Bioenergy Needs Assessment Study in Bhutan – Status, Issues, Concerns and Opportunities

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Executive Summary

The report outlines a need assessment research study on the status, issues, priorities, constraints and opportunities of bioenergy development prospects in Bhutan. The study is funded as part of the regional research initiative under the Technical Cooperation Program Facility undertaken by United Nation's Food and Agriculture Organization Regional Office for Asia and Pacific in Bangkok, Thailand. Similar research studies are carried out in Bangladesh, India, Nepal and Sri Lanka. The research describes the potentials of bioenergy sources, policies, gaps, and utilization options by strengthening the technical understanding and interrelationship between bioenergy usage and food security objectives in Bhutan. Subsequently, the study provides baseline information on existing bioenergy scenario in terms of policies, institutions, availability of bioenergy resources and investment viability options for enterprise development in the country.

Chapter 1 offers a quick overview on the definition and rationale of bioenergy research study in Bhutan and also presents a brief country profile highlighting its development philosophy of Gross National Happiness. Chapter 2 discusses the Renewal Natural Resource sector comprising agriculture proper, livestock and forestry. It highlights Bhutan being a least developed country with majority of the population dependent on the primary sector of farming and backyard livestock rearing. Subsistence agriculture continues as the dominant livelihood support in rural Bhutan with small amounts farm produce sold either in the weekend markets and other modest quantities of cash crops such as oranges and apples exported to regional markets of India and Bangladesh. Similarly, few non-wood forest products like high value mushrooms are exported to Japan and China. The country is working towards developing the renewal natural resource sector in partnership with other stakeholders to address and accomplish food security objectives. Chapter 2 also provides a glimpse on the national food security policy directives and related programs and plans. It also highlights the prevalence of poverty especially in rural areas of the country.

Chapter 3 discusses the energy sector in the country starting with existing policies in the pipeline towards energy diversification and broadening future energy security plans of the energy sector. It highlights the predominance of the relatively cheap supply of hydropower, resulting to a low policy priority for developing other bioenergy sources in the country. It further discusses the energy demand and supply scenarios elaborating on fuel wood consumption and over dependence on it as the main source of fuel particularly in the rural areas. The energy sector as described under Chapter 4 is controlled and managed by the Royal Government of Bhutan through various state owned corporations and agencies. Realizing the over dependence on a single energy

source, the government has initiated a renewable energy policy hinging on two main themes, namely diversifying the energy base and energy security objectives particularly with rising fossil fuel prices. This has provided opportunities towards developing potential enterprises in the biofuel subsector. Biomass constituting woody materials, forest materials, and crop and animal residues are areas examined in terms volume and enterprise viability. According to International Energy Agency (2005), Bhutan has been recorded the highest per capita energy consumption with 0.63 Tons of Oil Equivalent corresponding to 1,174 Kwh per capita per year. Of the total biomass material available in the country, almost 77 percent constitutes fuel wood followed by crop residues amounting to 21 percent. Cattle dung and biogas are other prospects with the country engaging in biogas plant installation with two pilot projects already underway in rural Bhutan. Chapter 4 describes on the needs assessment of bioenergy and potentials in the country focusing on the availability of biomass resources as an alternative source of energy. Subsequent discussions are elaborated on three sources of biomass namely, forest residues, crop residues and livestock residues including farm manure.

Chapter V provides a discussion on bioenergy development vis-à-vis food security objectives and goals in Bhutan. It has been observed that at present, cultivable agricultural land or forest land for human consumption has not competed with growing biofuel plantations. This has been particularly attributed to limiting factors such as limited land area, lack of economies of scale and high cost of production, and limited vertical integration. Nonetheless, it has been observed that there should be no room for complacency but rather build cautionary steps and guard against possible impacts on Bhutan's food security profile in the future from land use competition. In order to do so, important linkages between food security, land-use, biodiversity and water resources must be fully understood. This requires an analysis of a range of environmental, social and economic factors and that no particular option should allow any detrimental impact on food security either directly or indirectly. Although preliminary conclusions on economies of scale and the vertical integration required for biofuel production allows little scope for viability of enterprises. Furthermore, insufficient drivers constitutes conservative policies, e.g mandatory 60 percent forest cover, non-availability of minimum biomass volumes and quantities and threat towards biodiversity and water resources from encouraging exotic mono cropping species.

Abbreviations

AMS	Agriculture Marketing Services
BEA	Bhutan Electricity Authority
BEFS	Bioenergy and Food Security
BCCL	Bhutan Carbide Chemicals Limited
BFAL	Bhutan Ferro Alloys Limited
BPC	Bhutan Power Corporation
DOE	Department of Energy
DOF	Department of Forest
DOL	Department of Livestock
DOT	Department of Trade
DGM	Department of Geology and Mines
DGPC	Druk Green Power Corporation
GEF	Global Environment Facility
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GJ	Giga Joules
GOI	Government of India
GNH	Gross National Happiness
FAO	Food and Agriculture Organization
FAORAP	Food and Agriculture Organization Regional Office for Asia and Pacific
FRDD	Forest Resources Development Division
FMU	Forest Management Units
FYP	Five Year Plan
IEA	International Energy Agency
KWH	Kilo Watt per Hour
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MOEA	Ministry of Economic Affairs
MOAF	Ministry of Agriculture and Forests
MSW	Municipal Solid Waste
MU	Mega Units
NRDCL	Natural Resource Development Corporation
NSB	National Statistical Bureau
NTFP	Non Timber Forest Products
PAR	Poverty Analysis Report
RGOB	Royal Government of Bhutan
RNR	Renewal Natural Resource
SNV	Netherlands Development Assistance
TCP	Technical Cooperation Program
TCPF	Technical Cooperation Program Facility
TERRI	Energy Resource Institute
TOE	Tons of Oil Equivalent
UNDP	United Nations Development Program

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I. Introduction

1.1 What is Bioenergy?

Bioenergy is energy produced from biomass such as energy crops, forest residues and organic wastes. When biomass is produced in a sustainable manner, it is a renewable energy source. It stores chemical energy that can be used to produce power and heat as well as liquid and gaseous fuels (*FAO, 2008, HLC/08/INF/3, page 1*).

Definitions

Biomass: *non-fossil material of biological origin, such as energy crops, agricultural and forestry wastes and by-products, manure or microbial biomass.*

Biofuel: *fuel produced directly or indirectly from biomass such as fuel wood, charcoal, bioethanol, biodiesel, biogas (methane) or biohydrogen.*

Bioenergy: *energy derived from biofuels.*

1.2 Why Bioenergy Needs Assessment Study in Bhutan?

As part of the regional initiative under the Technical Cooperation Program (TCP) Facility undertaken by United Nation's Food and Agriculture Organization (FAO), Bhutan has been extended technical assistance to conduct a needs assessment on the status, issues, priorities, constraints and opportunities of bioenergy development prospects in the country. The TCP Facility initiative covers similar assessment studies in Bangladesh, India, Nepal and Sri Lanka.

Corresponding to the Royal Government Bhutan's needs, the study intends to outline the potentials of bioenergy sources, policies, gaps, and utilization options by strengthening the technical understanding and interrelationship between bioenergy usage and food security objectives in the country. Subsequently, the assessment study is expected to provide baseline information on existing bioenergy scenario in terms of policies, institutions, availability of energy resources and viability options.

The study has been commissioned to Mr. Sonam Tobgay[1], Founder/Principal Consultant of Thimphu Consultants International Ltd. through a direct

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procurement from FAO's Regional Office for Asia and Pacific (FAORAP). Collaborations are held with Ms. Delgermaa Chuluunbaatar, Agriculture Officer for Biofuel and Industrial Crops and Mr. Damen Beau, BEFS Expert both working at the FAO Regional Office for Asia and Pacific in Bangkok. Ms. Bindu Tamang, Policy and Planning Division of the Ministry of Agriculture and Forests has been instrumental in addressing logistical concerns. Refer to Annex 1 for Terms of Reference.

1.3 Brief Country Profile and Development Philosophy

Bhutan the size of Switzerland is located in the Eastern Himalayas neighboring China and India in South Asian subcontinent with a population estimated at 700,000 (*NSB, Bhutan 2010 Datasheet*) and maintains an approximate 72 percent forest cover. Agriculture is the main source of livelihood with 65 percent of the population depending on subsistence farming as an important sector and holds the potential of broad based and pro-poor growth, furthering one step towards poverty reduction and food self-sufficiency. According to Statistical Year Book of Bhutan 2009, agriculture contributed 18.5 percent to the total Gross Domestic Product (GDP) in 2008. Agriculture in Bhutan constitutes agriculture proper, livestock and forestry services. Other sectors gaining gradual momentum constitute the construction industry and hydropower projects followed by high end tourism.

A least developed country, Bhutan has been ranked 132 out of the 182 countries on the United Nations Human Development Index with life expectancy of 69 years, and adult literacy rate recorded at close to 60 percent. Poverty continues to prevail at 23 percent (*PAR, 2007*) with the government pursuing objectives to address issues and concerns on household food security, quality of health facilities, quality of education and skillful employment, public transportation systems and road networks and income disparity. The country has recently transitioned into a parliamentary democracy with 47 constituencies distributed across the 20 districts.

The country is developing rapidly with increasing concentration on developing hydroelectricity[2] with strong support from the Government of India (GoI) and

[2] Hydropower resources in the country have been estimated at 30,000 megawatts. Hydropower has a dominant role in Bhutan's economy, even while increasing Bhutan's reliance on a single commodity exported to a single market and strengthening the role of the public sector in the economy. The Government aims to achieve 85.6% electrification by 2013 and develop 5,000 megawatts hydropower generation for export to India by 2020. Currently, Chukha hydropower dam generates 336 megawatts, Kurichu dam 60 megawatts, Tala hydropower 1020 megawatts. There are plans to build Amochhu with 620 megawatts generating capacity, Kuri Gongri with 1800 megawatts, Chamkharchhu-I with 670 megawatts, Kholongchhu with 486 megawatts, Wangchu storage 900 megawatts, Bunakha storage 180 megawatts and Sunkosh storage 4000 megawatts. Punatshangchhu I&II combined has a total generating capacity of 2200 megawatts. (Source: http://www.dgpc.bt).

other developmental partners. Starting from the First Five Year Plan (1961-1965) period till the current Tenth Five Year Plan (2009-2013), Bhutan has achieved considerable progress in its socio-economic development. This can be exhibited with the per capita gross domestic product soaring US$ 1,514 in 2007 as compared to US$ 639 in 1998[3].

However, formidable geography poses serious challenges, with elevations ranging from 100 to 7,500 meters above sea level, steep slopes, and the small size and dispersion of the population greatly increasing the marginal cost of providing services. Many villages are small and isolated, located several days walk from the nearest motor road. Indeed, improving access to health, self sufficiency in food, education development, markets and economic opportunities is one of the defining development issues in Bhutan's 10th FYP.

Although urbanization is continuing rapidly, almost 70 percent of the population lives in rural areas; and urban areas, such as the capital city - Thimphu (population of about 80,000), is expanding with basic urban infrastructure struggling to keep pace. This makes it difficult for the people to take advantage of economies of scale, and the majority of employment remains in agriculture, much of it in isolated subsistence activities. With Government of India assistance, hydropower resources are rapidly being developed, accelerating socioeconomic development through export earnings. Environmental considerations are high on policy makers' agendas, with any logging tightly controlled and over 60 percent of the country's land area to be preserved under forest cover in perpetuity. These factors frame the unique development opportunities and challenges faced by Bhutan.

Bhutan's distinctive approach to development is guided by the overarching philosophy of Gross National Happiness (GNH), propounded by the Fourth Monarch in the late 1980s. It is based on the four pillars: promotion of equitable and sustainable socio-economic development, preservation and promotion of cultural values, conservation of the natural environment, and establishment of good governance. The GNH development philosophy emphasizes the importance of balancing material, spiritual, emotional and cultural well-being as elements that together bring happiness to the individual.

These aspirations are further articulated in the document Bhutan 2020: A Vision for Peace, Prosperity and Happiness, which was prepared in 1999 through a highly consultative process involving representatives from the RGOB, the private sector, the non-governmental organizations, and the community. It seeks to translate the notion of GNH into a series of national objectives emphasizing: (i)

[3] Annual Report of the Royal Government of Bhutan presented by the Prime Minister at the National Assembly on June 2007, Annexure page 1.

human development, (ii) cultural heritage, (iii) equitable development, (iv) good governance, and (v) environmental conservation. Similar to the enunciation of the Millennium Development Goals (MDGs), Bhutan 2020 also lays out several long-term targets, such as providing electricity to 50 percent of the rural population, or ensuring that 75 percent of the rural population lives within half a day's walk from the nearest motor road by 2012. The development path is further elaborated in sector policies, strategies and programs through the planning process, most recently the 10th FYP document.

II. Agriculture Sector and Agriculture Sector Policies in Bhutan

Agriculture continues to provide a broad base of the Bhutanese economy with a majority of the population living in rural areas and primarily dependent on subsistence agriculture for their livelihood. Precisely, about three-fourth of the Bhutanese are essentially subsistence farming households, deriving income from sources consisting of farm income and agriculture wage labor. Cultivable land which is a main asset for smallholder households is already in short supply with an average land holding size of 0.89 hectares (Tobgay & McCullough, 2008). Per capita availability of agricultural land in Bhutan is one of the lowest in the world, even though the population density is also one of the lowest. Consequently, the prospects for agricultural expansion are constrained by a lack of arable land along with inadequate technology, poor road access and high transaction costs. Nonetheless, the sector engaging 44.4 percent[4] of the labor force holds high potential to have a relatively wider impact on poverty reduction assuming the right investments are made in the key niche areas of high value agriculture, non-farm income generation activities and developing strategic rural infrastructure and markets. According to RNR Census 2009, total agricultural land holdings are recorded at 94,903 hectares, wet land cultivation constitutes 20.57 percent estimated at 19,523 hectares. Main agriculture inputs used are commercial fertilizers in addition to farm manure with extension services provided by the Department of Agriculture on food farm management practices. Farm mechanization is limited to small diesel engine power-tillers and foot pedal rice threshers.

2.1 The Renewable Nature Resource Sector

The Renewal Natural Resource (RNR) sector in Bhutan is dominantly a rural phenomenon integrated into rearing backyard cattle and poultry, crop production including cultivation of rice, maize, chilies, potato, apples and

4 Labor Force Survey 2006, MoLHR, 2008

mandarin as major crops. About 69.1[5] percent of the population still continues to dwell in the rural areas dominated by smallholder farmers. Smallholder farmers are farms with less than the average agricultural size of 0.89 hectares not including less productive types of landholdings (Tobgay & McCullough 2008). Typically, these households are characterized as low income and resource poor, with relatively high vulnerability to economic and climatic shocks.

The RNR sector comprising agriculture proper, livestock and forestry constitute an important component in Bhutan's socioeconomic development and growth. While the contribution of the RNR sector to GDP has been declining[6] and is likely to decline even further in the future, it continues to be an important sector, particularly in the context of improving people's livelihoods and reducing poverty levels. This has been proven with the main thrust of the Ministry of Agriculture and Forest's tenth plan dedicated to enhancing sustainability of rural livelihoods through increasing agricultural productivity and transforming subsistence agriculture to small scale commercialization guided by the broad strategic approach of enhancing production, improving accessibility and promoting markets and marketing.

The majority of farmers are still using traditional cultivation techniques and limited application of inputs or improved seed. Poor land preparation and cultivation practices, low quality and often mixed seed and poor post harvest processing and storage all contribute to low yields and poor quality produce. Cropping intensity is low, incorporating mixed farming system of crop and livestock interfacing forest. Further, the lack of infrastructure limits Bhutanese farmers from producing more than that is actually required for their own consumption. Essential farm infrastructure like adequate irrigation facilities, farm roads, rural electrification, market information systems, research and extension are some of the key factors towards a prosperous agricultural sector.

2.1.1 Markets and Products of Export

In the absence of household market consumption data, comprehensive and precise estimates on consumption are non-existent. Markets for Bhutanese goods can be categorized broadly into domestic markets, regional markets and extra regional. Domestic market comprises mainly of weekend markets that is fast expanding and open to cheaper food imports mainly from India. Bhutanese domestic market is small and can easily be overburdened with excess supply experiencing price declines.

[5] Out of the 634,982 persons, 438, 871 are living in the rural areas, Population and Housing Census of Bhutan, 2005, RGOB.
[6] The share of the agriculture to GDP has declined from 22.6 percent in 2005 to 18.6 percent in 2007 (NSB, 2008).

Regional markets are geared towards Bangladesh and India for exporting apples, mandarin and off-season vegetables. Cash crops like potatoes are sold primarily through the auction market, whereas small surpluses of vegetables are sold in the district and weekend markets. Weekend markets are mostly referred to the main vegetable markets of Thimphu, Paro and P/Ling, while district markets are referred to the weekly markets conducted in respective districts.

As presented in Table 1, rice and maize are important staples recording an average annual production of 67,688 metric tons and 79,346 metric tons respectively. Potato a major cash crop has an annual average production of 57,545 metric tons and mandarin at 51,978 metric tons. Total production capacity of major crops aggregated results to roughly 282,522 metric tons. Compound average growth rate has shown highest for mandarin with close to 23 percent increase, while maize experiences negative growth rate, possibly contributed by wild animal crop damage and lack of active farm labor. Rice has witnessed a dramatic increase of 26 percent in 2007 as compared to production figures of 54,326 metric tones in 2004.

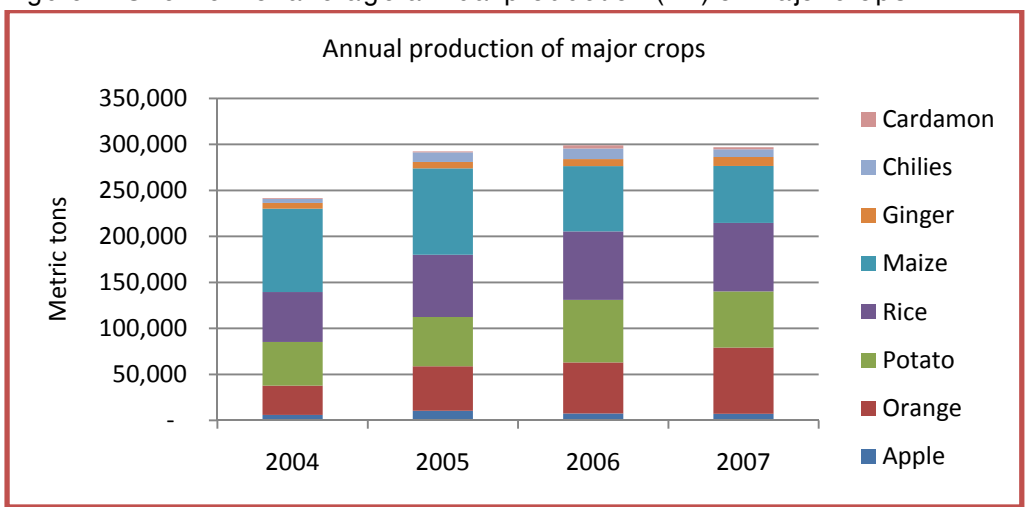
Import of rice in 2007 was recorded at 7,414 metric tons while import of dairy products (constituting butter, cheese and milk), was recorded at 3,038 metric tons according to Bhutan Trade Statistics, 2004-2007 figures. Currently, the Ministry of Agriculture and Forests claims the country is 50 percent self sufficient in rice production with the remaining 50 percent met through imports from India and Thailand. The draft Food and Nutrition Security Policy 2010 states 65 percent of the cereal requirement in the country is met by domestic production. However, rice is the main cereal consumed in the country and constitutes 60 percent of the cereal demand. It has been noted that domestic production is only able to meet 48 percent of the rice demand.

Table 1. Production in metric tons of major crops, 2004-2007.

Year	Apple	Mandarin	Potato	Rice	Maize	Ginger	Chilies	Cardamom	Total
2004	5,917	31,915	47,403	54,326	90,566	6,225	4,455	814.6	241,622
2005	10,421	48,367	53,594	67,606	93,968	6,901	10,447	1,190	292,494
2006	7,406	55,558	68,048	74,380	71,062	7,571	11,606	3,477	299,108
2007	7,076	72,071	61,133	74,438	61,789	9,870	8,368	2,121	296,866
Avg	7,705	51,978	57,545	67,688	79,346	7,642	8,719	1,901	282,522
CAGR	4.57%	22.59%	6.57%	8.19%	-9.12%	12.21%	17.07%	27.03%	

Source: Agriculture Statistics of 2004-2007.

Figure 1. Overview of average annual production (MT) of major crops.



Source: Agriculture Statistics various sources, AMS.

Mandarin and potato provide the highest export earnings recorded jointly close to US$ 10 million as shown in Table 2. However, sustainability on such positive outlook for the two export crops will largely depend on the vagaries of the weather, disease outbreaks and avoidance of wild life depredation. Processed fruit juices plough in US$ 2.68 million per annum followed by apple generating US$ 1.3 million per annum respectively. Ginger, cardamom and mandarin show promising export potential ranging between US$ 0.44 to 0.67 million. Small volume of rice exports are gradually picking up averaging 60 metric tons of exports to USA, Germany and United Kingdom annually valuing close to US$ 100,000 million. The total export market comprising prioritized products listed in Table 2 is estimated at US$ 14.66 million.

Table 2. Summary of production and export, 2004-2007.

	Avg. MT	Nu ('000)	$ value
Apple production	7,805	-	-
Apple exports	4,387	57,690	1,311,367
Mandarin production	50,784	-	-
Mandarin exports	18,535	218,441	4,965,460
Potato production	54,043	-	-
Potato exports	63,659	194,473	4,420,636
Rice production	57,467	-	-
Rice exports	59	4,353	98,959
Cardamom exports	371	22,171	503,967
Ginger exports	858	29,751	676,290
Fruit juice exports	4,080	118,059	2,683,640
Total	*262,050*	*644,937*	*14,660,319*

Source: Bhutan Trade Statistics, 2004-2007.

Similarly, non-timber forest products (NTFPs) play an important role in the daily lives and overall well being of the Bhutanese people especially among the rural farming community; for instance they are a major source of off farm income[7], food, medicine, fodder, fiber, and also used for local construction materials. Many of them are importantly traded commodities at local, national and international levels, providing employment and income at each level. The country has proven a haven for a wide array of NTFPs and to date more than 600 medicinal plants[8], 97 mushroom, 97 fruits and nuts, 34 bamboos, 14 canes, 25 oil/resin species, 20 species, 38 fibers, 70 ornamental plants, 181 fodder species, 36 dyes, 12 food crops (yams) and 77 forest vegetables have been identified and described (FRDD, 2008).

The most commercially important NTFPs exported are high value *matshutaki* mushroom *Cordyceps sinensis*, Himalayan incense (*Poe*) and lemon grass extract[9]. Attractive markets for *matsutaki* mushrooms are in Japan, Singapore, Thailand and United Kingdom. Bhutanese essential oils have been well received in the European markets with growing demands from United Kingdom and Canada. Incense sticks in Singapore, Taiwan, United States of America, United Kingdom and Hong Kong. *Cordyceps* are in huge demand from Hong Kong, Singapore, China and in the state of California in the USA.

Table 3. NTFP export in quantity and value.

	Average exports, 2004-2007		
	Vol (MT)	Value ('000 Nu.)	Value $
Other mushroom	2	3,967	90,176
Cordyceps	334[10]	1,483,971	1,483,971
Matshutaki	3	5,240	119,122
Lemon grass extract[11]	111	1,285	29,202
Incense	1	169,045	3,842,633
Total	*451*	*1,663,508*	*5,565,104*

Source: Bhutan Trade Statistics, 2004-2007, BAFRA, AMS, MoA.

As seen from Table 3 Himalayan incense or locally known as *Poe* ranks the first export product with value ranging close to US$ 4 million dollars per annum. *Cordyceps* is second with an average quantity of 334 kilograms earning US$ 1.5 million per annum. Total NTFP comprising the products listed in Table 3 constitute US$ 5.6 million per annum average.

[7] Farmers from Mongar, Lhuentse, Trashigang, and Trashiyangtse earned an income worth Nu. 51, 247,045 from the sale of lemon grass extract according to reports from Essential Oils Industry of Bhutan: A Perspective by EODP, 2004.

[8] Of which 267 or 85% of the species are collected for ingredients in traditional medicine by ITMS.

[9] Eastern Bhutan has the capacity to sustainably produce 50 MT lemongrass oil a year. If this could be realized it would capture about 10 per cent of the world market (Dhungyel, D 2002).

10 In Kilograms

[11] Volume is in actual liters.

Corydceps export value experiences a compound annual growth rate of 22.28 percent over last six years starting 2004 with an average total export value worth US$ 1.5 million. About 90 percent of the harvest is exported through local auctions organized by the Department of Agriculture Marketing and Cooperatives once a year. There is limited data on the remaining 10 percent that has not been auctioned and one could assume collectors either consuming it personally for medicinal purposes or engaging in informal trading both inside the country and across the northern borders to Tibet-China.

Livestock in Bhutan like in most developing countries play a vital role in agricultural development in rural economies and is a key element in the agricultural production system. Livestock statistics reveal annual production of fresh milk recorded at 20,748 metric tons worth US$16.5 million. Similarly, fresh cheese ranks second in production constituting 6,399 metric tons annually worth US$15.3 million. Local butter is estimated at 1,351 metric tons per annum worth over US$ 6 million, while pork and beef production estimated at US$ 1.5 each respectively. Total value of dairy production as shown from Table 4 is estimated at US$ 41.37 million also representing the size of the internal dairy and livestock market.

Table 4. Production quantities and value taken over 2006 and 2007 data.

	Qty. MT	Nu/MT	Nu. Value	$ value
Butter	1,351	200,000	270,266,000	6,143,526
Cheese	6,399	105,000	671,888,700	15,272,975
Milk	20,748	35,000	726,194,350	16,507,418
Pork	521	120,000	62,530,800	1,421,413
Beef	610	110,000	67,150,050	1,526,415
Yak meat	109	200,000	21,872,000	497,181
Total	*29,740*		*1,819,901,900*	*41,368,928*

Source: Livestock Statistics 2006, 2007.

Local production is supplemented through imports recorded worth US$ 12.47 million per annum including fish and eggs. Tetra pack milk and milk powder constitutes the highest imports worth US$ 4.3 million with overall imports estimated at US$ 12.49 million.

2.2 National Food Security Policy

Food security in Bhutan is very much an issue of access to resources and economic opportunities. For the rural households who make up about 69 percent of the population, it is particularly a matter of stable access to land and water as the basic resources from which to produce their own food. For the urban and non-farming rural population and the landless households, it is about economic opportunities to earn a living through productive employment. Therefore, the strategic approach to food security starts by identifying the size and location of the population and defining the various population groups in terms of their capacity to cope with food insecurity. Distance to markets and poor infrastructure can significantly influence what resources individuals can command to produce or access to food.

Food security is also a cross-cutting theme in the RNR Sector and the relevant policy objectives and strategies contained in the documents pertaining to the Tenth Five-Year Plan 10th FYP (2008-2013). These include the sub-sectoral planning documents of the Ministry of Agriculture and Forest on arable agriculture, horticulture, forestry and livestock. Each of these volumes has a bearing on food security issues and contributes to the Royal Government of Bhutan's overall food security policy objectives and strategies. Furthermore, food security for the people of Bhutan has long been recognized as a primary objective of the Royal Government of Bhutan (RGOB) through broad based macroeconomic interventions focusing on scaling up production, increasing availability of nutritionally adequate and safe food, and improved access to acquire food.

Policies have been outlined with respect to improving availability, enhancing accessibility and promoting nutrition. A focus has been put on improving food availability, targeting food grain self-sufficiency and increasing domestic production of rice and other major cereals although there is still a need for diversification of production, including increasing vegetable and horticulture production.

As an alternate to achieving food security and rural development, the Ministry of Agriculture and Forests has launched the One Geog Three Products small business concept, as a viable vehicle by which the lower income groups in the economy can gain access to economic opportunities through increased production and improved market linkages. Such a strategy emphasizes as one of the potential and effective instruments in promoting rural economic development resulting to an efficient absorption of subsistence farmers into the mainstream economy. Recent initiatives are taken on "compact signing" as

part of a national strategy to focus on key commodities with well developed supply chains reinforcing institutional responsibilities and accountability.

The strategy to meet the food security commitment includes implementing policies and practices to:

- alleviate poverty and improve physical and economic access of the poorest and most vulnerable to sufficient, nutritionally adequate and safe food;
- ensure agricultural trade is conducive to fostering food security for all, through an open market-oriented world trade system;
- promote rural development, including sustainable agricultural, livestock and forestry production and management of natural resources;
- undertake agricultural research and development;

2.3 Poverty in Bhutan

Poverty is another predominant factor that influences food security in Bhutan. Rural poverty continues to be Bhutan's most challenging problem and the most critical constraint on its economic development. Like elsewhere in South Asia, poverty in Bhutan is disproportionately concentrated in rural areas with 31 percent poverty prevalence in rural villages (Source: PAR, 2007). Rural poverty trends vary considerably by *dzongkhags* with Zhemgang, Gasa, Pemagyatshel, Dagana, and Samtse being the most vulnerability as compared to the other *dzongkhags*. Over time, the poverty gap between rural and urban is widening with a geni-coefficient ratio of 0.35[12]. A major reason for this rising inequality is the growing disparity in economic growth arising from a concentration of economic activity in certain areas to the exclusion of others. Less-favored areas and disadvantaged groups (women, indigenous peoples) face many problems related to production and market access. An important problem is personal immobility, which frequently impairs responses to changing incentives. Rural poor in remote areas find access to markets restricted by high transaction costs and by their lack of knowledge of market mechanisms, a consequence of lack of information and organization. The situation is further affected by the structure of the markets themselves, the limited market intermediaries and asymmetrical market power.

[12] The gini-coefficient is a measure of the inequality of a distribution, a value of 0 expressing total equality and a value of 1 maximal inequality. It is most commonly used measure of inequality using the Lorenz curve.

Typically, rural livelihood in Bhutan is supported by farming which is characterized by inherent interdependence among forests, livestock and agricultural enterprises. Therefore, enhancement of rural livelihood will involve improvement of economic returns from these enterprises. Improvement of economic value of farm enterprise is to be pursued through intelligent development, utilization, and management of forest, agriculture and livestock resources as a step towards poverty alleviation.

Since poverty in Bhutan is a massive problem, its sustained reduction will be crucial in achieving the Millennium Development Goal of halving poverty by the year 2015. Poverty in this country is basically a rural problem, as the overwhelming majority of the poor lives and work in rural areas. Therefore, for rural poverty reduction, key interventions are enhancing access of the poor to productive resources (land, water, and forests), technology, financial services, and markets, and to strengthen the capacity of the rural poor and their organizations. Given the geographical and social concentration of poverty among certain areas and groups of rural poor, it is suggested that rural poverty reduction efforts should focus on the less-favored areas (remote uplands and mountains, marginal areas and vulnerable *geogs*) and on socially marginalized groups such as women, and indigenous peoples. While the causes of poverty in Bhutan have yet to be thoroughly studied, there is consensus that poverty is linked to low economic growth and inadequate income-generating opportunities, particularly in rural areas of Bhutan.

III. The Energy Sector in Bhutan

Hydropower is the largest renewable energy resource in Bhutan with an estimated known potential of 30,000 megawatt, but only about 1,480 megawatt has been harvested at the time of writing. While hydro-power is the largest identified source of electricity in the country, at present it can only meet a fraction of the country's demand for energy. Bioenergy in the form of fuel wood is the by far the largest source of energy in Bhutan providing close to 60 percent, while electricity provides close to 16 percent. The remaining 24 percent of the energy resource is provided by imported petroleum products.

Department of Energy (DoE) under the Ministry of Economic Affairs (MoEA) is responsible for the formulation of energy and power sector policy, plans, programs and guidelines and regulations for hydropower and other sources of alternative energy. DoE also governs and facilitates integrated development of a sustainable and robust energy sector that drives the national economy and meets the demand for quality modern energy services of the Bhutanese society. The Department of Trade (DoT) handles import of oil and other petroleum

products while the Department of Geology and Mines (DGM) manages and controls mining of minerals and coal. Ministry of Agriculture and Forests (MoAF) and Natural Resource Development Corporation Limited (NRDCL) are responsible for the supply of biomass materials. Other institutions involved in the energy sector include Bhutan Power Corporation (BPC), Druk Green Power Corporation (DGPC) and Bhutan Electricity Authority (BEA).

3.1 National Energy Policy

It can be seen as being derived from an overarching national vision aiming to promote socio-economic development of the nation through optimum development of the energy sector particularly the hydro-power, giving due regard to the principles of sustainability, protection of environment and conservation and rational use of natural resources. An overarching national energy policy is to provide electricity for all by year 2020 and be able to generate 10,000 megawatt of hydroelectricity by 2020. The government plans to achieve this mission by introducing reforms, formulating appropriate policies and regulations, preparing plans and programs and strengthening institutional capacity.

Currently within the Department of Energy, specific approved policies on alternative sources of renewable energy with specific reference to bioenergy are scanty except for Article 60.3(v) of the Electricity Act 2001 that mandates the licensee to use renewable energy resources as part of the social obligation. In addition, an overall objective of the Energy Sector Tenth Plan report outlines the sustainable development and efficient use of energy resources for socioeconomic development in the country.

Within the energy sector, priorities are focused on the hydropower sector that has cost leadership and natural abundance advantage. However, realizing the over dependence on a single source of energy from hydropower alone has led decision makers to explore diversification of the energy base into other alternative forms of energy mix such as wind, solar, mini hydropower, and biomass. This has also led to creating a new division - Renewable Energy Division within the Department of Energy. A new policy formulation within this division hinges on two main themes namely, 1) energy security and 2) diversification of resources to a broader base.

The concept of energy security is taken seriously in Bhutan since the country has no known reserves of fossil fuel and has no option but to import oil to satisfy growing needs. While hydropower is available to meet country's needs, there are concerns about the shortage of electricity in the lean winter season, especially to meet the needs of the growing industry. The energy sector is also

vulnerable to the impacts of climate change, given that water flows are likely to be affected due to global warming.

As an ongoing initiative, Renewable Energy Division within the Department of Energy with financial support from the Asian Development Bank (ADB) is collaborating with the Department of Livestock (DoL) within the Ministry of Agriculture and Forest on setting up 1,600 biogas plants across the country. Two pilot projects are already undertaken with one in Paro and the other in Thimphu.

Similarly, the Renewable Energy Division with support from Global Environment Facility (GEF) is undertaking to distribute 20,000 biomass fuel efficient cooking stoves in all the 20 *dzongkhags* within the next three years. The proposed project intends to focus on the promotion and use of biomass energy resources for the provision of energy services in rural areas. Overall, the Project is expected to result in a reduction in the annual biomass/fuel wood consumption in Bhutan through the gradual utilization of biomass-based energy systems and efficiency improvements in the rural areas of the country as influenced by the Project.

3.2 Energy Demand and Supply Scenario

Bhutan's per capita energy consumption is relatively high compared to other neighboring countries because its forest resources provide an abundant and readily available source of energy with demand rising by about 12 percent each year. According to International Energy Agency (2005), per capita energy consumption for Bhutan has been estimated at 0.63 ton of oil equivalent (TOE), while the per capita electricity consumption of 1,174 kilowatt hour per year in South Asia (refer to Table 5).

Table 5. Comparison of per capita energy consumption and electricity supply.

Country	Per capita energy consumption (TOE/capita/year)	Per capita electricity supply (kWh/capita/year)
Bangladesh	0.16	140
Bhutan	**0.63**	**1,174**
India	0.53	457
Myanmar	0.28	104
Nepal	0.34	69
Pakistan	0.49	425
Sri Lanka	0.49	345
World	1.77	2,516

Source: International Energy Agency (2005). Key world statistics, except for Bhutan data.

A sectoral energy consumption undertaken by the Department of Energy, Ministry of Economic Affairs in 2005 revealed residential sector as the highest energy consuming sector, accounting for 48.7 percent of the total energy consumption, followed by the industrial sector consuming 25 percent of the total

energy and transport sector accounting for 14.3 percent of the total energy (Source: Bhutan Energy Data Director, 2005, fig. 2., pg. 86).

The present energy demand in Bhutan is primarily based on renewable energy sources. Firewood is the main source of primary energy for Bhutan, and it represents the largest slice of energy consumption with 1.3 tons per capita used for cooking, space heating and for lighting purposes in remote inaccessible areas (Source: Interview with officials from Renewable Energy Division, DoE). At a national level, about 75 percent of the energy consumption constitutes fuel wood and dominantly used in the rural areas. The household sector consumes 95 percent of the fuel wood, the government and commercial entities use 3 percent, and agriculture and industry use about 1 percent each (Bhutan Energy Data Directory, 2005, DoE). Since Bhutan has no known reserves of fossil energy resources such as oil and natural gas, all petroleum products such as kerosene, diesel oil, petrol, and liquefied propane gas are imported for lighting, transport, cooking and heating purposes. Figure 1 below gives the detail of energy supply mix of Bhutan.

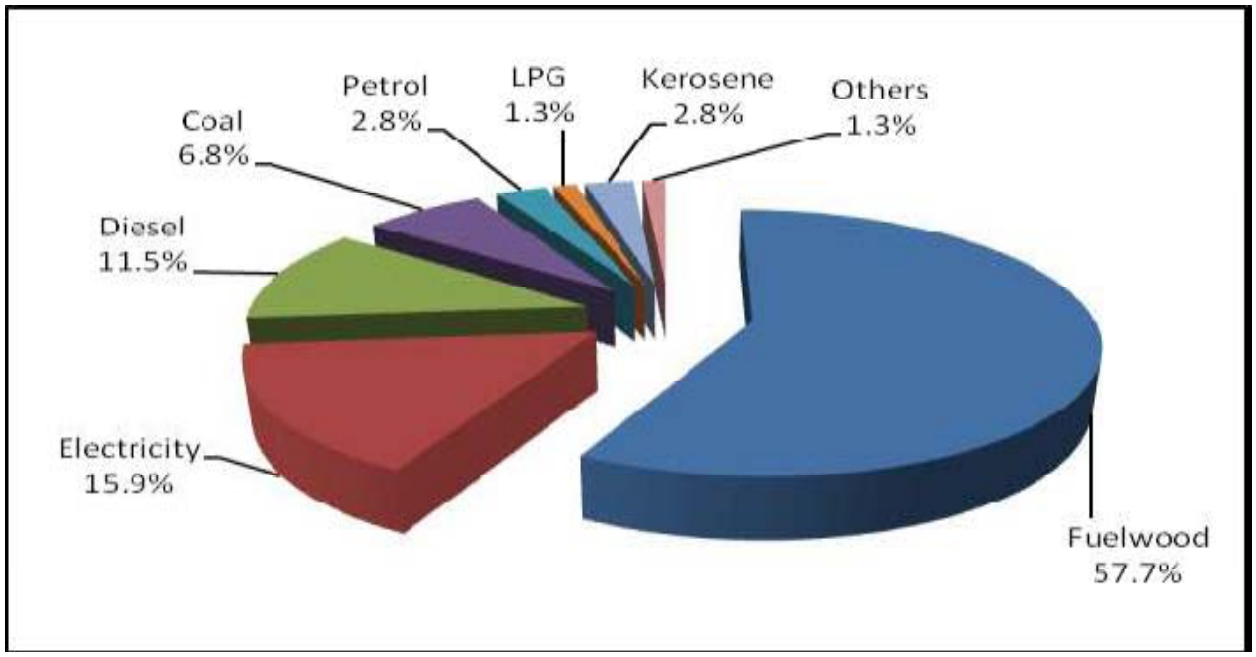


Figure 2. Bhutan Energy Supply Mix 2005 (*Source: Bhutan Energy Data Directory 2005*).

The country supplied 231,871 Tons of Oil Equivalent (TOE), roughly 724,597 metric tons of fuel wood in 2005, which accounted for 57.7 percent of the total primary energy supply (Source: Bhutan Energy Data Director, 2005, Ch.5., fig. 1., pg. 85). In addition to fuel wood, other biomass fuels that were used in small quantities including briquettes made from saw dust constituted 204 tons or 65 TOE (UNDP, 2010, Sustainable Rural Biomass Project Proposal under the UNDP Environmental Financial Services, pg.5).

3.2.1 Fuel wood consumption by industry type

Table 6 presents an estimated 817 tons of fuel wood consumed for lemon grass oil distillation during 2005 producing close to 10 tons of lemon grass extract. Similarly, BPBL used about 10,000 metric tons of fuel wood in its boilers for steam generation. BCCL and BFAL jointly consumed 46,500 metric tons of fuel wood in 2005. Carbon manufacturing consumed 29,000 metric tons with handmade paper factories utilizing 8,000 metric tons for the same year.

Table 6. Data on fuel wood used in industries.

Industry Type	Fuel wood consumption in 2005(tons)
Lemon grass	817
BPBL	10,000
BCCL/BFAL	46,500
Hand made paper	8000
Resin and turpentine	335
Yarn dying	91
Carbon manufacturing	29,000

Source: Department of Energy, 2005 in Bhutan Energy Data Director, 2005, pg. 48, Table 6.
Note: Bhutan Carbide Chemicals Ltd. (BCCL), Bhutan Ferrosilicon and Alloys Ltd. Bhutan Particle Board Ltd. (BPBL).

3.2.2 Energy Trade

In 2009, Bhutan imported motor spirit including aviation spirit amounting to 20 million liters worth Nu. 724 million. In the same year 5.7 million liters of Kerosene (SK Oil) was imported worth Nu. 49 million. While in the same year, on the export front, a combined (Chukha, Kurichu and Tala), 5,402 mega units (MU) of electricity worth Nu. 10, 090 million was exported to India.

3.2.3 Fuel Extracted by Natural Resource Development Corporation

Natural Resource Development Corporation (NRDCL) is the state owned corporation responsible for extracting timber from assigned forest management units (FMUs) in the country. The Corporation maintains seven (7) auction depots across the country. Table 7 below presents the quantity of timber harvested from the last three years.

Table 7. Abstract of timber harvested by NRDCL, 2008, 2009, 2010.

Region	2008	2009	2010
Wang	283,106	264,980	130,389
Rinpung	492,138	393,956	297,374
Zhonggar	231,089	263,715	202,071
Sha	310,010	365,819	347,670
Zhemgang	93,069	101,621	94,691
P/Ling	231,375	117,706	52,884
Jakar	417,129	358,597	310,013
Total	2,057,916	1,866,394	1,435,092

Source: NRDCL reports.

3.2.4 Types of fuel used by households

As shown from Table 8, 75.3 percent of the households use wood as a principle source of fuel for cooking purposes in rural areas followed by electricity constituting 28.6 percent. Wood fuel used for lighting purposes in rural Bhutan constitutes 40.2 percent of households depending on burning resin wood chips during the night hours.

Table 8. Distribution of households as per fuel used for cooking and lighting

	Cooking (% households)		Lighting (% households)	
Fuel Type	Rural	Urban	Rural	Urban
Wood	75.3	7.6	3.7	0.2
Electricity	28.6	82.2	40.2	96.4
Liquefied petroleum gas	20.3	77.1	0.1	0.1
Kerosene	8.8	9.5	51.3	2.6

Source: Computed from the data provided in the Population and Housing Census, 2005, Table 8.23., pg. 485.

From Table 8 one can surmise that the total energy consumption by urban households is much greater than rural households in absolute terms and the availability of electricity does not necessarily mean that households will stop using fuel wood. This information is interesting in terms of the difference between rural and urban household's ability and willingness to switch fuels for different purposes.

3.2.5 Average Energy Consumption by type by household

The average fuel wood consumption in rural un-electrified areas is estimated at 10.4 metric tons per household per annum, which is almost equivalent to the combined usage of rural electrified and urban consumers. Alternative fuel sources such as electricity and kerosene has reduced the consumption rates both in rural electrified and among the urban dwellers as presented in Table 9.

Table 9. Average energy consumption in households by energy type, 2005.

Fuel Consumption	Rural un-electrified	Rural Electrified	Urban
Wood (tons/hh/annum)	10.4	7.8	3.9
LPG (kg/hh/annum)	46	54	87
Kerosene (l/hh/annum)	201	323	1,202
Electricity (kWh/hh/annum)	-	874	1,579

LPG – Liquefied petroleum gas, l – Liters, hh – households, kWh – kilowatt hour. Average values are based on the actual number of households using a particular fuel.

Source: TERI (2005) in Bhutan Energy Data Directory, 2005, Table 5., pg. 44.

3.2.6 Biomass Consumption in Residential Areas

Presently, there is no usage of biomass for electric power generation in Bhutan. Biomass, mostly fuel wood is currently used in thermal applications such as heating and cooking purposes in the residential, industrial and commercial/institutional sectors. A smaller amount of biomass (fuel wood) is used in agricultural sector for cardamom drying. In 2005, a total of 724 thousand tons of fuel wood was used in Bhutan, of which the residential sector consumed 544 thousand tons (75.1%); the industrial sector (mainly non-energy intensive industries) used 95 thousand tons (13.1%); the commercial and institutional sector consumed 73 thousand tons (10.1%); and the remaining 12 thousand tons (1.7%) was used in agricultural sector (*UNDP, 2010*, *Sustainable Rural Biomass Project Proposal*).

About 91 percent of the energy demand of the sector is met by biomass, which is mostly used in rural households. Biomass is used for cooking, fodder cooking, space heating, and lighting in rural households, which accounts for 96% of the total biomass used in the sector. Table 10 presents the biomass consumption in the residential sector during 2005.

Table 10. Biomass consumption in the residential sector (2005)

End-user	Biomass consumption (thousand ton)	% of total
Rural	521.9	96.0%
Cooking	343.5	
Fodder cooking	155.8	
Space heating	22.6	
Lighting	0.0	
Urban	20.5	3.8%
Cooking	6.0	
Fodder cooking	0.0	
Space heating	14.5	
Lighting	0.0	
Others (e.g. for cremation)	1.3	0.2%
Total	543.7	100.0%

Source: MOIT. 2007

3.2.7 Bioenergy Technology

Current feasible bioenergy technologies are limited to installation of biogas plants and fuel efficient cook stoves. As mentioned in the above sections, Asian Development Bank and the United Nations Development Program through the Global Environment Facility fund are exploring to install fuel efficient cook stoves in rural Bhutan and energy saving biogas units particularly in southern Bhutan where cattle population is favorable.

On-going biomass related project is the briquette making factory in Romtokto in Thimphu. The plant capacity is small with only 250 briquettes per hour and is primarily supplied to Thinley Gang Primary School with free transportation subsidy provided by the NRDCL. The briquette factory though not making any profit is committed towards reducing the usage of fuel wood by collecting saw dust raw materials from about 17 sawmills. Other fuel wood savings technology is Bhutan Particle Board Limited that manufactures boards using wood residues. Likewise Bhutan Ferro Silicon Limited used wooden chips as alternative furnace fuel.

Future plans on *jatropha* cultivation and resin tapping are under discussion but to consider such proposals resource assessment and economic feasibilities would deem a necessary prerequisite.

3.2.8 Future Bioenergy Situation

Bioenergy development in Bhutan is faced with many challenges. Fuel wood remains the dominant energy sources in the rural areas of the country. Although there are interest among the government Ministries and private sectors in expanding use of biofuel derived from agriculture and forestry biomass, use of untapped pine resin and establishment of energy plantations (jatropha), however, to assure a comprehensive sustainable bioenergy development, the synergic contribution of various institutions from the agriculture, forestry, energy, industry, and environment is important. The future lies on the economic viability of the technologies, the social opportunities and constraints to bioenergy development, its environmental impact at the local and global levels, potentials and limits to reduce greenhouse gas emissions, effects on biodiversity due to land use changes, and effects of agriculture production on water and soil.

For example, electricity is likely to reach the entire country with the "Electricity for All by 2020" target proposed by the Ministry of Economic Affairs, however, there are commendable challenges in terms of accessibility, forest damage, high cost per unit of installation, so on and so forth. Another challenge would be the mindset of the rural populace to switch to electricity usage from the earlier dependence on fuel wood for energy sources particularly in terms of heating, cooking, and preparing cattle food. This is attributed to less cash income in rural areas and therefore farmers not wanting to spare the extra Ngultrum to pay utility bills, in this case the monthly electricity charges. A similar area of concern would be the increase in demand for gasoline and diesel as result of increased in vehicle imports into the country. This would have implications on trade balance and also on the environment in terms of pollution and traffic congestion on the roads.

IV. Assessment of Bioenergy Needs and Potential in Bhutan

4.1 Availability of Biomass Resources in the country

Bhutan is endowed with rich natural resources with forest as the main source of biomass used for energy purposes. Fuel wood obtained from forests is the main source of biomass used for energy purpose. Fuel wood accounts for about 76.9 percent of total potential of biomass energy in Bhutan. The second largest biomass resource is crop residues. These residues are produced as by-products from harvesting and processing of agricultural crops. In Bhutan, the main cereal crops grown are paddy, maize, wheat, barley, millets, and buck-wheat. The estimated total amount of crop residue generation is 0.39 million tons per annum or 5.75 million GJ/year, which constitutes 21.1percent of total biomass energy potential in Bhutan. Other biomass sources, such as municipal solid waste (MSW) and animal dung share a small part (2 percent) of total biomass energy potential in Bhutan (Ibid).

The potential for various bioenergy resources in Bhutan both in terms of volume and quality needs to be carefully determined in order to decide on promoting viable investments. Table 11 and Figure 3 presents the shares of each biomass type in the total potential on energy basis.

Table 11. Biomass Energy Potential in Bhutan (2005)

Type of Biomass	Potential biomass production (ton/year)	Maximum energy value (GJ/year)
Fuel wood	1,565,540	20,974,729
CROP RESIDUES		
Paddy straw	97,787	1,410,281
Rice husk	14,668	211,219
Maize stalk	190,193	2,795,834
Maize cob	43,473	669,479
Maize husk	24,453	352,128
Wheat straw	6,120	93,029
Barley straw	2,191	33,309
Millet stalk	3,669	53,932
Buck wheat straw	3,665	55,702
Mustard sticks	4,420	79,511
Animal dung	253,052	203,707[13]
MSW	81,119	358,608
TOTAL	2,290,350	27,291,468

Source: Bhutan Energy Data Directory 2005.

[13] Estimated for cattle population only, considering 1 ton of cattle dung yields 35 Nm3 biogas and typical biogas energy content is 23 MJ/Nm3.

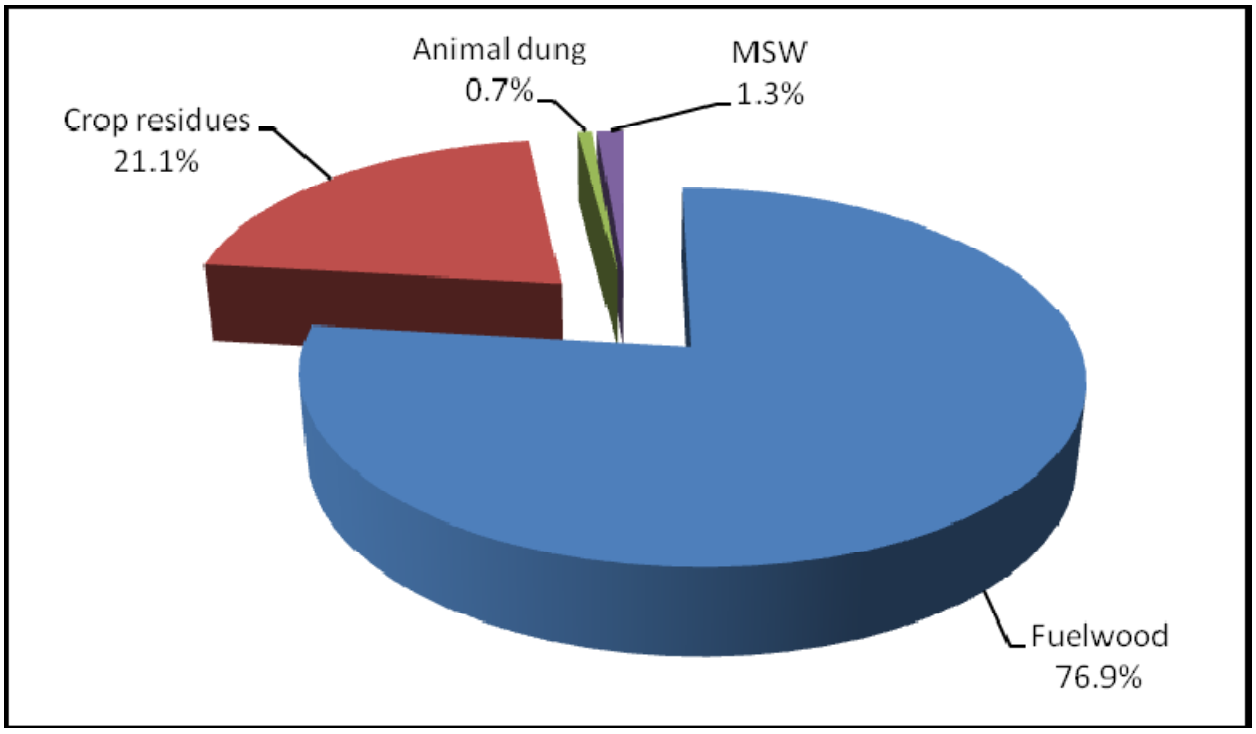


Figure 3. Biomass Energy Potential by Type of Biomass in 2005, (*Bhutan Energy Data Directory 2005*).

4.2 Forest Biomass

In 2009, NRDCL harvested over 2 million cubic feet of timber (*Timber Disposal Statement, NRDCL, 2010*); suggesting a saw dust residue of 200,000 cubic feet and 460,000 cubic feet of lops and tops resulted out of sawing activities. As presented in the Bhutan Energy Data Directory 2005, TERI, The Energy Resource Institute based in India has estimated 527.5 million cubic meters of total growing forest stock. This has been calculated based on forest cover by different forest classes as shown in Table 12.

Table 12. Forest cover in Bhutan by forest type, 2009.

Forest Type	Fir	Mixed Conifer	Blue Pine	Chir pine	Broadleaf+conifer	Broadleaf
Area (in square km)	3,453	4,868	1,342	952.42	1,357.91	13,748.70
Percentage of total	13.42	18.93	5.00	3.92	5.28	53.45

Source: DoF, MoAF (in Bhutan Energy Data Director, 2005, Table 3.12, pg. 31).

Growing forest stock and annual yield of forest by *dzongkhags* are provided in Table 13. Growing stock is defined as the volume over bark of all living trees more than 10 cm dbh (diameter at breast height), and includes the stem from ground level or stump height up to the top. The annual sustainable yield of forest biomass in the country has been estimated using the standard Van Montal's equation, i.e sustainable yield (tons/year) = 2 X growing stock/rotation.

Table 13. Growing stock of forests and sustainable annual yield by dzongkhag, 2004.

Dzongkhag	Growing stock (million cubic meters)	Annual yield (1000 tons)
Thimphu	10.46	65.89
Paro	7.62	47.14
Haa	17.58	118.07
Chukha	35.65	273.61
Samtse	29.10	233.29
Punakha	15.05	110.92
Gasa	16.85	100.91
Wangdue	46.04	328.68
Tsirang	10.68	85.73
Dagana	24.84	188.41
Bumthang	17.80	102.85
Trongsa	34.12	255.28
Zhemgang	42.45	334.29
Sarpang	41.87	341.12
Lhuentse	39.36	279.97
Mongar	37.00	282.83
Trashigang	32.17	232.30
Trashiyangtse	23.78	167.50
Pemagyaltse	5.99	48.38
S/Jongkhar	39.10	316.69

Source: TERI, The Energy Resource Institute estimates, Bhutan Energy Data Director, 2005, page 32.

The productivity, rotation, and basic density of different forest types in Bhutan are provided in Table 14.

Table 14. Forest productivity, rotation, and basic density.

Forest types	Productivity (M/ha)	Rotation (Year)	Basic Density (ton/m)
Mixed conifer	82.74	120	0.41
Fir	268.27	140	0.40
Blue pine	43.60	100	0.30
Chir pine	83.91	140	0.39
Broadleaf+conifer	528.45	120	0.45
Broadleaved forests/hardwood	224.59	140	0.49

Sources: DoF (1989), Forest Resources Development Division, FAO (2005).

Further, estimates on the total sustainable annual yield of forests that can be harvested in the country has been calculated at 3.91 million tons or 849,437 cubic meters. However, considering that most parts of the forest areas in Bhutan are inaccessible, the cost of extraction of both timber and fuel wood is prohibitive, and also taking into account the large tracks of the forests falling under the protected areas, the estimated extractable biomass that can be used as timber or fuel wood can be assumed to be about 40 percent of the total annual yield, amounting to 1.57 million tons.

4.3 Crop Residue

Bioenergy levels depend on bulk density of the particular crop. The total estimated bioenergy estimated amount is recorded at 366,185 metric tons per annum (Bhutan Energy Data Directory, 2005, pg. 22). While crop residues such as that of rice straw can be used for fodder, other non-fodder crop residues of wheat, maize, millet sticks, etc. could be utilized as an alternative fuel source. It has been estimated by TERI, The Energy Resource Institute in Bhutan Energy Data Directory, 2005; that about 63,000 tons of fuel wood (amounting to 10% of domestic fuel wood use) could be saved, if one-third of the total estimated maize stalk residues generated in the country are diverted to replace fuel wood.

Table 15. Crop residue potential in selected crops in Bhutan (2004-05).

Crop	Area (ha)	Production (tons/year)	Residue Type	RPR	Theoretical Residue Production (tons/year	Maximum energy value (GJ/year)
Paddy	46,585	54,326	Paddy straw	1.8	97,786.80	1,410,281.23
			Paddy husk	0.27	14,668.02	211,219.49
Maize	53,938	90,568	Maize stalk	2.10	19,0192.8	2,795,834.16
			Maize cob	0.48	43,472.64	669,478.66
			Maize husk	0.27	24,453.36	352,128.38
Wheat	7,583	4,192	Wheat straw	1.46	6,120.32	93,028.86
Barley	2,789	1,423	Barley straw	1.54	2,191.42	33,309.58
Millet	7,325	2,367	Millet stalk	1.55	3,668.85	53,392.09
Buckwheat	6,288	2,510	BW stalk	1.46	3,664.60	55,701.92
Millet	4,503	1,768	Mustard sticks	2.50	4,420.00	79,511.38

RPR – Residue Production Ratio

Source: Koopmans and Koppejan (1998) in Bhutan Energy Data Directory, 2005, Table 3.14, pg. 31.

4.4 Cattle Dung[14]

Cattle dung is a potential source of energy and can be used for cooking and lighting smaller homes. Considering only the cattle population, theoretical biogas production potential from recoverable cattle dung in the country is estimated at 8.86 MJ (Refer Table 16).

Table 16. Estimation of biogas energy generation potential using cattle dung.

Total cattle population (number)	308,310
Dung production (kg/head/day)	4.5
Total dung produced (tons/year)	506,104
Dung recovered (%)	50
Total dung recoverable (tons/year)	253,052
Dung utilized as fuel	NIL
Total dung available for energy (tons/year)	253,052
Theoretical annual biogas production potential if all recoverable dung is utilized as fuel (million Nm)	8.86
Maximum theoretical energy potential from biogas (MJ)	203

Source: Bhutan Energy Data Directory, 2005, pg. 22.

[14] Waste of sheep, goats, poultry and pigs are ignored because of their small and dispersed population.

4.5 Biogas from Cattle Dung

From a study undertaken by Department of Livestock (Ghimere & Nepal, 2009), about 19 percent of the total households in Bhutan have favorable conditions to install biogas plants of family-size (2-3 cubic meter) of the fixed dome type. This translates to roughly 16,879 households who are technically suitable and socioeconomically feasible. However, the fixed dome design is installed under SNV technical assistance and government subsidy. However, the program will only reach the farmers who own cattle and land, i.e., those who generally belong to the middle and upper income bracket. The subsidy policy treats users equally. The farmers should invest about more than 30 per cent of the total cost on their own in the form of labor. As a result, the subsidy will most likely not become accessible to the poor farmers not having their own cattle.

Southern *dzongkhags* comprising Samtse, Sarpang, Tsirang, S/Jongkhar and Chukha are rated with high potential for installation of biogas plants. However, concerns on providing alternative sources of feed and fodder demands arising out of stall feeding would need to be seriously explored for the sustainability of the project. Options like improved pasture development, procurement of affordable commercial feed and fodder are some areas worth considering.

V. Bioenergy and Food Security in Bhutan

The rising price of oil, along with concerns for climate change and a need for drastic cuts in carbon emissions, have led to a sense of urgency driven by the western countries for a shift away from dependency on petroleum and towards more environmentally friendly and renewable sources of energy. Biofuels have been identified as having the greatest potential to meet global demands for a substitute to fossil fuels, particularly for transport. In response to these demands, global biofuel production tripled between 2000 and 2007 as shown from the graph below.

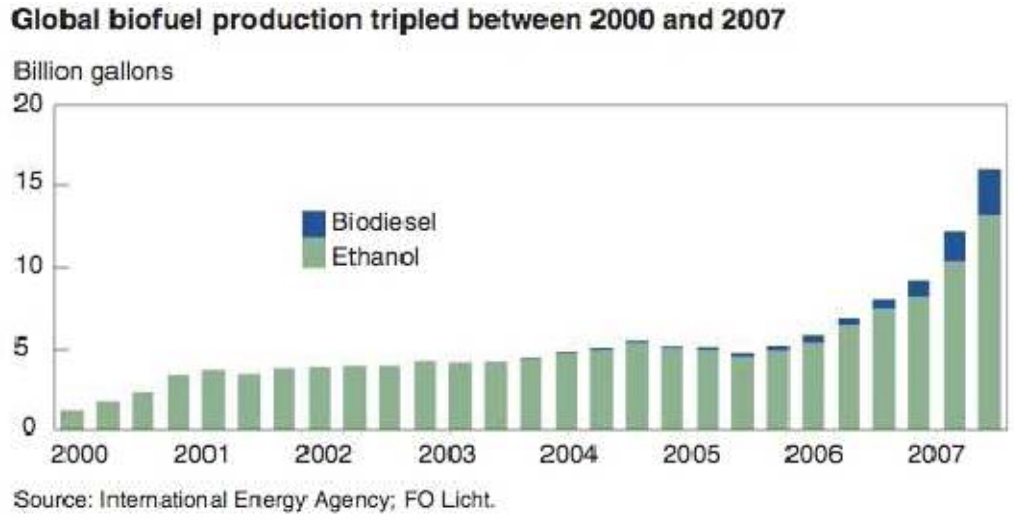


Figure 4. Global biofuel production scenario.

Such increasing trend is not an immediate concern in the Bhutanese scenario because firstly, cultivable agricultural land or forest land for human consumption has not competed with growing biofuel plants. Such an investment may not even be a viable enterprise even if policy decisions are introduced in favor of encouraging biofuel production. Limited land area, lack of economies of scale and high cost of production, and limited vertical integration are probable limiting factors for any preliminary engagement. Secondly, there is no land-use competition with available land used for crop cultivation kept unthreatened from growing energy crops.

Nonetheless, these bioenergy development pathways around the world provide a range of options which can be assessed for possible impacts on Bhutan's food security profile in the future. In order to do so, linkages between food security, land-use and water resources must be fully understood. By implication, this requires an analysis of a range of environmental, social and economic factors. It must be kept in mind that no particular pathway should allow any detrimental

impact on food security either directly or indirectly. Therefore, policies must be put in place which protect and ideally seek to increase national food security. In no instance should food security be compromised in the pursuit of bioenergy development.

5.1 FAO's BEFS Analytical Framework

Serious concerns on the food security impacts, social feasibility and sustainability of bioenergy have arisen over time, especially with first generation bioenergy. In this context FAO set up the Bioenergy and Food Security (BEFS) project to analyze how bioenergy developments could be implemented without hindering food security. Over its term, the BEFS project has been supporting Peru, Tanzania and Thailand in analyzing the competitiveness of the bioenergy sector, potential impacts on food security, growth and poverty. In this effort, BEFS has constructed an analytical framework that can assist countries with the development of bioenergy policy and/or clarification of the potential impacts of the bioenergy developments.

With support from the German government, the aim of the project is to help policy-makers assess the potential effects of biofuel production on food security and land-use in developing countries. BEFS an analytical framework was developed to understand who gains and who loses from biofuel production at the household level. Five modules on analysis constitute the BEFS analytical framework, with each module using different types of data from within the country. Once the country specific bioenergy scenario has been defined, each module is addressed in turn to examine technical biomass potential, supply curves, economic potential, macro-economic analysis and food security analysis. The food security module mainly uses household level data based on the Living Standards Measurement Study established by the World Bank.

The following presents BEFS analytical framework and tools to support policy and start a continuous process that can inform policy over time. The crucial element in developing a sustainable bioenergy sector lies in the management of the sector.

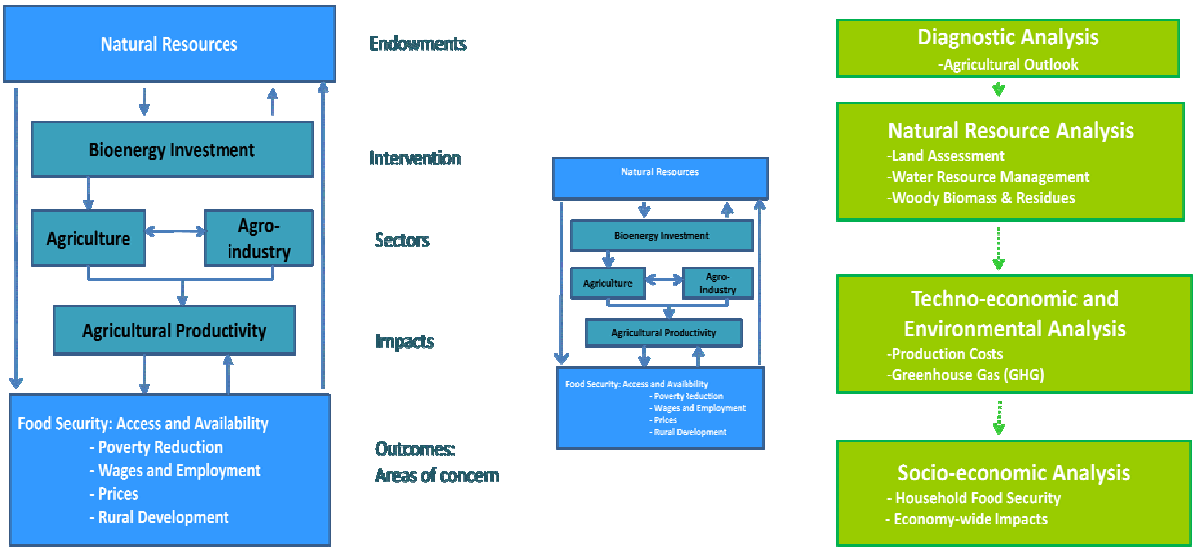


Figure 5. FAO's BEFS Analytical Framework

5.2 Insufficient Drivers towards Bioenergy Development in Bhutan

5.2.1 Policy, resources and viability

Threatening food security objectives in Bhutan may be unlikely even if policy alternatives are geared towards promoting bioenergy crops and plantations at the cost of cultivable agriculture land for human consumption purposes. For instance, under the current scenario, biofuel production in Bhutan is not a viable enterprise being limited by non-availability of vast cultivable land and inadequate volume of feedstock, geographically inaccessible terrain, poor road networks and technology, and high transaction cost. Further, the Constitutional mandate of maintaining 60 percent forest cover at all times to come automatically prohibits probable expansion opportunities for commercial estate enterprises in non-agricultural land or forest land. As a result, food availability could not be hampered by biofuel production in Bhutan since there is no competing pressure on land-use between food crops versus biofuel plantations. While on the other hand, there are possibilities of exploring integrated food and energy production systems under second generation biofuels production. Feasibility studies could be carried out whether the cellulose-rich biomass could be grown on marginal and degraded lands that do not compete with food crops, although it remains to be seen whether this will be socioeconomically viable.

At present, the Biogas Project initiated by the Department of Livestock in partnership with the Department of Energy is soon to kick start with the

installation of 1,600 biogas digesters using animal dung as the main fuel source. Two pilot sites are already underway, with one in Paro and the other in suburbs of Thimphu. As a strategy to support rural development, this is intended to provide farmers with multiple benefits. First, to encourage farmers to switch from indigenous cattle breeds that are less productive to improved varieties that provide much higher yield, and second to generate greater volumes of animal dung through stall feeding, thus reducing land degradation and soil erosion from over grazing of cattle in the wild. And third, aside from providing gas for cooking purposes, the slurry from the fixed dome biogas plants provide a good source of farm manure.

Similarly, a sustainable rural development project has been initiated by the Ministry of Economic Affairs through UNDP/GEF funding attempting to distribute 20,000 biogas fuel efficient improved cook stoves with the intention to reduce fuel wood consumption in rural areas.

5.2.2 National Energy Security Objectives

The search for renewable energy is being driven by volatile crude oil prices and the perceived threat to national security of over-dependence on one single source of energy - hydropower. Further, crude oil prices are likely to increase over the long term as fossil reserves diminish and global demand increases, particularly in the newly emerging economies of Asia and Latin America. The national newspaper *Kuensel* for January 17, 2011 reported another increase in fuel prices skyrocketing to Nu. 54[15] a liter for petrol. However, the potential of biofuels to enhance energy security is limited in Bhutan.

Globally, the huge volume of biofuels required to substitute for fossil fuels is beyond the capacity of agriculture with present day technology. For example in 2006-07, the USA used 20 percent of its maize harvest for ethanol production, which replaced only three percent of its petrol consumption (World Bank, 2008). More significant displacement of fossil fuels will be likely with second and third generation biofuels (SOFA, 2008).

5.2.3 Impact on Environment

Biofuel production is also likely to impact the environment through its effect on water resources and biodiversity. Declining availability of water for irrigation, most notably in rural Bhutan, may necessitate using the most water-efficient biofuel crops and cropping systems for long term sustainability; if at all proposals

[15] Current exchange rate is USD 1:Nu. 44.35 as per www. bnb.bt.com

are approved. Similarly, the use of degraded land, conservation agriculture techniques with minimal soil disturbance and permanent soil cover, intercropping and agroforestry systems while lessens negative environmental impacts but biodiversity may likely be threatened by large-scale mono-cropping of exotic species.

VI. Conclusion and Recommendations

Bhutan has a comparative advantage for a single bioenergy production namely the availability of hydropower resources in the country with a known potential of 30,000 megawatts. Presently, there is no usage of biomass for electric power generation in Bhutan. Nonetheless, policy makers realizing the overdependence on a single energy source such as hydropower have initiated new policies keeping in mind the importance of diversifying the energy base and energy security concerns with rising fossil fuel prices and increasing market demands. This has resulted to pilot projects installing energy saving technology related to improved cook stoves and biogas digesters plants in rural Bhutan[16]. Biomass, mostly fuel wood is currently used in thermal applications such as heating and cooking purposes in the residential, industrial and commercial/institutional sectors. About 91 percent of the energy demand of the sector is met by biomass, which is mostly used in rural households. Fuel wood accounts for about 76.9 percent of total potential of biomass energy in Bhutan. Fuel wood is the main source of primary energy for Bhutan, and it represents the largest slice of energy consumption with 1.3 tons per capita used for cooking, space heating and for lighting purposes in remote inaccessible areas.

The second largest biomass resource is crop residues produced as by-products from harvesting and processing of agricultural crops. Main cereal crops grown are paddy, maize, wheat, barley, millets, and buck-wheat with an estimated total amount of crop residue generation at 0.39 million tons per annum or 5.75 million GJ/year, which constitutes 21.1percent of total biomass energy potential in Bhutan. Although preliminary conclusions on economies of scale and the vertical integration required for biofuel production allows little scope for viability of such enterprises, feasibility for enterprise development from such estimates will need to be determined in terms of minimum required volume, technology, collaborators and markets. Further, the interrelationship between land use and the probable competing needs of energy and food security are key issues that

[16] However, the project initiative program will only reach the farmers who own cattle and land, i.e., those who generally belong to the middle and upper income bracket as the subsidy policy treats users equally. As a result, the subsidy will most likely not become accessible to the poor farmers not having their own cattle.

should be considered in the future. Bioenergy production may also entail harmful environmental effects such as deforestation, degraded lands and water resources, desertification and loss of biodiversity. Regulation is required to curtail the negative impacts of large-scale production, as well as to ensure that the most cost-effective and highest-energy conversion technologies are used.

At present, cultivable agricultural land or forest land for human consumption has not competed with growing biofuel plantations. However, there should be no room for complacency but rather build cautionary steps and guard against possible impacts on Bhutan's food security profile in the future from land use competition. In order to do so, linkages between food security, land-use, biodiversity and water resources must be fully understood. This requires an analysis of a range of environmental, social and economic factors and that no particular option should allow any detrimental impact on food security either directly or indirectly.

It must also be noted that under the present circumstances in Bhutan, tapping bioenergy alternative sources of fuel is promoted not as the next best alternative source of energy *per se*, but rather approached from perspectives such as forest conservation, minimizing land degradation from over crazing of cattle, reduction on the usage of fuel wood, addressing food security and poverty alleviation.

Following are some possible recommendations;

1. Carry out an assessment of bioenergy resources with particular focus on availability of biomass materials. This will provide insight in the amount of residues, wastes and energy crops that are available for bioenergy generation. The assessment should involve carrying out detail field surveys looking at the quantity of crop residues, animal manure production, forest product residues and municipal waste. Subsequent research should evaluate converted potential energy production from the biomass inventory obtained using anaerobic digestion and simple combustion as representative conversion technologies. This inventory should also represent as a first step toward a sustainable energy policy and vision within the country since information on type and geographic distribution of biomass is being perceived as critical for feasibility analysis and project prioritization.

2. Develop a biomass inventory using agriculture, forests and municipal statistics and databases along with personal. The biomass and bioenergy databases in the entire county across the varying categories should be mapped on geographical information system (GIS). The resulting biomass

should be standardized to represent total dry matter. The woody or straw-like materials should be evaluated for potential energy production using combustion as a conversion technology. Similarly, the wet biomass, represented largely by the animal manures and processing wastes should be evaluated for potential energy production. The inventory should also reflect the use of biomass in different purposes and different sectors. For example, about 80 percent of crop residue can be used for animal feed and 10 percent for field cover, and maybe there is none available for energy. However, the inventory will only be useful if it can identify resources as well as how and where the resources are being used.

3. The potential for various bioenergy resources in Bhutan both in terms of volume and quality needs to be carefully determined in order to decide on promoting viable investments.

4. It is also important to recognize that land which may be perceived as unused or underutilized may in fact be extremely valuable to local communities as it can provide an important source of biomass. Equally, pastoralists/nomads may depend on such land for passage and feeding of livestock. Therefore, a comprehensive and participatory assessment of land-use is required to inform decision makers on suitable locations for biofuel cultivation. Participatory land-use planning and design processes should bring together local communities and key stakeholders (government, civil society, private investors, etc.) to evaluate and agree plans for future land-use. Integral to this process is an assessment of current land-use and potential conflicts of interest, along with consensus building and conflict resolution where required.

5. Formulate an enabling bioenergy policy statement hinged onto the Renewable Energy Policy Framework developed by the Department of Energy under the Ministry of Economic Affairs. The policy framework for the bioenergy sector should be shaped by policies keeping in mind various sectors, mainly agriculture, energy, environment and trade. The major policy objectives driving biofuel expansion should be based on energy security, climate change mitigation, agricultural and rural development. Government support should consider along the form of production subsidies and tax exemptions and tariffs. The expansion of bioenergy development may help make the case for increased support towards the agricultural sector through the strengthening of institutions and policies. Measures to ensure that bioenergy production is conducive to reducing poverty and hunger should include among other aspects of policy support for the participation of small-scale farmers in rural Bhutan.

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Annex 1. Terms of Reference for Consultant

Job Title	National Consultant - needs assessment study on bioenergy		
Division/Department	RAPG		
Program/Project Number	TCP/RAS		
Location	Bhutan (Sri Lanka, India, Bangladesh, Nepal – 1 national consultant in each country)		
Expected Start Date of Assignment	Dec 01– Dec 30 , 2010	Duration:	1 month
Reports to	Name: Delgermaa Chuluunbaatar	Title: *Agricultural officer for Bioenergy crops*	

General Description of task(s) and objectives to be achieved

To collect all possible data/information on current bioenergy status, activities, policies, and key stakeholders of the country

To identify issues, priorities, opportunities and constraints for bioenergy development in the country

To coordinate with PPD, MOAF prepare, organize, and conduct a national participatory needs assessment workshop on bioenergy

To compile and prepare a final report of the study including fact findings and workshop results

To help developing a national project proposal on bioenergy based on the results of the needs assessment study.

Key performance indicators

Expected Outputs:	Required Completion Date:
Wrote a final report of the needs assessment study including fact findings and workshop results, and Developed a national project proposal on bioenergy.	1 month (outputs should be delivered no later than December 30, 2010.)

Required Competencies

Technical Competencies and Experience Requirements:

At least 3 years of experience in working experience and good knowledge in rural development and agriculture based bio-energy

A proven record of working on a similar tasks and writing reports in English

Annex 2. Brief on *Jatropha curcas*

Jatropha is believed to have been spread by Portuguese seafarers from its centre of origin in Central America and Mexico via Cape Vqerde and Guinea Bissau to other countries in Africa and Asia. It is now widespread throughout the tropics and sub-tropics. Jatropha's potential as a petroleum fuel substitute has long been recognized. It was used during the Second World War as a diesel substitute in Madagascar, Benin and Cape Verde, while its glycerine by-product was valuable for the manufacture of nitro-glycerine.

Source: PISCES, 2010.

Jatropha curcas L. was first described by Swedish botanist Carl Linnaeus in 1753. It is one of many species of the genus *Jatropha*, a member of the large and diverse *Euphorbiaceae* family. Many of the *Euphorbias* are known for their production of phytotoxins and milky white sap. The common name "spurge" refers to the purgative properties of many of these *Euphorbias*. There are some 170 known species of jatropha, mostly native to the New World, although 66 species have been identified as originating in the Old World (Heller, 1996).

Jatropha grows readily from seed which germinate in around 10 days, or from stem cuttings. Growth is rapid. The plant may reach one metre and flower within five months under good conditions (Heller, 1996). Jatropha has proven effective in reducing the erosion of soil by rainwater. The taproot anchors the plant in the ground while the profusion of lateral and adventitious roots near the surface binds the soil and keeps it from being washed out by heavy rains. Jatropha also improves rainwater infiltration when planted in lines to form contour bunds.

Annex 3 People consulted during the assignment period

1.	Dasho Sherab Gyaltshen	MoAF Secretary
2.	Karma Sonam	Offtg. Chief Planning Officer, PPD, MoAF
3.	Bindu Tamang	Assistant Planning Officer, PPD, MoAF
4.	Chadho Tenzin	Assistant FAO Representative, Bhutan
5.	Tayan Raj Gurung	Specialist, CORRB, MoAF
6.	Chencho	Senior Research Officer, CORRB, MoAF
7.	Dorji Gyaltshen	Biogass Project Director, DoL, MoAF
8.	Sthar Dorji	GOI, Project Director, DoL, MoAF
9.	Abilal Baskota	Offtg. Director, DoF, MoAF
10.	K.J. Temphal	Social Forestry Division, DoF, MoAF
11.	Chimi Rinzin	Offtg. Director, DoA, MoAF
12.	Mewang Gyaltshen	Chief Engineer, DoE, MoEA
13.	Nar Bdr. Khatiwa	Renewal Energy Division, DoE, MoEA
14.	Yeshy Wangdi	Director General, DoE, MoEA
15.	Gyem Tshering	CEO, NRDCL
16.	Megan Ritche	Country Director, SNV
17.	Rober S Brunt	Business Development Coordinator, SNV
18.	Dophu Dukpa	Private Entrepreneur
19.	Rory	CEO, Samden Group of Companies
20.	Dorji Dradhuel	Director, DAMC, MoAF
21.	Phub Dem	Senior Marketing Officer, DAMC, MoAF
22.	Dechen	Biogas Farmer Collaborator, Paro
23.	Wangchuk	Biogas Farmer Collaborator, Paro

Annex 4 People attended the national workshop on Bioenergy and Food Security, 13/01/11

1.	Sonam Cheki	Research Officer
2.	K.J Temphel	SFD, DoF, MoAF
3.	Dorji Gyaltshen	Project Director, Biogas Project, DoL, MoAF
4.	Nar Bdr. Khatiwa	Renewal Energy Division, DoE, MoEA
5.	Karma Sonam	PPD, MoAF
6.	Tensin Drugyel	DoA, MoAF
7.	Karma	Advisor, SNV, Bhutan
8.	Dechen Lham	Biodiversity Officer, NBC, MoAF
9.	Abilal Baskota	DoF, MoAF
10.	Chencho	CORRB, MoAF
11.	Bindu Tamang	PPD, MoAF
12.	Chadho Tenzin	FAO, Bhutan
13.	Dema	PPD, MoAF
14.	Mewang Gyaltshen	RED, DoE, MoEA
15.	Sonam Tobgay	Consultant
16.	Damen Beau	FAORAP
17.	Degi Chuluunbaatar	FAORAP

Annex 5. Bioenergy Resource Assessment Project Proposal

Project Proposal	**Resource assessment on biomass materials with special focus on residues from crops, animal and forest resources available and generation of data set, cost and benefit of bioenergy development, and alternative energy sources that does not hinder biodiversity, food security, and environmental and social issues.**
Lead Agency	**Ministry of Agriculture and Forests in close collaboration with the Department of Energy, Ministry of Economic Affairs, Royal Government of Bhutan.**

I. Background and Rationale

The emergence of the bioeconomy and its focus on energy development has significant ramifications for the environmental and economic well-being. However, on the contrary if utilized more judiciously, the subsector has potential towards providing alternative sources of fuel and over time poverty reduction gains especially in economies of Bhutan and other least developed countries.

Bhutan's bioenergy harvesting is been limited to harnessing hydropower energy mainly because of the comparative cost advantage. However, it is now time those other sources of bioenergy such as usage of biomass for cooking, lighting, and even electric power generation in Bhutan is worth exploring. Biomass resource in Bhutan constitutes crop residues produced as by-products from harvesting and processing of agricultural crops with an estimated total amount of crop residue generation at 0.39 million tons per annum or 5.75 million GJ/year.

Empirical data is required to deduce conclusions on economies of scale and the feasibility of vertical integration that are two prerequisites for biofuel enterprises. Measures to ensure that bioenergy production is conducive to reducing poverty and hunger will include among other aspects of policy support for the participation of small-scale farmers in rural Bhutan.

II. Objectives

1. Quantify the potential of sustainable bioenergy resources for climate change mitigation through resource assessment surveys in potential areas.

2. Increase the understanding among decision makers and community leaders of the potential implications of production of fuel and fiber crops on soil, water, and wildlife habitat resources.

3. Increase interest, skills and confidence for bioenergy generation and environmental sustainability and improve understanding of the costs (socio-economic-ecological) associated with bioenergy generation.

4. Assess impact o poverty reduction through bioenergy production, i.e creating better incomes for local farmers than food production, e.g biogas installations.

III. Scope of Work and Outputs

1. The project will provide support to conduct a resource assessment of bioenergy components with particular focus on availability of biomass materials. The assessment will involve carrying out detail field surveys looking at the quantity of crop residues, animal manure production, forest product residues and municipal waste. This will provide insight in the amount of residues, wastes and energy crops that are available for bioenergy generation.

2. The biomass inventory will attempt to represent as a first step toward a sustainable energy policy and vision within the country since information on type and geographic distribution of biomass is being perceived as critical for feasibility analysis and project prioritization.

3. The biomass and bioenergy databases in the entire county across the varying categories should be mapped on geographical information system (GIS).

IV. Research Questions

1. Is there land on which biomass growth for bioenergy as a primary objective is viable or is bioenergy only viable if it is produced from residues from crop, forest and livestock in the country?

2. How can bioenergy contribute towards poverty alleviation? What would be the institutional framework for poverty reduction?

V. Expected Outcomes

1. A comprehensive and participatory assessment of land-use to inform decision makers on suitable locations for biofuel cultivation. Participatory land-use planning and design processes will bring together local communities and key stakeholders to evaluate and agree plans for future land-use. Integral to this process is an assessment of current land-use and potential conflicts of interest, along with consensus building and conflict resolution where required.

2. Bioenergy policies put in place which protect and ideally seek to increase national food security. In no instance, should food security be compromised in the pursuit of bioenergy development. The bioenergy policy framework will be shaped by policies keeping in mind various sectors, mainly agriculture, energy, environment and trade. As a result an enabling bioenergy policy statement hinged onto the Renewable Energy Policy Framework developed by the Department of Energy under the Ministry of Economic Affairs.

3. Provides a biomass inventory along with an assessment of potential growth in biomass resources and power generation that could help to satisfy the government's renewable portfolio.

4. Guidelines and recommendations for policy makers to better decision on bioenergy development in an environmentally, socially and economically.

5. Cost Estimates and Component

Component 1 - Determine availability of biomass in the country using dynamic maps, GIS data, and analysis tools.

Component 2 – Assess and analyze potential bioenergy development based on natural and agricultural resources.

A complete inventory of its biomass will allow to fully assess the range of options for bioenergy development. When assessing the availability of potential biomass, it is important for decision makers to consider all types, including waste/opportunity fuels and energy crops.

Budget = USD _____

6. Proposed Project Management Plan

The project can be jointly managed by Ministry of Agriculture and Forests and Ministry of Economic Affairs in coordination with the National Statistical Bureau and the donor organization(s).

A project steering committee can instituted for accountability, reporting, and transparency purposes.

The project may take a minimum of 12 months with technical assistance from donor bilateral and multilateral organizations.