, and if energy efficiency gains in manufacturing could reach 25%, reductions would only amount to little more than 1,000 tCO_2e – which does not yield significant results.

Transportation

The largest city in Lesotho is the capital, with about 250,000 inhabitants. This does not suffice for BRT considerations under the CDM, and is barely enough to consider for emissions reduction, in general. In 2008, oil products made up 10.5% of Lesotho's import, corresponding to about 200 million USD[38]. This equates to slightly more than 2 million barrels, or 300 million litres, if imported as crude oil. Lesotho imports refined oil products at prices estimated to be about 25% higher than the crude price[39]. Emissions from combustion of 225 million litres of diesel (or petrol) are about 90,000 tCO_2e/year. A 50% conversion to biofuels, most likely biodiesel, would lead to emissions reduction of about 45,000 tCO_2e/year. Though most of the cities in the country are electrified, a share of this is used for power generation in small isolated diesel generators, as large portions of Lesotho remain un-electrified with grid power, due to the small demand and very difficult, mountainous terrain. For example, a project that replaces 40 diesel generators powering base stations for mobile telecommunication was estimated to reduce just over 4,000 tCO_2e/year, for a full replacement with wind/solar[40]. The status of biofuels production in Lesotho is uncertain. No activity was reported for jatropha, by 2008[41]. Halving the indicated potential for specific usage only for transport a biodiesel production activity might have an estimated potential for reducing emissions of 22,500 tCO_2e/year, from transport.

Type of Technology	Emission Reduction Potential per year (tCO_2e)	Baseline Methodologies
Biodiesel for transportation	22,500	ACM17, AMS-III.C., AMS-III.T.

Summary

Lesotho has an overall abatement potential of 456,384 tCO_2e. The total investments needed to achieve these reductions can only be roughly assessed, as a sizeable share of the reductions relate to technologies for which no data currently exists -- in terms of their investment to CER-revenue ratio.

[37] *http://www.bsr.org/reports/BSR_Apparel_Supply_Chain_Carbon_Report.pdf*

[38] *http://www.tradingeconomics.com/lesotho/fuel-imports-percent-of-merchandise-imports-wb-data.html*

[39] *http://www.dieselserviceandsupply.com/Diesel_Fuel_Prices.aspx*

[40] *http://www.gsma.com/developmentfund/wp-content/uploads/2012/06/Econet-Lesotho.pdf*

[41] *http://www.jatropha-alliance.org/fileadmin/documents/GEXSI_Global-Jatropha-Study_FULL-REPORT.pdf*

Technology type	Emission Reduction Potential per year (tCO_2e)
Afforestation/ Reforestation	38,902
Charcoal production	75,082
Domestic biogas	29,200
Forest residues	55,000
Solar PV	42,700
Solar Water Heaters	18,900
Efficient stoves	200,000
CFL distribution	3,700
Afforestation/ Reforestation	38,902

These estimates should not be regarded as being precise. Rather, they represent a form of calculation that allows comparison among economies, and their relative attractiveness as destinations for carbon finance.

It should be emphasized that while attempting to be exhaustive, the estimates here do not claim to be all-inclusive. There may be unidentified sources of reductions not included in the technology overview, and not represented by existing methodologies, but in all likelihood these would be minor compared to the potentials identified.

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