Chapter 3

Economic Aspects of Biomass Utilisation

March 2008

This chapter should be cited as
Working Group for Sustainable Biomass Utilisation Vision in East Asia (2008), 'Economic Aspects of Biomass Utilisation', in Sagisaka, M. (ed.), *Sustainable Biomass Utilisation Vision in East Asia*, ERIA Research Project Report 2007-6-3, Chiba: IDE-JETRO, pp.38-69.

CHAPTER 3

ECONOMIC ASPECTS OF BIOMASS UTILISATION

3.1. Introduction

In 2007, Renewable sources supply 11% of the global energy demand. Biomass is by far the largest energy provider contributing a total of 1,150 million tons of oil equivalent (Mtoe) which translates to a 79% share of the total energy supply sourced out from these renewable sources. In terms of final energy consumption worldwide, biomass ranks fourth with a 10% share after the non-renewable fossil fuels such as oil with 34%, coal with 26%, and natural gas with 22% (Blauvelt, 2007).

Biomass refers to organic materials, either plant or animal, which undergoes the process of combustion or conversion to generate energy. Currently, the largest source of biomass is wood. However, biomass energy may also be generated from agricultural residues, animal and human wastes, charcoal, and other derived fuels. Biomass may be used either directly or indirectly. Direct use, more often termed as the traditional use of biomass, primarily involves the process of combustion. The energy that is generated is usually utilised for cooking, space heating, and industrial processes. Indirect use or the modern use concerns the more advanced processes of converting biomass into secondary energy. This includes gasification and electricity generation. In terms of cross-country adoption, the traditional use of biomass is prevalent among the developing countries. According to the Energy Future Coalition, "more than 2.4 billion people, generally among the world's poorest, rely directly on wood, crop residues, dung, and other biomass fuels for their heating and cooking needs". The modern or commercial use of biomass is more observable in industrialized countries such as the U.S. and in Europe (Blauvelt, 2007).

Renewable energy technologies give rise to economic advantage for two fundamental reasons. First, renewable energy technologies are labour intensive whereas fossil fuels are more capital intensive. Essentially, more jobs per dollar of investment in such technologies rather than conventional electricity generation technologies are created. Second, these technologies utilise indigenous resources. In effect, dollar savings arise from reduced fuel imports. According to the Wisconsin Energy Bureau, the favourable economic impacts of renewable energy are maximized when locally available resources can be substituted for imported fuels at a reasonable price and have a great supply in-state. Furthermore, renewables can create three times as many jobs as the same level of spending on fossil fuels (NREL, 1997).

The Biomass Energy Resource Centre (BERC), an independent, non-profit organisation that assists communities, schools and colleges, state and local governments, businesses, utilities, and others in the development of biomass energy projects, enumerates the positive impacts of biomass energy on local and regional economic development as follows:

- Creation and perpetuation of jobs in the region's economy since biomass fuel is locally produced, harvested, and processed
- Dollars spent on fuel are kept in the local economy compared with fossil fuel systems which generally export fuel dollars
- Employment generation in the regional economy through the building and maintenance of biomass energy systems

- Growth of the whole regional forest products industry (creation of new local markets) by adopting new ways of utilizing forest byproducts for fuel
- Generation of important local, state, and federal tax revenues due to all the jobs and economic activity created by biomass projects

The multiplier effect illustrated in Figure 3.1 causes different types of economic benefits as a result of investments in renewable energy technologies:

- Direct effects — these are on-site jobs and income created as the result of the initial investment; the people who assemble wind turbines at a manufacturing plant, for example.
- Indirect effects — these are additional jobs and economic activity involved in supplying goods and services related to the primary activity; people such as the banker who provides loans to the plant's owners, and the workers who supply parts and materials to the turbine assemblers.
- Induced effects — this are employment and other economic activity generated by the re-spending of wages earned by those directly and indirectly employed in the industry; jobs created by the manufacturing plant workers spending their wages at the local grocery store, for example.

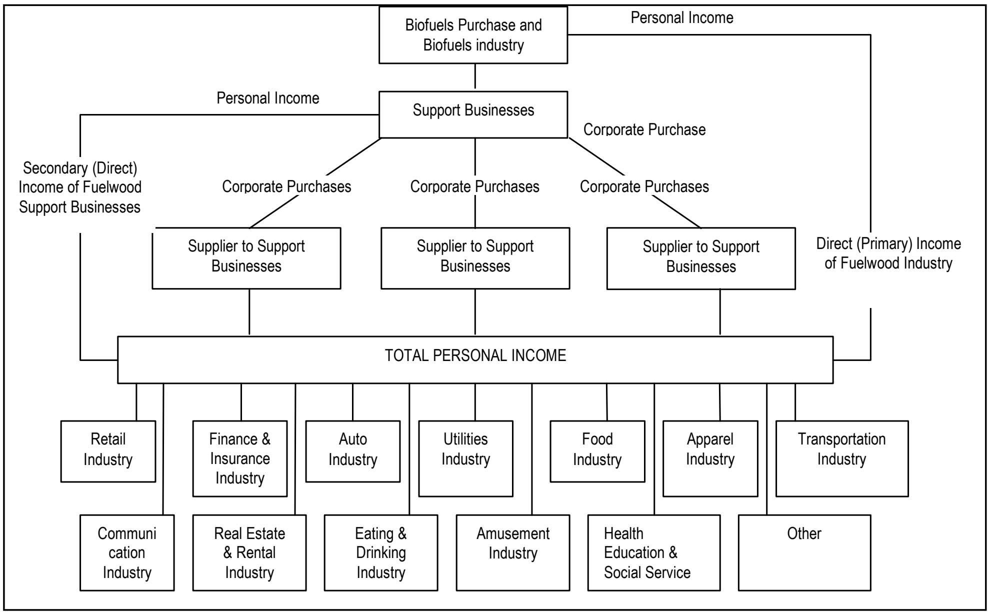

Figure 3.1. The Economic Ripple Effect of the Fuel Wood Industry

Source: National Bioenergy Industries Association

In view of contributing to policy decisions regarding sustainable development, socio-economic and environmental impacts of biomass use must be evaluated. Impacts of increased biomass use on agricultural markets, prices, land availability for food and food security are among the emerging and pressing issues that need to be addressed.

Economic and environmental benefits of biomass utilisation vary at each scale or level of analysis. Values of benefits and costs vary by individual, community, or nation and by firm or industry. In assessing the economic benefits of biomass use, it is important to consider several levels - a) the individual facility level); b) the community level; and c) the national level. Results at the national level can be pooled to present the global status.

At the individual level (i.e. use of a conversion facility or a dedicated energy farm production), the main focus is the profitability of using biomass energy systems compared to alternative energy systems (primarily fossil fuel systems) or of the replacement of conventional crop production with dedicated energy crop production.

At the community level (i.e. interaction of farms/facility with each other, and their interactions with and impacts on local infrastructure, institutions, and economic base), the number and quality of jobs produced or lost, impacts on the tax base, and changes in infrastructure (e.g., roads, schools, waste management facilities, water and sewer, etc.) needs and costs are the basis for economic valuation.

At the national level (i.e. interaction of all farms/facility and users resulting from the production and use of bioenergy, and the interactions and effects on national institutions), of interest are the total economic value added (gross domestic product); trade balance; job creation (loss); impacts on government expenditures; the cost and economic impact of maintaining national security; and the economic cost and effectiveness of environmental regulation.

Assessing patterns in the role of biomass in today's developing economies in East Asia can be done at the national level by looking at the history in the countries that have long time series data. The countries considered in this study are: China, India, Japan, Korea, the Southeast Asian[1] nations, including New Zealand, and Australia.

The succeeding sections present a review of the economic aspects of biomass energy use; the past, present and future situation in the said countries in terms of; and an analysis of biomass contribution to the economy in terms of GDP, employment, energy security, and dollar savings.

3.2. Review of Economic Aspects of Biomass Energy Use

This section presents a review of available literature on the economic aspects of biomass utilisation. It is not uncommon to note an enumeration of the advantages of biomass use in most literature, yet this report focused more on the viewed economic benefits. Economic studies on the impact of biomass use are likewise presented and summarized.

3.2.1. Economic Advantages

Modern use of biomass energy has been increasing worldwide. In many countries, it has been made a focal point of renewable energy plans and policies. This is because of several advantages that modern bioenergy offers compared to fossil fuels and/or other renewable energy sources.

Biomass can provide all the major energy carriers—electricity, gases, liquid fuels for transport and stationary uses, and heat on a decentralized (standalone) basis at scales of 10s or 100s of kilowatts (kW) and upwards. It therefore has great potential to

[1] Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam

substitute fossil fuels or other energy supplies in many contexts. Modern bioenergy technologies can also replace traditional cooking fuels with clean, smokeless, efficient and easily controlled liquid and gas alternatives based on renewable biomass rather than fossil fuels. Substitution of fossil fuels by biomass can lead to significant dollar savings.

The added value and income generation due to bioenergy systems is often retained locally, thereby helping reduce rural poverty. Indeed, modern bioenergy is viewed as a key means of promoting rural development (UNDP, 1995; Ravindranath and Hall, 1995; Kammen et al., 2001, Utria and Williams, 2002). In developing countries, modern bioenergy can provide a basis for rural employment and income generation. For many forestry and agroprocessing industries, biomass serves as an abundant, dependable and cheap fuel which can reduce energy costs.

Since biomass production is labour intensive, feedstock production could be an important source of both primary employment and supplemental income in rural areas. Many farmers could sell farm residues or even purpose-grown wood. Biomass production can be a new source of revenue. Indirectly, other rural enterprises can benefit from biomass feedstock production activity especially providers of agricultural inputs such as fertilizer, suppliers of farm equipment, transporters and marketers of goods. Employment is also generated in processing biomass and working at the bioenergy conversion facility.

Despite these potential advantages, expanding bioenergy use will not automatically contribute to sustainable development. Negative effects on food and the environment are threatening to offset the positive effects on welfare as an energy source. Bioenergy fuels are intensive in the use of inputs, which include land, water, crops, and fossil energy, all of which have opportunity cost. Understanding how bioenergy will affect resource allocation, energy and food prices, technology adoption, and income distribution, etc., is thus essential.

3.2.2. Economic Studies on the Impact of Biomass

Economic studies use a number of techniques to model the impacts from different angles. These are microlevel, single sector and multi-sector models. Microlevel models like cost accounting models and models of technology adoption and resource allocation are useful for calculating the economics of bioenergy from the perspective of an individual economic agent. Sector models are often used from a policymaker's perspective. They are meant to assess the aggregate response of the entire sector to a policy, such as pollution taxes and standards, blending mandates, trade regulations, etc (World Bank, 2007).

We can apply input-output (I-O) models in economic general equilibrium analyses to simulate multi-sector behaviours. It mathematically portrays the transactions among various industries as these industries provide goods and services for consumers, businesses, and government. It provides a systematic method of analyzing inter-industry relationships, thus describing the complete economic impacts of industry activity. The I-O approach is based on the idea that any transaction is both a purchase and a sale, depending on the point of view. A sale by one merchant is viewed as a purchase by the buyer (US Department of Commerce, 1997). The main purpose of which is to measure the overall economic impact of changes in energy prices on employment, government payments, total economic activity, and balance of trade (Manne, Richels, and Weyant 1979; Bhattacharyya 1996).

It is interesting to note that in the studies reviewed, those that involved microlevel models were conducted in New Zealand, Australia and Asian countries like Malaysia, Indonesia, Philippines and India. I-O models were often used in the biodiesel, ethanol, biomass power industries primarily in the US, EU countries, Brazil, India and Indonesia.

While almost all countries in East Asia and the Pacific have already embarked on their renewable energy and sustainable development strategies, projects that involved biomass utilisation were mostly concerned in establishing economic feasibility so as to influence decisions by an entity (farmer, investor or public sector) whether to venture into such activity or not.

The only studies meant to assess biomass contribution to economy in this region are: the assessment of the Indonesian palm oil industry (Kehati, 2006); the macroeconomic trends in biomass intensity and GDP ratio in developing economies in Asia (Victor and Victor, 2002); the assessment of economic contribution of sustainable energy industries in Australia (Mark Ellis and Associates, 2002); and the impact of IREDA funded biomass power and cogeneration projects in India (Rajkumar, 2004).

Studies on bioethanol production show significant impacts to labour income, tax revenues and employment. The Renewable Fuels Association (2004) estimated 694 total jobs out of a 40 million gallon per year ethanol plant and average tax receipts of \$1.2 million. Resource Systems Group, Inc. (2000) estimated a range of \$170M -

$200M labour income and 4000-6000 total jobs from a 50 million gallon per year ethanol plant. Likewise, total direct employment of 4752 and 9906 jobs would be generated from a 200 million gallon and 400 million gallon per year ethanol plants in California, respectively (California Energy Commission, 2001). In Brazil, a large scale expansion of ethanol production were assessed with the annual production assumed to increase by 104.55 billion liters in 20 years, so as to replace 5% of the estimated global demand for gasoline in 2025. Economic impacts due to the installation of 615 autonomous distilleries (each produces 170 million liters of ethanol from 2 million tonnes of sugarcane yearly) with an estimated investments of R$ 195.81 billion (2005 values), on the average, would generate about 487,300 jobs and a GDP increase of R$ 12.47 billion (2002 values). Operations-related impacts yields an 11.4% increase in GDP (R$ 153.75 billion) and 8% increment in employment (5342 jobs) (Scaramucci and Cunha, 2006).

Studies on biodiesel facilities likewise yield jobs thus contributing to local economy. In Vermont, USA, direct and induced output ranges from approximately $14 million to over $30 million, or approximately 3-6% of the total system output. The biodiesel facility and oilseed processor are predicted to generate about 764 new jobs in the state (Mulder, 2004).

The U.S. biodiesel industry is comprised of 65 manufacturing plants with annual capacity of 395 million gallons per year in 2006. If all new construction and expansion projects are completed and come on line, they will add an estimated 714 million gallons of capacity. The existing and new biodiesel plants will spend $7.6 billion (2005 dollars) on goods and services between 2006 and 2015. Feedstock costs (soybean oil and other feedstocks) are the largest component of operating costs, accounting for about 80 percent of production costs. These expenditures will add $15.6 billion (2005 dollars) to GDP between 2006 and 2015, increase household income by almost $5.4 billion (2005 dollars), and support the creation of as many as 27,400 jobs in all sectors of the economy (LECG, 2006).

Studies that analyze the impacts of policy options in bioenergy use are also in this review. To encourage biofuel policy in the EU, CEC (2006) assessed the impacts of three policy options: 1) Business as usual; 2) Regulated market-based approach; and 3) Deregulated market approach. Option 1 **(**where biofuels directive stand as it is at the time of study) would result in direct employment effects of 34000 full time jobs per year. Option 2 (which encourages biofuels projects, promotes biofuels assistance projects in developing countries) would result in more than 100,000 jobs or a potential to create an additional 67,000 jobs (direct employment), most of which would be in rural regions. Option 3 (which will phase out energy crop premium and tariff duties on biofuels and biofuel feedstocks by 2010 at the latest) would have a similar positive effect on employment in agriculture as option 2, because potential additional employment is linked to an expanded land use and in both cases the area currently set-aside would be reused.

Most studies found in literature involving I-O models focus on the economies of the United States and the EU and have not considered in detail the conditions in developing countries. Moreover, the distribution of the impacts within a given sector of the economy is rather implicit. Microlevel studies or cost-benefit analysis of a bioenergy venture predominates in the developing countries in Asia. Such studies do not actually assess the impact of biomass use to the local economy. Most of the studies estimated positive effects of policies and ethanol and bio-diesel production to local income, taxes and rural employment (direct or indirect).

These impacts however were mostly based on US, EU studies. Hence there is need for developing countries in Asia to employ the models used in the studies to come up with a developing economy perspective on biomass production and use. At the microlevel, there is need to conduct studies that would lead to the adoption of biomass technologies by farmers, processors, and consumers. There is little understanding of the timing, location, and extent of adoption. There is little or no treatment of the cost of environmental externalities, which could greatly affect economic analysis.

3.3. Analysis of Biomass Contribution to Economy

In order to analyze biomass contribution to economy in the East Asian countries considered, a macro-economic approach was used. Data on biomass share in energy mix and GDP per capita were obtained from online statistical databases. The limitation of such analysis is that reported statistics on energy use normally do not include traditional or non-commercial uses of biomass, hence reports of biomass share in some countries do not depict the actual scenario. Nevertheless, certain degree of correlation could still be deduced from the succeeding analysis.

3.3.1. Gross Domestic Product

Victor et al (2002) projected biomass intensity and GDP ratio for selected developing countries in Africa, Asia and Latin America. A steady and rapid improvement of biomass intensity for all countries was seen. A rise in income yields to a decline in biomass intensity. The rate of change varies considerably. However in Thailand and China, the rate of increase in biomass intensities was 8 percent annually

Victor et al (2002) also looked into the pattern of biomass use and incomes in developing countries[2]. Using 1996 data, it was observed that as income increased, the share of fuelwood in total household energy consumption declined. The exact share of fuelwood varied greatly across countries, but the declining pattern of fuelwood share with income was specific at low income levels. Furthermore, for countries with high per capita income, industrialization and urbanization, the share of biomass in energy consumption is smaller. In the countries with low per capita incomes, the share of biomass in total energy can reach 80% or more. On one hand, US historical data confirm that with socio-economic development, households and industries move from low-quality fuels, such as traditional biomass, to more convenient and efficient fuels, such as kerosene, coal, oil, gas and electricity.

In Table 3.1, the value of the wood energy contribution to the Asian countries' Gross Domestic Product (GDP) is observed. Economic growth could be achieved through increases in a country's GDP. The data covers the years 1998, 2000, and 2002. Among the Asian countries, the largest earner from wood energy was consistently China, followed by India and Indonesia.

---

2 Includes Nepal, Bhutan, Laos, Bangladesh, Vietnam, Cambodia, Pakistan, India, Sri Lanka, Indonesia, Maldives, Philippines, China, Thailand, Malaysia

Table 3.1. Gross domestic product (in US$ million) – wood energy activities[3]

Country	1998	2000	2002
Bangladesh	44,092	47,181	47,328
Bhutan	403	484	594
Cambodia	3,035	3,367	3,677
China	946,301	1,080,429	1,237,145
India	413,813	460,616	515,012
Indonesia	95,446	150,196	172,911
Laos	1,285	1,711	1,680
Malaysia	72,175	90,041	95,157
Maldives	540	624	618
Myanmar	NA	NA	NA
Nepal	4,892	5,480	5,493
Pakistan	62,228	60,756	60,521
Philippines	65,172	74,862	77,076
Sri Lanka	15,795	16,305	16,373
Thailand	115,849	120,968	126,407
Vietnam	27,150	31,168	35,110

Source: World Bank, 2002

Conservation and Development Specialist Foundation (CDSF, 2007) case study evaluated the economic impacts of biomass in the Philippines in terms of value addition accumulated from rice and coconut conversion or processing.

The final value added amounted to PhP10.14 or US$0.24 (US$= PhP42) per kilogram of mature coconut processed into coconut methyl ester (Table 3.2) for a total

3 Refers to different wood-based fuels which include fuelwood (cut directly from trees and forests); charcoal and wood-derived fuels and by-products of forest processing industry such as black liquor and other wood residues.

value added of PhP7,068,000,000 or US$ 168,000,000 (Table 3.4). Total value addition for rice amounted to PhP7.13 or US$0.1698 per kilogram of palay processed into milled rice (Table 3.3) for a total value added of PhP882,996 or US$21,023 (Table 3.5). The computed values already include the profits generated out of the by-products of rice and coconut processing.

Table 3.2 Summary of value added (in PhP) by product form produced from a kilo of mature coconut.

PRODUCT FORM	GROSS REVENUE (in PhP)	PRODUCTION COST (in PhP)	PARTIAL VALUE ADDED	VALUE ADDED FROM BY-PRODUCTS				FINAL VALUE ADDED
				Husk	Shell	Copra Meal	Glycerin	
Mature Coconut	5.00	2.42	2.58	1.09	—	—	—	3.67
Copra	7.20	3.93	3.27	1.09	0.19	—	—	4.55
Unrefined Oil	11.52	6.22	5.30	1.09	0.19	0.24	—	6.82
Coconut Methyl Ester	16.74	9.39	7.35	1.09	0.19	0.24	1.26	10.14

Table 3.3. Summary of value added for the different sectors in rice trading.

SECTOR	GROSS REVENUE (in PHP/KG)	PRODUCTION COST (in PHP/KG)	PARTIAL VALUE ADDED	VALUE ADDED FROM BY-PRODUCTS Husk & Bran	FINAL VALUE ADDED
Production	9.00	6.50	2.50	—	2.50
Up to Milling	13.44	8.47	4.97	0.71	5.68
Up to Wholesaling	14.56	8.76	5.80	0.71	6.51
Up to Retailing	15.68	9.26	6.42	0.71	7.13

Another important economic contribution of biomass is in terms of tax revenues generated from the different entities within the industries as estimated in the CDSF case study. The income generated from mature nut, copra, unrefined oil, and methyl ester productions amounts to PhP7,216 million per year. Adding this value to the net profit generated from all by-products gives the total annual income of PhP7,068 million from the coconut industry. Taxes are set at 32% of the total taxable income. Coconut farmers are exempted from paying taxes, hence, only the copra producers, unrefined oil producers, and methyl ester producers are subjected to 32% income tax. Total tax revenues amount to PhP1,380 million or US$33 million annually (Table 3.4).

By adding the income generated out of the sale of by-products, the total annual net income generated out of the rice industry in Quezon was ultimately valued at PhP882,996. Total taxable income is set at 32%. Since the farmers are exempted from paying taxes, total tax revenues from the rice industry amounts to PhP179,834 or US$4,281 annually from tax dues paid by the millers, wholesalers, and retailers (Table 3.5).

Table 3.4 Total annual net income and taxes generated from coconut production and processing in Quezon.

PRODUCT FORM	Total Net Profit (M PhP)	Taxes Paid (M PhP at 32%)
Mature Coconut	2,755	exempted
Copra	674	215.56
Unrefined Oil	1,703	545.01
Coconut Methyl Ester	1,936	619.62
ALL	7,068 $168	1,380.19 $33

Table 3.5. Total annual net income and taxes generated from rice production and processing in Quezon

SECTOR/OUTPUT	NET PROFIT (in PhP)	TAXES PAID (in PhP at 32%)
Farmer/Wet Palay	321,013	exempted
Miller/Milled Rice	411,348	131,631
Wholesaler/Milled Rice	70,248	22,479
Retailer/Milled Rice	80,387	25,724
ALL SECTORS	882,996 US$21,023	179,834 US$4,281

3.3.2. Employment

Employment impacts could be well assessed through I-O models, however, to represent microlevel activities effects to other sectors is rather complicated. First, employment impacts (direct and indirect) are specific to a biomass generation facility, and so to come up with a total employment impact from all facilities, I-O analysis must be conducted to every specific type. Extrapolation is possible to same facilities of different capacities; however, the input requirements would be enormous. Additional literature on employment impacts were thus resorted to.

In terms of employment generation, global scenarios differ with respect to biomass utilisation. For developing countries, the traditional way of using biomass energy is prevalent. The rapid population growth entails great pressure on the countries' existing resources with the persistence of such trend in biomass utilisation. In contrast, developed countries give weight on investing in research and development for further advancement of biomass technology (Domac, 2004).

The use of wood and some other forms of biomass energy generates at least 20 times more local employment within the national economy than any other form of energy, per unit. A large amount of unskilled labour is engaged in growing, harvesting, processing, transporting and trading the fuels, which generates off-farm income for rural populations, either regularly or off-season (FAO, 1997).

Estimated employment figures among various developing countries due to production and distribution of bioenergy resources are shown in Table 3.6.

Table 3.6 Estimated employment figures among various countries

Country	Estimated Employment Figures	Description and Nature of Employment
Pakistan	600,000	Wholesalers, retailers in the WF trade. Many are involved in production, conversion, and transportation. About three-quarters are full time, the rest part time. The ratio between traders and gatherers is 1:5
India	3–4 million	The woodfuel trade is the largest source of employment in the energy sector
Philippines	700,000 hhs (productions) 140,000 hhs (trade)	Biomass energy production and trade

Source: Domac, 2004

A more detailed account of job creation, earnings and employment in bioenergy projects is presented in Table 3.7. Three types of systems are shown here: intensive production in marginal lands, woodfuel production with intensive inter-cropping, and large-scale woodfuel production on previously forested lands. Total employment per unit of energy in person-years was derived for the activities of establishment, weeding, harvesting, chipping and administration.

Table 3.7 Employment and earnings from selected studies among developing/tropical countries (partial) biofuel production

Type	Establishment	Weeding	Harvesting	Transport	Chipping	Administration	Total
				Person years/PJ			
Intensive production, farmers	112	338	248	70	13	19	799
Intensive inter-cropping	71	196	251	71	13	19	620
Large-scale "energy forestry"	34	59	85	51	13	11	252
				Earnings $ per PJ			
Intensive production, farmers	82,305	205,761	257,202	68,587	13,717	68,587	696,159
Intensive inter-cropping	54,870	126,886	257,202	68,587	13,717	68,587	589,849
Large-scale "energy forestry"	17,147	27,435	37,723	20,576	13,717	34,294	150,892

Source: Domac, 2004

Domac (2004) also highlighted that the use of renewable energy technologies will more than double by 2020 and will lead to the creation of about 900,000 jobs. An approximate of 500,000 of the total number of projected jobs will be in the agricultural industry in order to provide the primary biomass fuels (Table 3.8).

Table 3.8 Impact on employment in renewable technologies for European Union

	2005	2010	2020
Solar thermal heat	4,590	7,390	14,311
Photovoltaics	479	−1,769	10,231
Solar thermal electric	593	649	621
Wind onshore	8,690	20,822	35,211
Wind offshore	530	−7,968	−6,584
Small hydro	−11,391	−995	7,977
Bioenergy	449,928	642,683	838,780
Total	453,418	660,812	900,546

Source: Domac, 2004

Melhuish (1998) estimated the contribution of energy systems to sustainable development in New Zealand. There were a total of 12,920 jobs and 9,900 jobs in the energy sector in 1990 and 1996, respectively. These data show a 23% decline in 6 years or 3.8% annually. Out of these totals, 4.6% (600 jobs) and 8.1% (800 jobs) were in the energy efficiency and renewable energy sector in 1990 and 1996, respectively.

In Australia, Gerardi (2006) reported the economic contribution of renewable energy technologies in three sectors namely generation, manufacturing, and services. The renewable energy industry generates a total of 6,212 direct jobs and 9,069 indirect jobs. Of these totals, the leading contributor is bioenergy which renders 27.4% (1,813 direct jobs) and 29.3% (2,664 indirect jobs) (Table 3.9).

Table 3.9. Economic contribution of renewable energy technologies in Australia, 2005

Technology	Current capacity (MW)	Committed capacity (MW)	Total assets ($million)	Total revenue ($million/yr)	Direct jobs	Indirect jobs
Bioenergy	566	130	626	304	1,813	2,664
Hydro	6,989	156	6,234	985	1,655	1,510
Wind	561	338	864	252	956	1,802
Wave	1	1	6	1	4	6
Solar heater	Na	na	na	106	1,000	1,772
PV solar	46	na	10	220	1,185	1,316
TOTAL	8,612	625	7,740	1,866	6,212	9,069

Source: Gerardi (2006)

A Philippine case study conducted by CDSF (2007) estimated the employment impacts in terms of the man-day requirement of biomass-based industries. Results showed that biomass-based industries such as coconut and rice could generate a total of 6,591,174 man-days (Table 3.10) and 2,867,437 man-days (Table 3.11) in a year, respectively.

Table 3.10. Summary of annual employment generation product form in coconut industries in Quezon, Philippines.

PRODUCT FORM	TOTAL OUTPUT IN QUEZON (in MT)	LABOUR REQUIREMENT (in mandays)
Mature Coconut	750,155	3,439,864
Copra	300,062	1,500,310
Unrefined Oil	270,056	1,500,310
Coconut Methyl Ester	270,056	150,691
TOTAL EMPLOYMENT (mandays)		6,591,174
Employment per Hectare (mandays)		33.56
Number of Labourers Employed (total)		27,464

Table 3.11. Summary of annual employment generation per palay/rice operation in Quezon, Philippines.

OPERATION	TOTAL OUTPUT (in MT)	LABOUR REQUIREMENT (in mandays)
Palay Production	128,405	2,504,370
Rice Processing	120,701	241,401
Rice Marketing (Wholesaling and Retailing)	72,420	121,666
TOTAL EMPLOYMENT (mandays)		2,867,437
Employment per hectare (mandays)		75.24
Number of labourers (@ 240 mandays /yr)		11,948

Employment impacts of biomass use are actually modest compared to other sectors of economy. However, unique to the sector is its ability to stir rural economy and development. When a biomass facility has great potential for replication in different rural areas, even the smallest of impacts could be magnified and significantly contribute to the national economy.

3.3.3. Energy Security and Dollar Savings

Wood and other types of biomass are widely used as fuels in the private and industrial sectors, basically because they are cheaper than other fuels. Local availability and reliability of supply add to the economic advantages. Modern applications in both industrialized countries and in South-East Asia have demonstrated that biomass energy can also be competitive for larger-scale industrial applications. For fuel-importing countries, the use of local biomass can save substantial amounts of foreign exchange.

Presently, it is anticipated that shifting to renewable energy could save countries in East Asia as much as two trillion US dollars in fuel costs over the next 23 years, or more than 80 billion dollars annually, according to the environmental group Greenpeace. As projected by the International Energy Agency (IEA), investment costs for new power plants in East Asia would total 490 billion dollars between 2004 and 2030. However, under the Greenpeace scenario, investment costs on renewable energy would amount to 556 billion dollars over the same time frame. The IEA projections stated that fuel costs would amount to $6.3 trillion over a 23-year period. Nonetheless, if East Asian countries shifted to renewable energy, fuel costs over the same period would total $4.2 trillion dollars, translating into savings of $2.1 trillion (Terra Daily, 2007).

The Philippines is one of the countries which are heavily dependent on imported fuels. As a result, the national government is continuously promoting the utilisation of indigenous renewable sources such as coconut methyl ester as diesel enhancer. With such advocacy, diesel imports could be reduced significantly which translates to dollar savings. CDSF (2007) estimated that 270,058 MT of coconut methyl ester produced in the chosen study area could generate US$80 million worth of savings from reduced diesel imports (Table 3.12). Biomass-based product development is a great opportunity for an agricultural country like the Philippines to exploit its vast biomass sources.

Table 3.12 Annual foreign exchange savings from CME production to replace diesel.

ITEM	VALUE
Forex savings per diesel displacement (US$/li)*	0.64
Volume of CME produced in Quezon (MT)	270,058
Volume of CME (MT) consumed locally (40%)	108,023
Volume of diesel (in liters) to be displaced at 1% blend	125,608,372.09
Total forex savings (US$)	80,389,358.14

Note: *Based on Dept of Energy's computation, 2007

3.4. Summary and Conclusions

In 2007, Renewable sources supply 11% of the global energy demand. Biomass is by far the largest energy provider contributing a total of 1,150 million tons of oil equivalent (Mtoe) which translates to a 79% share of the total energy supply sourced out from these renewable sources. In terms of final energy consumption worldwide, biomass ranks fourth with a 10% share after the non-renewable fossil fuels such as oil with 34%, coal with 26%, and natural gas with 22% (Blauvelt, 2007).

Biomass energy benefits the local and regional economic development through creation and perpetuation of jobs since biomass fuel is locally produced, harvested, and processed. It also keeps fuel dollars in the local economy unlike with fossil fuel systems which generally export fuel dollars. It also leads to development of new local markets by adopting new ways of utilizing forest byproducts for fuel. Moreover, tax revenues are also generated due to all the jobs and economic activity created by biomass projects

A review of available literature on economic studies on biomass use was conducted. The studies covered in this review are not exhaustive, but they somehow represent works on the economic impacts of biomass use in developed countries and in some developing economies of Asia. The economic studies on biomass involve 3 types: microlevel studies which provide point estimates of average costs and profitability of biomass production; sector-wide studies that analyze the impacts of policies at the sector or economywide level; multisector studies that analyze inter-industry relationships, thus describing the complete economic impacts of an industry or a biomass production facility.

Most studies found in literature involving I-O models focus on the economies of the United States and the EU and have not considered in detail the conditions in developing countries. Most of the studies estimated positive effects of policies and ethanol and bio-diesel production to local income, taxes and rural employment (direct or indirect). Microlevel studies or cost-benefit analysis of a bioenergy venture predominates in the developing countries in Asia. Such studies do not actually assess the impact of biomass use to the local economy.

These impacts however were mostly based on US, EU studies. Hence there is need for developing countries in Asia to start assessing the economic impacts of biomass use to come up with a developing economy perspective.

To assess the role of biomass in today's developing economies in East Asia, the past, current and future trends of biomass utilisation were reviewed. The countries included in the study are: China, India, Japan, Korea, the Southeast Asian nations, including New Zealand, and Australia. To indicate biomass contribution to the East Asian countries' economy, GDP employment, energy security and dollar savings were used.

Past and current trends in biomass energy use in the countries considered generally show a declining share in the energy mix, though the actual figures of consumption are increasing. Fossil fuels remain to be the key fuels.

Employment opportunities (direct and indirect) abound in the biomass energy industry especially in the services sector. The services sector offers the largest employment both in terms of direct and indirect jobs as it encompasses a wide variety of employment opportunities including installation, fuel collection and extraction, distribution and sales, consulting and research and development. Employment impacts of biomass use are actually modest compared to other sectors of economy. However, unique to the sector is its ability to stir rural economy and development. When a biomass facility has great potential for replication in different rural areas, even the smallest of impacts could be magnified and significantly contribute to the national economy.

Taking the case of a developing economy like the Philippines, the economic impacts of biomass production and processing on a micro level were estimated through monetary equivalents. The economic impacts that were assessed were value addition, job creation, tax revenue generation, and foreign trade impacts in terms of dollar earnings and savings. Biomass energy occupies a large fraction in the country's total energy mix. Generally, the overall economic impact of the biomass-based industries was found to be significant. Economic benefits were favourable not only on the provincial or regional level but also to the national economy as a whole.

The potential benefits of biomass energy are extensive. This review has seen a generally positive trend in the macroeconomic indicator (GDP) with biomass share, whereas a number of employment opportunities can be achieved from the industry. For countries who are net importers of fuels, biomass use could not only save them billions of US dollars but also be able to diversify their energy sources and achieve energy security in the long term.

References

Blauvelt, E. 2007. Biomass – The largest source of renewable energy. Retrieved from the World Energy Discussion on-line database on the World Wide Web: http://worldenergydiscussion.blogspot.com/2007/08/biomass-largest-source-of-renewable.html

Bournakis, A.D., Cuttica, J.J. and Mueller, S. 2005. The Economic And Environmental Impacts Of Clean Energy Development In Illinois. Retrieved from the University of Illinois Chicago on-line database on the World Wide Web: http://www.erc.uic.edu/PDF/Clean_Energy_Development.pdf

BP Global. 2006. Statistical Review of World Energy 2007. Retrieved from the BP Global on-line database on the World Wide Web: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2007/STAGING/local_assets/downloads/spreadsheets/statistical_review_full_report_workbook_2007.xls

California Energy Commission. 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in Califronia. http://www.energy.ca.gov/report/2001.

Commission of the European Communities. 2006. An EU Strategy For Biofuels Impact Assessment. Retrieved from the European Commission on-line database on the World Wide Web: http://ec.europa.eu/agriculture/biomass/biofuel/sec2006_142_en.pdf

Domac, J. 2004. Socio-economic drivers in implementing bioenergy projects. Retrieved from Science Direct on-line database on the World Wide Web: http://www.sciencedirect.com/

East Harbour Management Services. 2002. Drivers of Woody Bioenergy in New Zealand. Retrieved from the Bioenergy Association of New Zealand on-line database on the World Wide Web: http://www.bioenergy.org.nz/documents/publications/articles/WPS/DriversOfBioenergyInNZ_021114a.pdf

East Harbour Management Services. 2005. Availabilities and Costs of Renewable Sources of Energy for Generating Electricity and Heat 2005 Edition. Retrieved from the NZ Ministry of Economic Development on-line database on the World Wide Web: http://www.med.govt.nz/upload/26015/renewables.pdf

Elauria, M.M., Almazan,P.L.P.,Castro,M.L.,and Elauria,A.J.,2008. Case Study on the Economic Impacts of Biomass Production and Processing in the Philippines.

FAO 1997. Biomass energy in ASEAN member countries. Retrieved from the Food and Agriculture Organization on-line database on the World Wide Web: http://www.fao.org/sd/EGdirect/EGan0008.htm

Gerardi, W. 2006. Renewable Energy - A Contribution to Australia's Environmental and Economic Sustainability. Renewable Energy Generators Australia. Retrieved from the REGA on-line database on the World Wide Web: http://www.rega.com.au/Documents/Publications/J1281%20Final%20Report%20V3.pdf

Judd, B. 2003. Feasibility of Producing Diesel Fuels From Biomass in New Zealand. Retrieved from the NZ Energy Efficiency and Conservation Authority on-line database on the World Wide Web: http://www.eeca.govt.nz/eeca-library/renewable-energy/biofuels/report/feasibility-of-producing-diesel-fuels-from-biomass-in-nz-03.pdf

Kehati. 2006. Indonesian Path Toward Sustainable Energy: A case study of developing palm oil as biomass in Indonesia. The Indonesian Biodiversity-KEHATI; Sawit Watch Social Economic Research Institute–INRISE; Bogor Agricultural Institute Media Indonesia Group/Daily Research & Development. Retrieved from the Both Ends on-line database on the

World Wide Web:

http://www.bothends.org/strategic/061211_Biomass%20case%20study%20Indonesia.pdf

LEGC. 2006. Contribution Of The Biodiesel Industry To The Economy Of The United States. Retrieved from the National Biodiesel Board on-line database on the World WideWeb:http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060720_gen-371.pdf

Melhiush, M. 1998. Energy for Economic, Environmental and Social Sustainability. New Zealand Report to GEO Project. Sustainable Energy Forum. Wellington, New Zealand. Retrieved from the Helio-International on-line database on the World Wide Web:
http://www.helio-international.org/Helio/anglais/reports/newzealand.html

Mulder, K. 2004. An Ecological Economic Assessment of a Proposed Biodiesel Industry for the State of Vermont. Gund Institute for Ecological Economics Rubenstein School of the Environment and Natural Resources University of Vermont. Retrieved from the University of Vermont on-line database on the World Wide Web:
http://www.uvm.edu/~susagctr/Biomass%2004%20Final%20Report.pdf

National Bioenergy Industries Association, Economic Benefits of Biomass Power Production in the U.S. Reprinted from Biologue Issue Volume 10, Number 1

http://www.nyserda.org/rps/Article.pdf

NREL. 1997. Dollars from Sense: The Economic Benefits of Renewable Energy. Retrieved from the NREL on-line database on the World Wide Web: http://www.nrel.gov/docs/legosti/fy97/20505.pdf

Pang, S. and Li, J. 2005. BIGCC System For New Zealand: An Overview And Perspective. Retrieved from the NZ University of Canterbury on-line database on the World Wide Web: http://ir.canterbury.ac.nz/bitstream/10092/166/1/12603290_Main.pdf

Rajagopal, D. and Zilberman, D. 2007. Review of Environmental, Economic and Policy Aspects of Biofuels. The World BankDevelopment Research Group Sustainable Rural and Urban Development Team. Retrieved from the World Bank on-line database on the World Wide Web: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2007/09/04/000158349_20070904162607/Rendered/PDF/wps4341.pdf

Rajkumar, D. 2004. Biomass Power For Rural Energy And Sustainable Development In India – Role Of Ireda. Retrieved from the Natural Resources Institute on-line database on the World Wide Web: http://www.nri.org/biomass/conference_papers/funding_renewable_energy_programmes_in_india.pdf

Resource Systems Group, Inc. 2000. Economic Impact Of Fuel Ethanol Facilities In The Northeast States. Retrieved from the Northeast Regional Biomass Program on-line database on the World Wide Web: http://www.nrbp.org/pdfs/pub25.pdf

Renewable Fuels Association. 2004. Ethanol Industry Outlook http//www.ethanolrfa.org

Scaramucci, J.A. and Cunha, M.P. Undated. Bioethanol As Basis For Regional Development In Brazil: An Input-Output Model With Mixed Technologies. Retrieved from the Wilson Center on-line database on the World Wide Web: http://www.wilsoncenter.org/news/docs/bioethanol%20regional%20dev%20strategy%20brazil.pdf

Southeast Biomass State and Regional Partnership. 2006. Fact Sheet: Economic Impacts of Bioenergy Production and Use. Retrieved from the Arkansas Energy Office on-line database on the World Wide Web: http://www.arkansasrenewableenergy.org/fact%20sheets/Economics.pdf

Stucley, C.R., Schuck, S.M. Sims, R.E.H., Larsen, P.L., Turvey, N.D. and Marino, B.E. 2004. Biomass Energy Production In Australia: Status, Costs And Opportunities For Major Technologies. Retrieved from the Rural Industries Research and Development Corporation on-line database on the World Wide Web: http://www.rirdc.gov.au/reports/AFT/04-031.pdf

TERRA DAILY. 2007. Renewable energy can save East Asia two trillion US dollars in fuel costs. Retrieved from the Terra Daily on-line database on the World Wide Web: http://www.terradaily.com

United Nations Environment Program. 2007. Analysing our Energy Future: Some Pointers for Policy Makers. Retrieved from the UNEP on-line database on the World Wide Web: http://www.unep.org/pdf/dtie/energyfuture.pdf

Victor, N.M. and D.G. Victor.2002. Macro Patterns in the Use of Traditional Biomass Fuels. Retrieved from the Stanford University on-line database on the World Wide Web: http://iis-db.stanford.edu/evnts/3920/VICTOR_ppr.pdf

Waters, D. and McKissick, J. 2004. An Economic Impact Analysis of a Large-Scale (533 WTPD) Biomass Gasification Facility on Georgia's Economy. Retrieved from the University of Georgia on-line database on the World WideWeb: http://www.agecon.uga.edu/~caed/biomass.pdf

Weisbrod, G. and Lin, X. 1996. The Economic Impact Of Generating Electricity From Biomass In Iowa: A General Equilibrium Analysis. Retrieved from the Massachusetts Institute of Technology on-line database on the World Wide Web: http://ocw.mit.edu/NR/rdonlyres/Urban-Studies-and-Planning/11-482JFall-2005/356A077F-D8CE-41B7-A6FC-E825C0C9B0ED/0/biomass.pdf