The Future Energy Potential of Replanting Wastes in Malaysia

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ABSTRACT

Energy that is potentially available in Malaysia from future replanting wastes of rubber, oil palm, cocoa and pepper is estimated. When compared to the potential of rubber wood and oil palm replanting wastes, the future potential of the replanting wastes from pepper is negligible while that from cocoa will only be significant in the next century. It is found that by itself the energy potentially available from future replanting wastes is equivalent to about 2% of the nation's total cumulative energy requirements from now till the year 2005. However, if this 2% is added to the current annual production of plant matter wastes, about 10% of the nation's total cumulative energy demand from now till 2005 can be met by the utilisation, as fuel, of most of the plant matter wastes produced. In this, no growth in the present agricultural and logging activities is assumed. A conversion to usable energy at 20% efficiency is also assumed.

INTRODUCTION

In the previous paper we have estimated the total amount of energy that is potentially available at the present time, if wastes from agriculture and logging activities in Malaysia are to be harnessed for use as fuel. It was also mentioned that currently other than rubber wood, wastes generated during the replanting of oil palm, coconut, cocoa and pepper are not very substantial. These as well as rubber are long term crops with trees having economic life spans of a decade or more. It is the intent of this paper to discuss the future energy potential of replanting wastes from these agricultural activities.

RUBBER

Large quantities of rubber wood are available during replanting. Table 1 shows the total replanted or newly planted areas for the years 1951 to 1980 while Table 2 shows the amount of wood that will become available because of replanting for the years 1981 to 2007.[1] To arrive at Table 2 from the data of Table 1, it was assumed that 1 hectare of plantation produces about 180 m^3 of green wood and that 1 m^3 of green wood weighs about 0.72 tonne. Tan[2] reported that the moisture content of green rubber wood is about 60%. Using this figure, the amount of dry

Table 1
Rubber cultivation – total replanted and newly planted areas

Year	Total Area Replanted/ New Planted (ha)	Year	Total Area Replanted/ New Planted (ha)
1951-55*	245 105	1970	49 900
1956-60*	290 375	1971	52 700
1961	89 800	1972	49 900
1962	94 200	1973	59 700
1963	105 600	1974	45 300
1964	86 600	1975	48 200
1965	81 500	1976	33 100
1966	54 100	1977	35 200
1967	52 900	1978	44 400
1968	25 700	1979	36 300
1969	33 600	1980	40 800

*Shows total area for the period.

Table 2
Quantity of rubber wood and energy potentially available

Year	Amount of Green Wood (X 10^3 m^3)†	Amount of Green Wood (X 10^3 tonnes)	Amount of Dry Organic Matter (X 10^3 tonnes)	Energy Potentially Available (X 10^{13} J)	Energy Potentially Available (X 10^4 boe)
1981-55*	44 118.9	31 765.61	19 853.51	39 250.39	6 361.49
1986-90*	52 267.68	37 632.73	23 520.46	46 499.95	7 536.46
1991	16 164	11 638.08	7 273.8	14 380.30	2 330.68
1992	16 956	12 208.32	7 630.2	15 084.91	2 444.88
1993	19 008	13 685.76	8 553.6	16 910.47	2 740.76
1994	15 588	11 223.36	7 014.6	13 867.86	2 247.63
1995	14 670	10 562.40	6 601.5	13 051.17	2 115.26
1996	9 738	7 011.36	4 382.1	8 663.41	1 404.12
1997	9 522	6 855.84	4 284.9	8 471.25	1 372.97
1998	4 626	3 330.72	2 081.7	4 115.52	667.02
1999	6 048	4 354.56	2 721.6	5 380.60	872.06
2000	8 982	6 467.04	4 041.9	7 990.84	1 295.11
2001	9 486	6 829.92	4 268.7	8 439.22	1 367.78
2002	8 982	6 467.04	4 041.9	7 990.84	1 295.11
2003	10 741	7 733.52	4 833.5	9 555.83	1 548.76
2004	8 154	5 870.88	3 669.3	7 254.21	1 175.72
2005	8 676	6 246.72	3 904.2	7 718.60	1 250.99
2006	5 958	4 289.76	2 681.1	5 300.53	859.08
2007	6 336	4 561.92	2 851.2	5 636.82	913.59

*Shows total amount for the period.
†Reference 1.

organic matter potentially available is calculated and shown in column 4 of Table 2. We have determined in our laboratory that the fuel value of rubber wood is about 19.77 × 10^6 J per kg dry weight. Using this figure, the energy that is potentially available from rubber replanting wastes is as shown in columns 5 and 6 of Table 2. It must be noted that these data are actually conservative estimates in that the volume of wood shown in column 2 of Table 2 excludes branches whose diameter is less than 5 cm.[1]

As discussed in the previous paper, presently about 67% of all available rubber wood is being utilised in one form or another. Thus, in a sense, available rubber wood is not wasted. However, in view of the expected increase in the supply of rubber wood in the first 5 years of the next decade, efforts are now being made by the Forest Research Institute of Malaysia and the Rubber Research Institute of Malaysia to find further use for rubber wood. The Forest Research Institute concentrates on characterising the technical properties of rubber wood as well as on sawing for recovery and drying, while the Rubber Research Institute is mainly involved in the promotion of the use of rubber wood as lumber and in the preservation and treatment of the wood.[1]

OIL PALM

Table 3 shows the total area under oil palm cultivation for the years 1920 to 1986. Assum-

Table 3
Area cultivated with oil palms in Malaysia*

Year	Area Cultivated (ha)	Year	Area Cultivated (ha)
1920	404	1968	226 888
1925	3 237	1969	273 644
1930	20 639	1970	308 515
1935	25 900	1971	349 629
1940	31 566	1972	407 122
1950	38 850	1973	485 782
1955	44 921	1974	510 000
1956	46 620	1975	604 551
1957	46 904	1976	697 769
1958	49 372	1977	759 568
1959	51 072	1978	805 143
1960	54 674	1979	918 518
1961	57 142	1980	1 048 237
1962	62 080	1981	1 138 676
1963	71 023	1982	1 226 585
1964	75 556	1983	1 258 000
1965	93 990	1984	1 361 176
1966	123 046	1985	1 400 000 (estimated)
1967	143 365	1986	1 440 000 (expected)

*Data for:
1920-1962 reference 3
1963-1967 references 4 & 5
1968-1971 references 5 & 6
1972-1986 reference 7

ing that replanting occurs after about 25 years, the areas that are due for replanting in the years to come are as shown in column 2 of Table 4. It has been estimated in the previous paper that about 203 boe of energy is potentially available from one hectare of replanting wastes. Thus the total amount of energy that is potentially available from felled palm trees during replanting in the years ahead is as shown in columns 4 and 5 Table 4. Unlike rubber wood which is currently being utilised as fuel and as timber, felled palm trees are now simply burnt. Since the amount, and therefore the energy, potentially available from the felled palms is going to be substantial in the future, efforts have to be initiated now to find potential uses for these replanting wastes whether as an energy source or otherwise.

COCONUT

In our previous paper we mentioned that replanting of coconuts is presently not carried out on a large scale as most of the plantations are on small holdings. Large scale replanting may perhaps occur well into the 21st century if more estate scale plantations are cultivated or operations of small holdings coordinated. For the near future, not much replanting wastes are expected from this crop. As such no estimate on the energy potentially available will be made here.

Table 4
Dry matter and energy potentially available from oil palm replanting wastes

Year	Area Due for Replanting (ha)	Dry Matter Available at Replanting (X 10^4 tonnes)	Energy Potentially Available at Replanting	
			(X 10^{15} J)	(X 10^3 boe)
1986	2 468	19.843	3.090	501.0
1987	4 938	39.702	6.182	1 002.4
1988	8 943	71.902	11.197	1 815.4
1989	4 533	36.445	5.675	920.2
1990	18 434	148.209	23.079	3 742.1
1991	29 056	233.610	36.378	5 898.4
1992	20 319	163.365	25.439	4 124.8
1993	83 523	671.525	104.571	16 955.2
1994	46 756	375.918	58.539	9 491.5
1995	34 871	280.363	43.658	7 078.8
1996	41 114	330.557	51.475	8 346.1
1997	57 493	462.244	71.981	11 671.1
1998	78 660	632.426	98.482	15 968.0
1999	24 218	194.713	30.321	4 916.3
2000	94 551	760.190	118.378	19 193.9
2001	93 218	749.473	116.709	18 923.3
2002	61 799	496.864	77.372	12 545.2
2003	45 575	366.423	57.060	9 251.7
2004	113 375	911.535	141.946	23 015.1
2005	129 719	1 042.941	162.408	26 333.0
2006	90 439	727.130	113.230	18 359.1
2007	87 909	706.788	110.062	17 845.5

COCOA

The total area cultivated with cocoa is shown in Table 5.[7,8] The areas shown are for sole crop equivalent i.e. areas planted solely with the particular crop. Since cocoa trees are replanted after about 25 years,[9] the expected level of replanting in the years ahead is as shown in Table 6, column 2.

Table 5
Area under cocoa in Malaysia for the year 1960-1984[7,8]

Year	Area Planted Under Cocoa (ha*)			Malaysia
	Peninsular Malaysia	Sabah	Sarawak	
1960	577	n.a.	–	577
1961	575	1 538	–	2 133
1962	585	1 942	–	2 527
1963	591	2 023	–	2 614
1964	664	2 145	–	2 809
1965	761	2 187	–	2 940
1966	822	2 643	–	3 465
1967	865	2 793	–	3 658
1968	1 124	3 117	–	4 241
1969	1 902	3 331	–	5 233
1970	3 362	4 019	–	7 381
1971	7 492	4 517	–	12 009
1972	12 043	5 447	–	17 490
1973	15 715	6 241	–	21 956
1974	13 624	8 126	–	21 750
1975	17 586	9 823	2 843	27 409
1976	20 796	9 827	2 843	33 466
1977	29 708	14 670	2 843	47 221
1978	27 409	22 110	4 700	53 219
1979	33 076	37 440	6 400	71 156
1980	42 046	57 980	8 500	108 526
1981	50 231	89 360	10 700	150 291
1982	60 055	121 400	14 000	195 455
1983	–	–	–	205 000
1984	–	–	–	237 000

*Sole crop equivalent.
(Total sole crop equivalent area = 100% sole crop area + 75% main crop area + 50% mixed crop area.).

Thong and Ng[10] reported that for plants grown on inland Malaysian soils, the average total dry matter content of 7 year old trees is about 56 kg per tree.[10] From the data provided by Arumugam,[9] we estimated that total dry matter is about 41 kg per tree. It must, however, be noted that the trees in Thong & Ng's report are taller. For purposes of calculations, it can be quite safe to assume that the average dry organic matter per tree at replanting is about 48 kg. Using this figure and the data of Table 5 and assuming that replanting occurs after about 25 years, the approximate amount of replanting wastes expected to be generated from 1985 to 2007 is as shown in Table 6. Also shown are data for the expected energy that is potentially available during replanting. Since stems and branches account for close to 70% of the dry weight of trees,[10] the energy content of Table 6 has been estimated using the fuel value of stems which is about 17.28×10^6 J per kg dry weight.

Table 6
Energy potentially available during replanting of cocoa

Year	Area Requiring Replating (ha)	Dry Organic Matter Generated at Replanting ($\times 10^6$ kg)	Energy Content of Wastes Generated at Replanting	
			($\times 10^{13}$ J)	($\times 10^4$ boe)
1985	577	33.235	57.497	9.319
1986	1 556	89.626	155.053	25.130
1987	394	22.694	39.261	6.363
1988	87	5.011	8.669	1.405
1989	195	11.232	19.431	3.149
1990	131	7.546	13.055	2.116
1991	525	30.240	52.315	8.479
1992	193	11.117	19.232	3.117
1993	583	33.581	58.095	9.416
1994	992	57.139	98.850	16.021
1995	2 148	123.725	214.044	34.691
1996	4 628	266.573	461.171	74.744
1997	5 481	315.706	546.171	88.520
1998	4 466	257.242	445.029	72.128
1999	–	–	–	–
2000	5 659	325.958	563.907	91.395
2001	6 057	348.883	603.568	97.823
2002	13 755	792.288	1 370.658	222.149
2003	5 998	345.485	597.689	96.870
2004	17 937	1 033.171	1 787.386	289.690
2005	37 370	2 152.512	3 723.846	603.541
2006	41 765	2 405.664	4 161.799	674.522
2007	45 164	2 601.446	4 500.502	729.417

PEPPER

Table 7 shows the level of Malaysia's pepper cultivation and production.[7] The economic life of pepper vines is reported to be about 12-15 years.[11] Thus vines planted in 1973 and 1974 are due for replanting about now. Table 8 is an estimate of the area due for replanting till 1993. Since in the previous paper it has been estimated that the energy potentially available from replanting wastes is about 39.5 boe per ha, the amount of energy that is potentially harnessable from replanting wastes of pepper is as shown in columns 3 and 4 of Table 8. Compared to the replanting wastes potential of rubber and oil palm the potential from pepper is indeed not significant.

Table 7
Cultivation and production of pepper in Malaysia*

Year	Area Cultivated (ha)	Production (tonnes)
1973	7 757	25 862
1974	8 610	32 000
1975	9 444	33 000
1976	10 935	40 920
1977	11 700	29 500
1978	11 520	36 618
1979	12 160	40 307
1980	12 475	31 460
1981	12 865	28 767
1982	11 660	25 379
1983	11 362	23 400
1984	10 550	15 000
1985	10 550	17 000
1986	–	17 000

*Hectarage prior to 1978 are estimated values. Production figures for 1973, 1985 and 1986 are also estimated values.

Table 8
Energy potentially available from replanting wastes of pepper

Year	Area Due For Replanting (ha)	Energy Potentially Available	
		(X 10^{13} J)	(X 10^{3} boe)
1986	853	20.81	33.69
1987	834	20.35	32.94
1988	1 491	36.38	58.89
1989	765	18.67	30.22
1990	–	–	–
1991	640	15.62	25.28
1992	315	7.69	12.44
1993	390	9.52	15.41

DISCUSSION AND CONCLUSION

Table 9 is a composite of the data presented in Tables 2, 4, 6 and 8. The entries in column 6 of the same Table are graphically illustrated in Fig. 1. Results in Table 9 indicate that compared to the replanting wastes of oil palm and rubber, those generated by pepper replanting are significant while those produced by cocoa replanting will not be substantial for many more years. Thus any effort initiated at utilising replanting wastes should take into account this observation.

Table 9
Energy potentially available from future replanting wastes in Malaysia

Year Available	Rubber Wood (X 10^5 boe)	Oil Palm Trees (X 10^5 boe)	Cocoa Plants (X 10^5 boe)	Pepper Vines (X 10^5 boe)	Total (X 10^5 boe)
1986	150.729	5.010	2.513	0.337	158.589
1987	150.729	10.024	0.636	0.329	161.718
1988	150.729	18.154	0.141	0.589	169.613
1989	150.729	9.202	0.315	0.302	160.548
1990	150.729	37.421	0.212	–	188.362
1991	233.068	58.984	0.848	0.253	293.153
1992	244.488	41.248	0.312	0.124	286.172
1993	274.076	169.552	0.942	0.154	444.724
1994	224.763	94.915	1.602	–	321.280
1995	211.526	70.788	3.469	–	285.783
1996	140.412	83.461	7.474	–	231.347
1997	137.297	116.711	8.852	–	262.860
1998	66.702	159.680	7.213	–	233.595
1999	87.206	49.163	–	–	136.369
2000	129.511	191.939	9.140	–	330.590
2001	136.778	189.233	9.782	–	335.793
2002	129.511	125.452	22.215	–	277.178
2003	154.876	92.517	9.687	–	257.080
2004	117.572	230.151	28.969	–	376.692
2005	125.099	263.330	60.354	–	448.783
2006	85.908	183.591	67.452	–	336.951
2007	91.359	178.455	72.942	–	342.756

Figure 1 shows that the total energy potentially available from replanting wastes is expected to increase rather sharply in the first year of the next decade and there after the potential will be sustained for most of the next 17 years. Except for further sharp increases in 1993 and 2005 and a rather precipitous decrease in 1999, variations in the energy potentially available for the next 17 years or so are not very large. For most of those years, the energy potentially available falls within the 230 to 340 X 10^5 boe range. Thus any system developed for using these wastes as fuel should also take into consideration this situation on variation.

Lim[12] reported that from now till the year 2005, the total cumulative energy requirement for Malaysia is expected to reach some 4751 X 10^6 boe. In this estimate a constant 8.2% p.a. increase in demand is assumed. For the years 1987 to 2005, column 6 of Table 9 shows that the total energy potentially available from the replanting wastes discussed in this paper is about 5201 X 10^5 boe. If this amount can be converted to usable energy at say 20% efficiency, then the total amount usable is some 1040 X 10^5 boe. This quantity is only equivalent to about 2% of the country's total energy requirements for that period. It must, however, be remembered that the figure of 2% does not take into account the current availability of plant matter wastes discussed in the previous paper. If the present availability of replanting wastes is excluded the amount is estimated to be about 10^8 boe. This annual amount will add up to some 19 X 10^8 boe if accumulated up to the year 2005. If we again assume a 20% conversion efficiency, this 19 X 10^8 boe is equivalent to about 3.8 X 10^8 boe of usable energy. This latter figure is about 8%

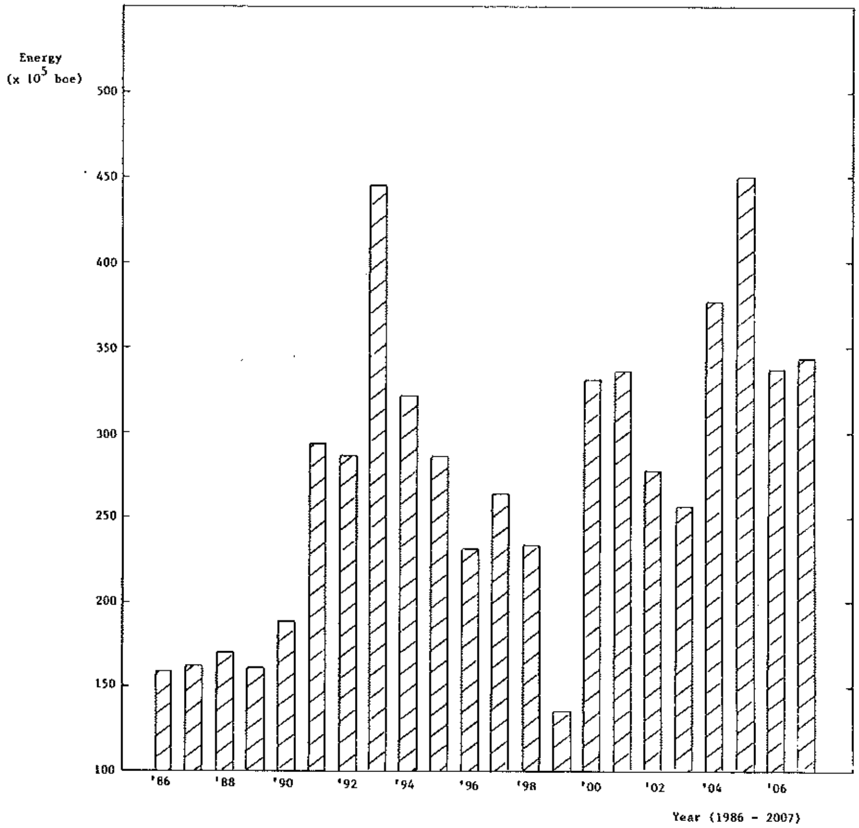

Fig. 1 Energy potentially available from future replanting wastes of rubber, oil palm, cocoa and pepper.

of the country's total energy requirements for up to the year 2005. In this we have assumed that the country's present agricultural and logging activities do not experience any significant growth. Any change in this assumption will naturally lead to quite a different picture. Thus even in a scenario of no significant growth in the present agricultural and logging activities, the total plant matter wastes produced can still contribute about 10% to the country's total energy requirements for the next 20 years or so as long as most of the wastes generated are utilised as fuel.

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