*Trans. Nat. Acad. Science*
*& Technol. 1984.6:155-162*

# THE COCONUT PALM AS A SOURCE OF FIREWOOD

Julian A. Banzon
*Emeritus Professor of Food Science and Technology*
*University of the Philippines at Los Baños*
*Laguna, Philippines*

## ABSTRACT

Shell, husk and leaf petiole ("palapa") constitute firewood from the coconut palm. The energy output, E from P palms each bearing N nuts/bunch is E = (8.5 N + 8.4) p. Kitchen needs range from 300 MJ to 1400 MJ per month. Calculations from the energy equation indicate that at least 11 coconut palms can meet average kitchen needs indefinitely. Leaf petioles alone from about 90 palms can achieve same purpose.

We are going back to firewood. Liquefied petroleum gas has become too expensive, and worse, it may no longer be easily available because of restriction in foreign exchange outflow. There are several sources of firewood. The present paper deals with a source that has merited hardly any attention: The coconut palm.

While shell and husk of the "nut" are sometimes mentioned as being used for fuel, the petiole of the leaf ("palapa") is more extensively employed for this purpose by people in coconut areas. Flower/fruit stalks, spikes, flower sheaths, etc. also make good fuel (Cornista, 1983).

How firewood from the coconut compare with others of this kind is shown in Table 1. Coconut husk is nearly as good as, while the shell is better than the other listed firewoods as far as MJ/kg are concerned.

Table 1. Heating Value of Some Firewoods in MJ/Kg.

| | | |
|---|---|---|
| Coconut husk | 14.7-17.5 | Festin, 1976; Wilson, 1930 |
| Coconut shell | 23.0 | Paddon & Parker, 1979 |
| Ipil-Ipil, common | 19.4-19.6 | Aguilar, 1943; Wells, 1917 |
| Ipil-Ipil, "giant" | 17.4-18.6 | Bawagan & Semana, 1976 |
| Philippine woods | 15.4-21.0 | Aguilar, 1943; Cox, 1911 |

The task set in the present study is to determine how many coconut palms, contributing husk, shell and petiole as firewood, can sustain a kitchen indefinitely. Two quantities are needed: the energy output of a coconut palm and the energy requirement of the kitchen.

*Energy output of a coconut palm.* The biomass and associated energy from husk, shell and petiole are given in Table 2. Per month the coconut palm bears one

Table 2. Basic Data Used in Calculations

| | | |
|---|---|---|
| Mass/unit (in kg) | | |
| husk | 0.242 | Hagenmaier 1980 |
| shell | 0.193 | Hagenmaier 1980 |
| petiole | 0.5 | Zuñiga et al. 1965 |
| Energy/unit (in MJ) | | |
| husk | 4.05 | Festin 1976; Wilson 1930 |
| shell | 4.44 | Paddon and Parker 1979 |
| petiole | 8.4 | Same value as for wood. |

LPG, assumed as $C_4H_{10}$; 49.6 MJ/kg Hougen *et al.* 1954
Kerosene, 42.02 MJ/kg; 41.42 MJ/L. Hougen *et al.* 1954
Fuel wood assumed ave. 16.7 MJ/kg
Fuel biomass from coconut palm, per month: one bunch of nuts and one leaf petiole.

bunch of N nuts and sheds one leaf. The energy output, per month, of a coconut palm is therefore

$$\begin{aligned} E &= (4.05 + 4.44)\,N + 8.4 \\ &= 8.5\,N + 8.4 \text{ in MJ/month} \quad \text{-------- Equation 1} \end{aligned}$$

The energy output of a coconut palm, as it varies with increasing number of nuts/bunch, is shown in chart 1. The equivalent in liters kerosene (41.4 MJ/L) and in wood fuel (16.7 MJ/kg) are also given. A coconut palm yielding one leaf petiole and a 10-nut bunch in one month produces 93.4 MJ of energy equivalent to 2.25 liters of kerosene or 5.6 kg wood fuel.

*Number of coconut palms which yield energy equal to one LPG tank of 11 kg gas.*

Putting E as equal to 546 MJ (The energy in 11 kg of LPG), the value of p may be solved in the equation:

$$E = (8.5N + 8.4)\,p \quad \text{------ Equation 2}$$

Chart 2 gives the calculated values of p as N varies from zero to 16. Thus when N is 8, p is 7. The energy value of 7 petioles and that of the husks and shells of 56 nuts equal the energy in one 11 kg LPG.

*Firewood requirements of a family.* Evidently firewood requirements depends on size of family, types of food cooked, efficiency of stove, kind of fuel, frequency of cooking, management of fuel, etc. NEDA, as reported by PCARRD, states that in a survey of 23,430 households, the monthly consumption was 22.1 kg of wood charcoal which it was stated, equal to 13.5 kg of LPG. Therefore

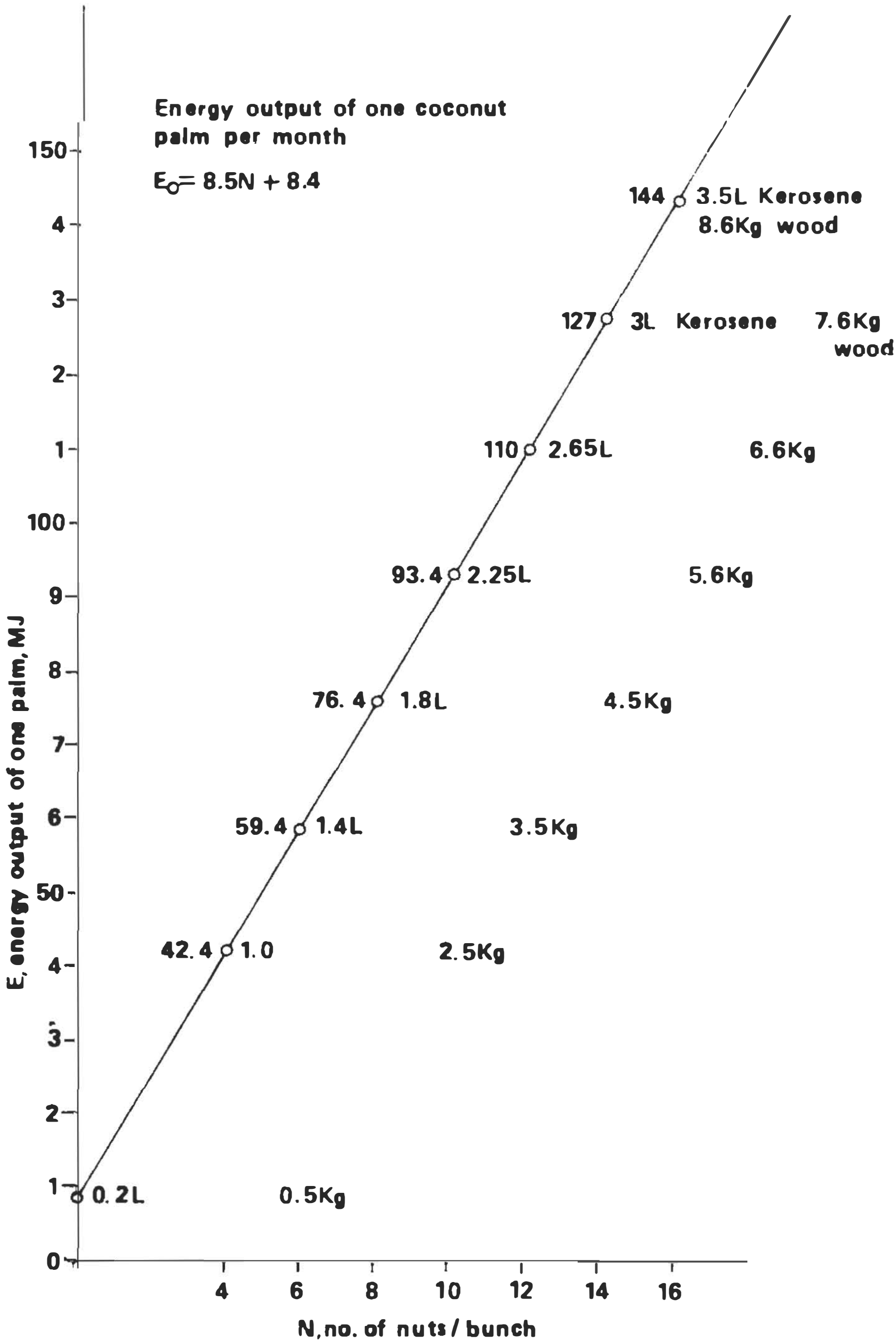


Chart 1. Energy Output of One Coconut Palm per Month.

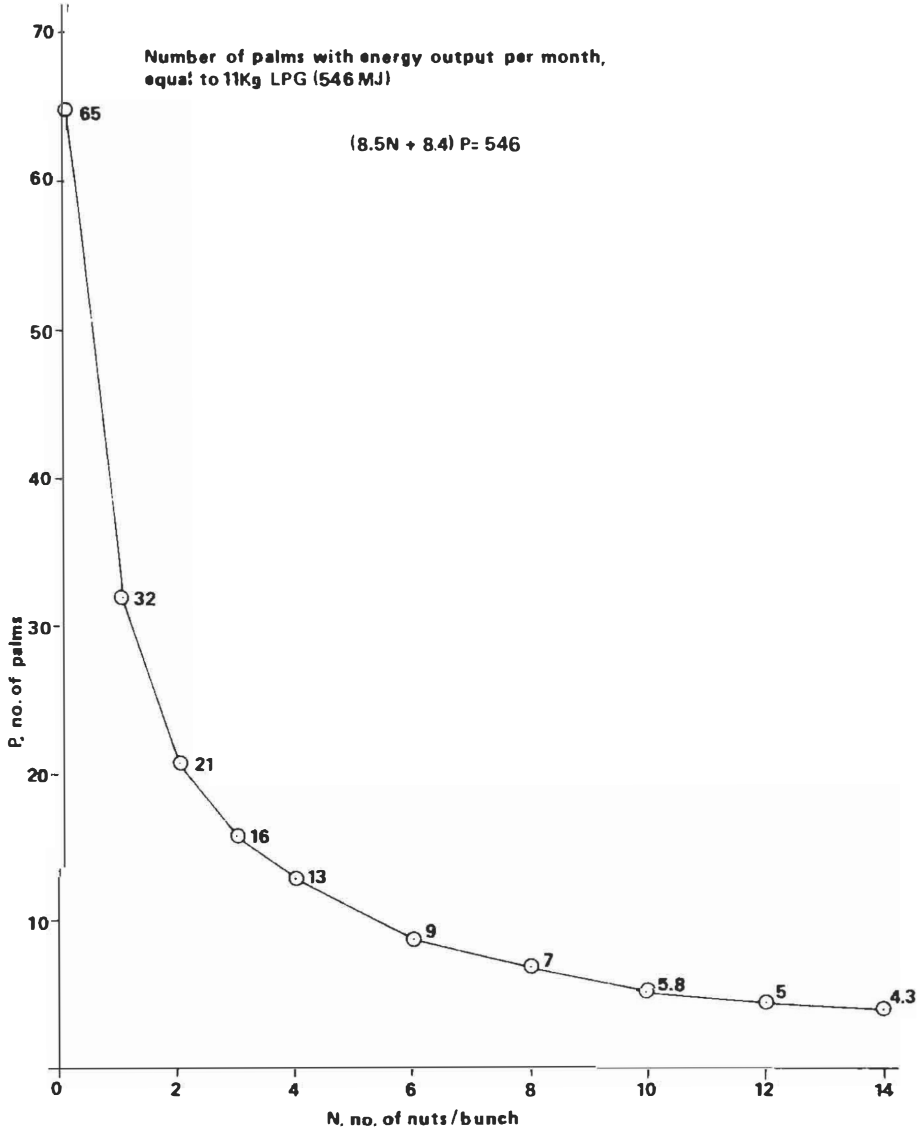


Chart 2. Number of Palms with Energy Output per Month, Equal to 11 Kg LPG (546 MJ).

this amounts to 670 MJ/month. The US Academy of Science in its recent publication, Firewood Crops, states that in a woodshort area such as India, the average user burns annually about a fifth of a ton of wood (about 300 MJ/month) and as much as over a ton (about 1400 MJ/month) in parts of Africa and Southeast Asia. LPG is the preferred fuel in cities and large towns; the consumption is about one

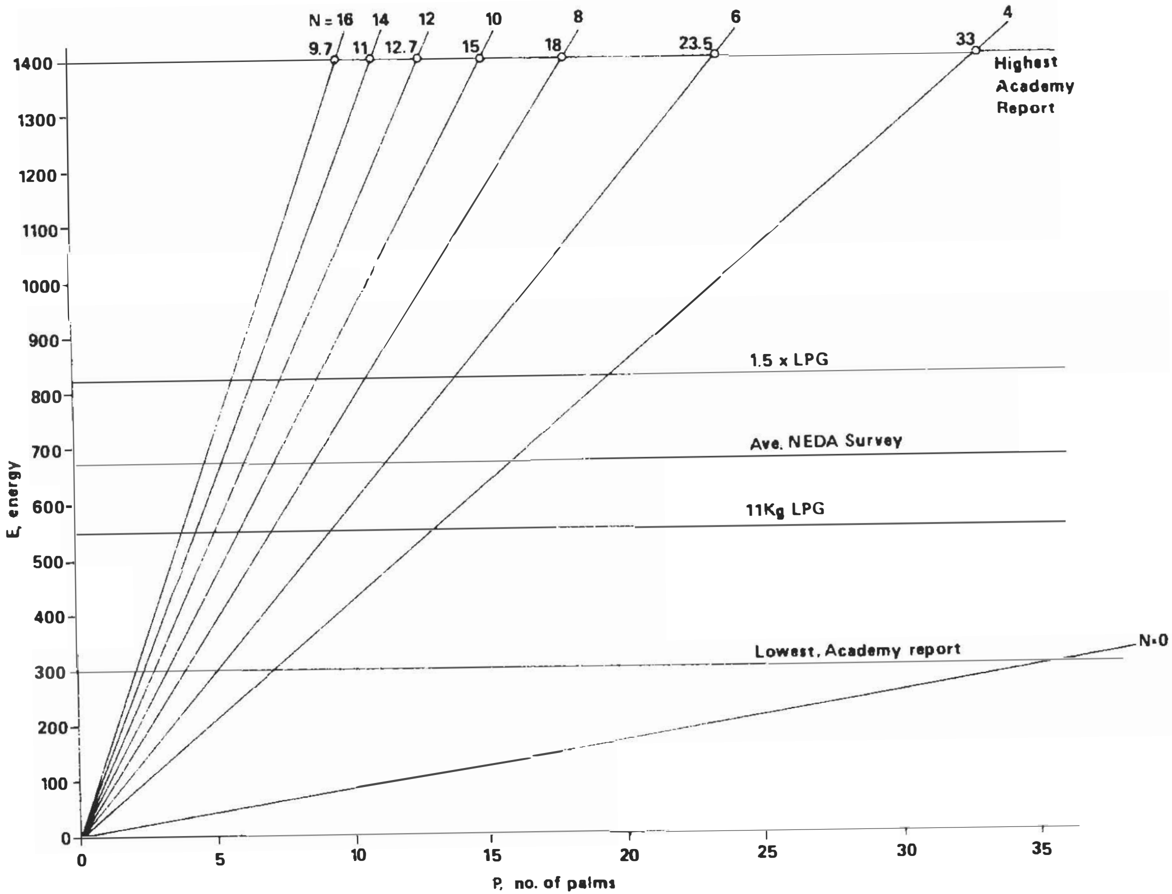


Chart 3. No. of Coconut Palms Whose Energy Meets Kitchen Firewood Needs.

11-kg tank per month (546 MJ/month). LPG, however is an "efficient" fuel, since a high degree of control can be exercised in its use, by way of limiting size of flame, instant ignition and instant shutting off. (Compare for example, with use of firewood).

Now, comes the question which we have sought to answer: how many coconut palms can supply indefinitely all the fuel needed by a kitchen? The fuel is to consist of husk, shell and leaf-petiole.

*Number of coconut palms to fuel a kitchen.* As stated earlier several factors determine the energy needs of a kitchen. Making use of the NEDA survey (670 MJ/month), the number of coconut palms, p, may be obtained from the equation:

$$p = \frac{670}{8.5\,N + 8.4}$$

p therefore depends also on N, the number of nuts/bunch. When N is 8, p is 9 palms. It is of interest to get a general picture of the situation, that is, what are the values of p for increasing kitchen energy demands say 300 MJ to 1400 MJ per month, and for increasing number of nuts per bunch? This information is obtained by using equation 2. Chart 3 summarizes the situation. Consider a coconut palm which bears an average of 8 nuts/bunch. When the husks, shells and petiole are used for fuel, the following values of p are obtained for selected kitchen energy requirements:

| E (MJ/mo.) | P | Remarks |
|---|---|---|
| 300 | 4 | lowest, US Academy |
| 546 | 7 | LPG user |
| 670 | 9 | NEDA survey |
| 820 | 11 | 1.5 times LPG |
| 1400 | 18 | highest, US Academy |

To answer the question: how many coconut palms can sustain an average kitchen indefinitely with fuel? The answer is at least 11.

*Coconut leaf petiole as firewood.* The dried leaf petiole of the coconut (palapa) is more often used as firewood than the shell and husk of the "nut". This petiole was reported as weighing an average of 2 kg (Zuñiga, 1965). Losses in mass due to several causes and uncertainties in moisture content, leads to an approximation of 0.5 kg average weight per dry petiole. Like wood, its energy value would then be 16.7 MJ/kg. At an energy output of 8.4 MJ/month, the energy associated with p palms would then be:

$$E = 8.4\,p.$$

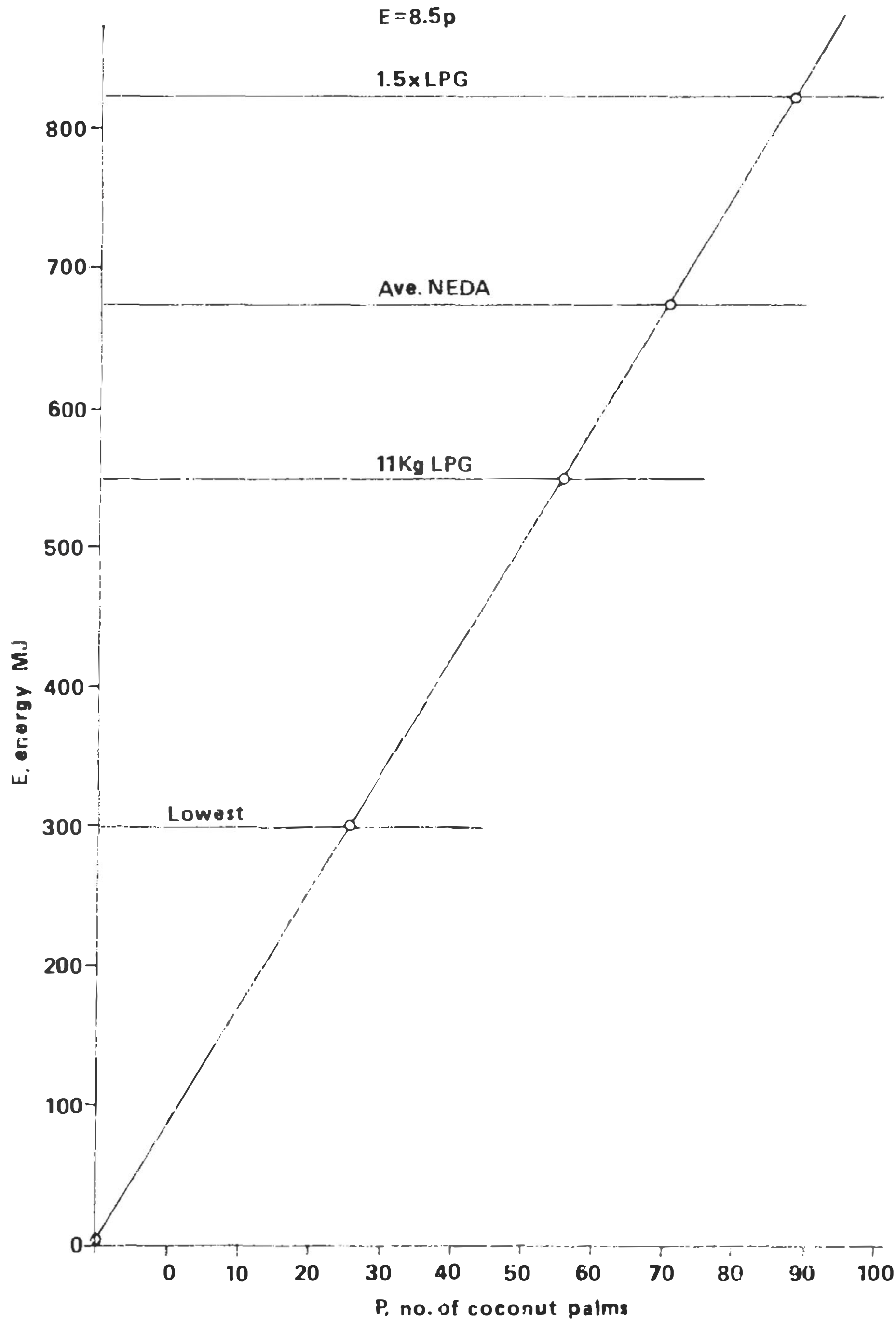


Chart 4. Energy Output/Month of Leaf Petioles in Relation to Number of Palms.

This relationship is shown in chart 4. It is indicated here that a kitchen that demands 670 MJ/month will need a grove of about 80 coconut palms. Even if the palms do not produce fruits or in the event that the palms are tapped for sap (tuba), or if all the fruits are sold, the leaf-petioles are still there to provide the fuel.

## Literature Cited


1. Academy of Science (USA) 1980. Firewood crops. Washington. DC.
2. Aguilar, L. 1943. Calorific value of Philippine woods. *Phil. J. Forestry.* 6(2):217-228.
3. Bawagan P.V. and J.A. Semana. 1979 Utilization of ipil-ipil. Ipil-ipil conference 2-4 Sept. 1976. PCARR. Los Baños.
4. Cornista, L.E. 1983. Private communication.
5. Cox, A. J. 1911. Philippine Firewoods. *Phil J. Science.* 6(1):1-19.
6. Estudillo, C.P. *et al.* 1979. Proceedings Cocowood Conference. Manila-Zamboanga.
7. Festin, T.F. 1976. Energy from coconuts. Seminar Proceedings: Coconut Industrial Research PCA-NSDB-PCRDF. Tagaytay City.
8. Hagenmaier R.D. 1980. Coconut Aqueous Proceeding. 2nd ed. San Carlos Univ., Cebu City
9. Hougen *et al.* 1984. *Chemical Process Principles.* Wiley
10. Paddon, A.R. and P.A. Parker 1980. Charcoal production using portable metal keln. Tropical Products Institute, London. G 119.
11. Philippine Coconut Authority (PCA). 1978 Magnitudes of the Coconut Industry. *Farmers Bulletin* 2(2): 15-17.
12. Wells A.H. 1917 Destructive distillation of Philippine Woods. *Phil J. Science* 12.111-125.
13. Wilson. S.K J 1930. Calorific value of coconut husk. *Chem Abstr* 24:4914
14. Zuñiga. L.C. *et al.* 1965 Report No. 2.93 to the National Science Board (Philippines).

## Florentino O. Tesoro, Discussant

### Introduction

It is recognized by economic planners that the core of economic development strategies for the future is energy. Thus, it is fitting and significant that energy is one of the subjects presented in this sixth annual scientific meeting of the National Academy of Science and Technology.

The paper of Dr. Banzon shows the potential of coconut husk, shell and petiole as firewood for domestic use, and is therefore relevant to the national economic development program.

The subject of firewood or dendro-thermal energy is one of the areas in which FPRDI is seriously doing R & D studies. As a matter of fact in the present organizational set-up of FPRDI, one program -- *The Dendro-Energy Program* is currently pursuing research projects on solid, liquid and gaseous fuels from wood. Coconut husks, shells and petiole are included in our research projects.

FPRDI contributions to the paper of Dr. Banzon are focussed: first, on some assumptions and relate them to information available from other sources. We would, in addition, like to highlight the influence of moisture content on the calorific value of wood or biomass because firewood is being used with certain moisture content and *never with zero* moisture content. Since the calorific value of wood is given on the *oven-dry basis*, such value has to be corrected for the influence of moisture content in actual use which in our view is a basic consideration.

A. *Coconut Palm As Energy Source*

If we graph the growth of forest trees, including coconut trees, with the ordinate as *rate of growth* and the abscissa *number of years*, we come up with a sigmoid curve, representing a slow start followed by an increasing growth, then a decline at old age. Finally, the tree dies. Such growth pattern, however, is influenced by soil fertility and climatic conditions.

In Laguna, farmers are able to harvest coconut fruits every 45 days because of the favorable climate and relatively fertile soil. But, in the Visayas, particularly in Cebu province, harvesting of coconut fruits every 2 to 3 months is a common practice.

Thus, in estimating the potential contribution of coconut trees to the overall firewood supply, we suggest that a comprehensive study be undertaken for the coconut producing provinces to account for the influence of soil type and climatic type as well as the influence of age of the tree during its productive period. All these relevant facts would lend support to the present paper.

B. *Firewood Requirements of a Family in the Philippines*

We fully agree with the author that firewood requirements depends on size of family, types of food cooked, efficiency of stove, kind of fuel, frequency of cooking, management of fuel and others. We could not reconcile, however the cited figures of 670 MJ/month/family with the figures in the report of Eric L. Hyman entitled "Wood As an Energy Source for the Philippines" presented at the 28th Natural Resources Management Forum on February 19, 1981 at the U.P. Asian Institute of Tourism (AIT) House, Diliman, Quezon City. The figures cited by Hyman on woodfuels consumption range from *one-half to one cubic meter per person per year*. Hyman cited Van Den Beldt's (1983 – personal communication) figure of 5 cubic meters per year for Philippine family of five. Knowland and Ulinski give figures for selected Asian Countries in 1976, as follows:

**Fuelwood Consumption in Selected Asian Countries in 1976**

| *Country* | *Per Capita Commercial Energy Consumption (kg coal Equivalent)* | *Official Woodfuel Consumption (1000 m)* | *Per Capita Official Woodfuel Consumption (kg coal Equivalent)* | *Woodfuel as Percent of Total Energy* |
|---|---|---|---|---|
| Philippines | 329 | 22,960 | 226 | 41* |
| Burma | 49 | 19,611 | 273 | 85 |
| India | 218 | 118,179 | 83 | 28 |
| Indonesia | 218 | 111,708 | 360 | 62 |
| Nepal | 11 | 8,700 | 291 | 96 |
| South Korea | 1,020 | 7,350 | 91 | 8 |
| Thailand | 308 | 16,091 | 160 | 34 |
| Malaysia | 578 | 5,613 | 195 | 25 |

Source: Knowland and Ulinski 1979, Appendix I

*This number was erroneously listed as 0.41 in the source and error was duplicated in U.S. Interagency Task Force (1980)

(Taken from: Eric L. Hyman, 1981. Wood As An Energy Source for the Philippines, *p. 31*) )

If the 5 cu.m. fuelwood per year for Philippine family of five is used in the estimate for "P" (no husk and shells), the figure of 80 obtained in the estimate could easily double to 160.

With reference to our work at FPRDI on stove designs and efficiency, we would like to cite the following results.

In a report (PCARRD-IBRD 5.4 entitled "Development of Efficient Household Fuelwood Stove) submitted by Estudillo and Toroy to PCARRD in 1982, actual experiments on the efficiency of different stove models were carried out. Based on the findings (page 50), a two-burner concrete stove consumed 0.900 kg (oven-dry weight) of fuelwood (ipil-ipil) to cook 1.10 kg. rice, 0.454 kg chicken, 0.200 kg vegetables and 0.800 liter water. From this information, 81.0 kg fuelwood would be consumed by family cooking three times a day for 30 days. The total energy consumption, therefore is *1352.7* MJ/mo. (16.7 MJ/kg fuelwood) which is twice the 670 MJ/month.

C. *Influence of Moisture Content on Heating/Calorific Values.*

The calorific values for coconut husk, shell and petiole as given in the report are based on *moisture-free materials*. As such, they are higher than the calorific values of air-dried materials which may contain 16 – 20% moisture. It is alright in the case of kerosene and LPG because they are practically moisture-free – for which the calorific values used do not need any correction.

Water adds to the weight of the material without increasing its calorific value and it takes energy to vaporize the water. Water also effects the ignition properties and efficiency of combustion. For example, oven-dry wood (zero MC) may have 15% more heat value than air-dry wood (12-20% MC) and 50% more than green wood (50-100% MC).

The effect of moisture is reflected in the following formulae for net heating value (NHV) of wood (Stephenson, J. Newell (Ed. Chief) 1955. Auxilliary Paper Mill Equipment, Vol. 4, First Edition. In Pulp and Paper Manufacture, McGraw Hill Book Company, Inc., New York p. 489):

$$NHV = HHV(1 - MC) - MC \times 1053$$

NHV is the Net Heating Value in BTU/lb.
HHV is the higher Heating Value in BTU/lb, oven-dry basis
MC is the moisture content
(1-MC) – This represents the moisture-free wood or biomass.
MC X 1053 – This represents the loss due to heat of evaporation of moisture.

It is therefore, appropriate that the Net Heating value which varies inversely with moisture content, should be used instead of HHV. Thus, equations 1 & 2 will be affected. Overall, the use of Net Heating Value will increase the value of "P". The lower combustion efficiency in the case of husk, shell and petiole as compared to LPG and kerosene has to be accounted for in the equations, which will further increase "P". Such corrections, if accounted for, will alter charts 1, 2, 3, and 4.

## Closing Remarks

In closing, we would like to thank NAST, specially Dr. Tito Mijares and the organizers of this scientific seminar, for inviting me and Dr. Pancracio V. Bawagan as discussants to the paper of Dr. Julian Banzon. Dr. Bawagan could not attend today's seminar because of prior appointment and besides we would be presenting the same views. We sincerely hope that the facts we presented here would be viewed as a contribution for the sake of science and never intended to contradict the views of the author, who we respect very much as a person and as a professor.