CHAPTER VI

DISCUSSIONS AND CONCLUSIONS

The analysis of the gasification systems using RCDM has demonstrated that the influence of such variables as initial investment cost of the gasifier, fuel prices, annual operating period, labor time for the operation and maintenance, variable costs of the system, availability of local biomass, and specific condition of the community are factors to consider by decision makers concerning economic feasibility of gasifiers. The main information obtained from the model for design engineers may be categorized as follows:

1. For charcoal gasifiers, the most economic system which could be accepted by this particular rural community, at gasoline and diesel prices above 8.9 and 6.3 BT/LIT respectively, is the dual-fuel diesel engine system with a capacity of 10 KW with an investment cost not exceeding 12,635 BT/KW for charcoal prices up to 1.50 BT/KG. The system should be utilized throughout the year in both wet and dry season with a minimum operating time of 2880 HRS/YEAR. For a charcoal price of 1.30 BT/KG, the maximum variable cost permissible is 756.68 BT/MWH, and slightly lower for increasing charcoal prices, that is, the labor time for operation and maintenance should be less than 0.2 hours per one hour of operating period. The second most attractive charcoal gasification system which could compete with conventional diesel systems is the small one of 2KW capacity equipped with a gasoline engine for which the maximum

permissible investment cost is 14,500 BT/KW and variable costs varying from 1211.45 down to 681.96 BT/MWH depending on fuel prices as shown in Table 5.3.

2. For wood gasifiers, among the systems we have introduced in the case study of Nongwang, the optimum design is the 50 KW dual-fuel diesel engine system at gasoline and diesel prices above 8.9 and 6.3 BT/LIT respectively with the gasifier investment cost of 13,965 BT/KW. From economic analysis, the maximum wood price for the gasification system compatible with a conventional diesel system is 1,082 BT/TON. The model has suggested the maximum investment and variable cost of the gasification systems in different capacity permissible for the villagers at specific fuel prices as shown in Table 5.4 or in Figures 6.1 and 6.2.

The model has also shown the minimum operating hours for the systems to be economic at different fuel prices in Figure 6.3.

These empirical curves are specific for the case study at Nongwang only, however due to similarity of several villages the results could serve as guidelines for other villages.

3. For rice husk gasifiers, the most favorable system introduced to the community suggested by the model is the gasifier-gasoline engine in the capacity of 50 KW, with the gasifier's investment cost of 13,965 BT/KW, at gasoline and diesel prices above 8.9 and 6.3 BT/LIT respectively. The rice husk price is relatively insensitive to the total system cost. Figure 6.4 shows the maximum investment and variable cost of the systems in different capacity

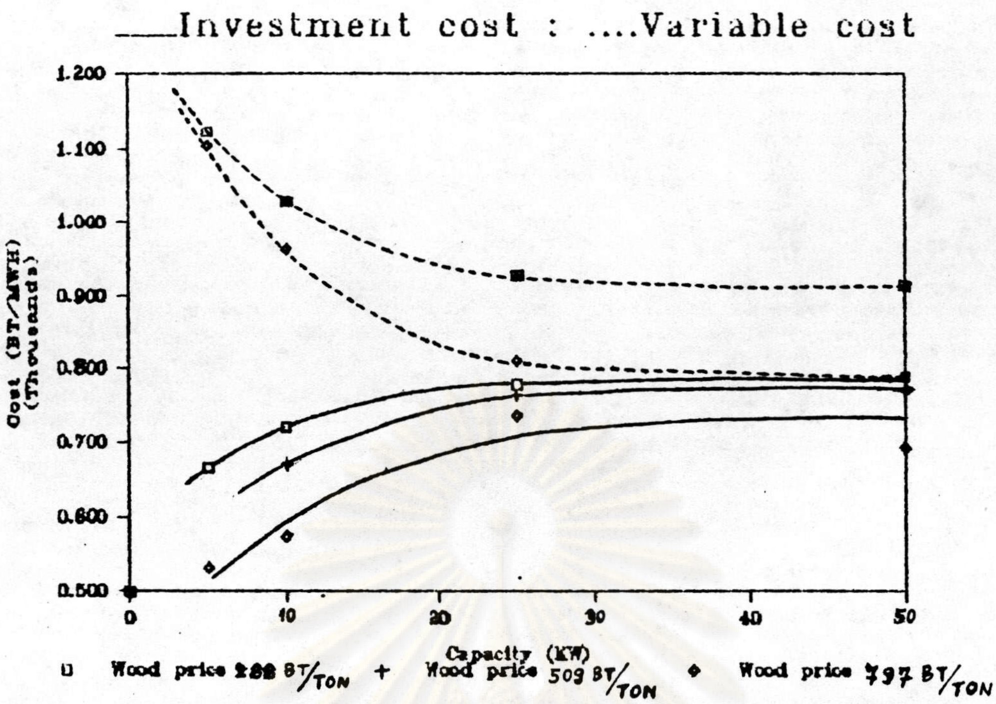

Fig. 6.1 Maximum investment and variable costs permissible for wood gasifiers of different capacity at wood prices of 288, 509, 797 BT/TON, and a diesel price of 6.7 BT/LIT.

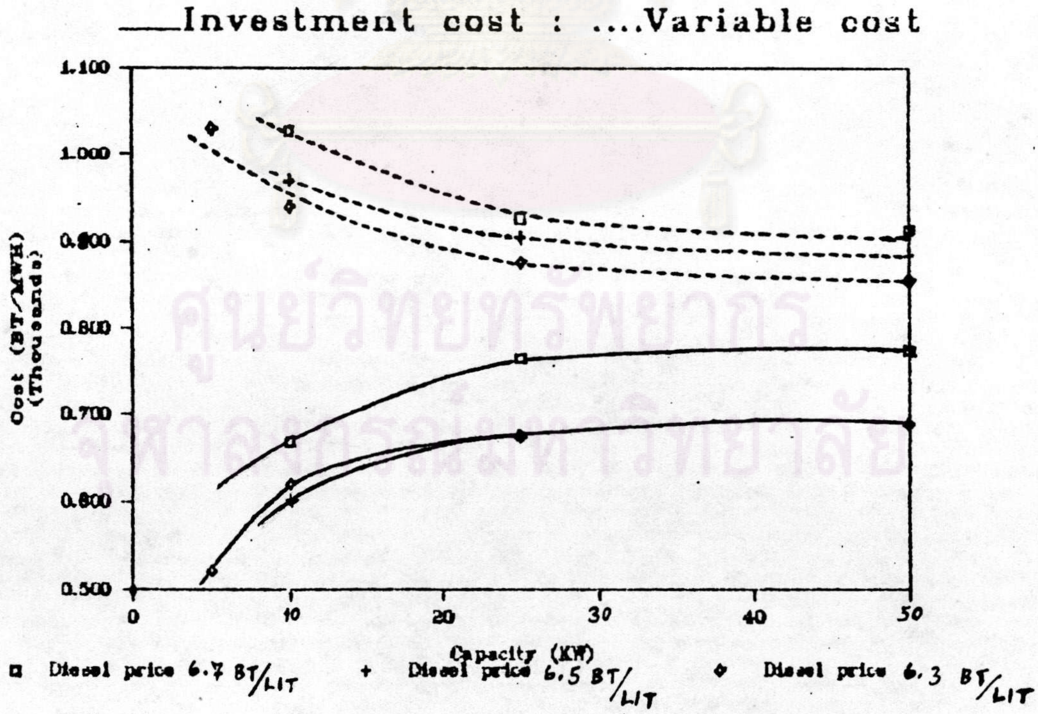

Fig. 6.2 Maximum investment and variable costs permissible for wood gasifiers of different capacity, at a wood price of 509 BT/TON, and diesel prices of 6.7, 6.5, 6.3 BT/LIT.

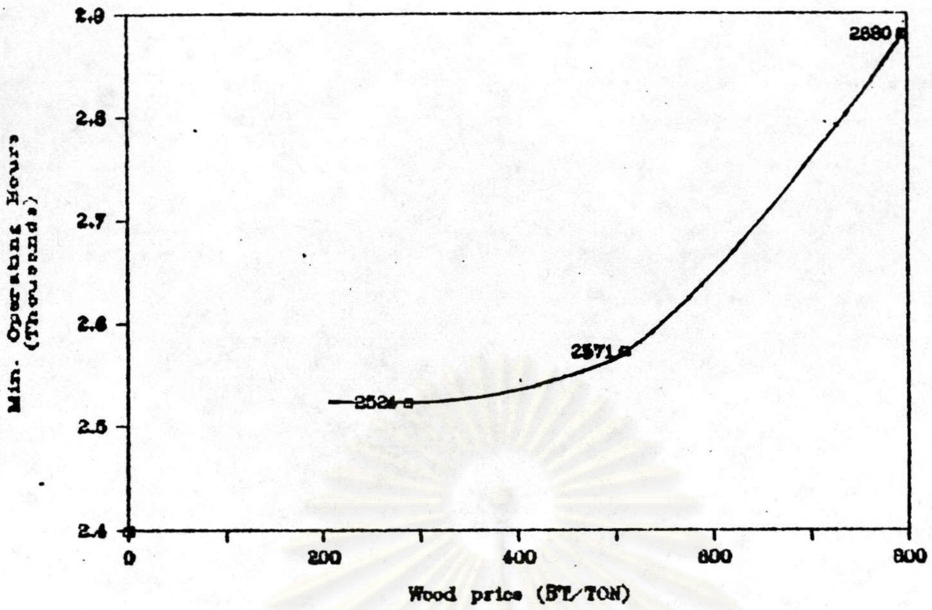

Fig. 6.3 Minimum operating hours for wood gasifiers to be economic at a diesel price of 6.7 $^{BT}/_{LIT}$.

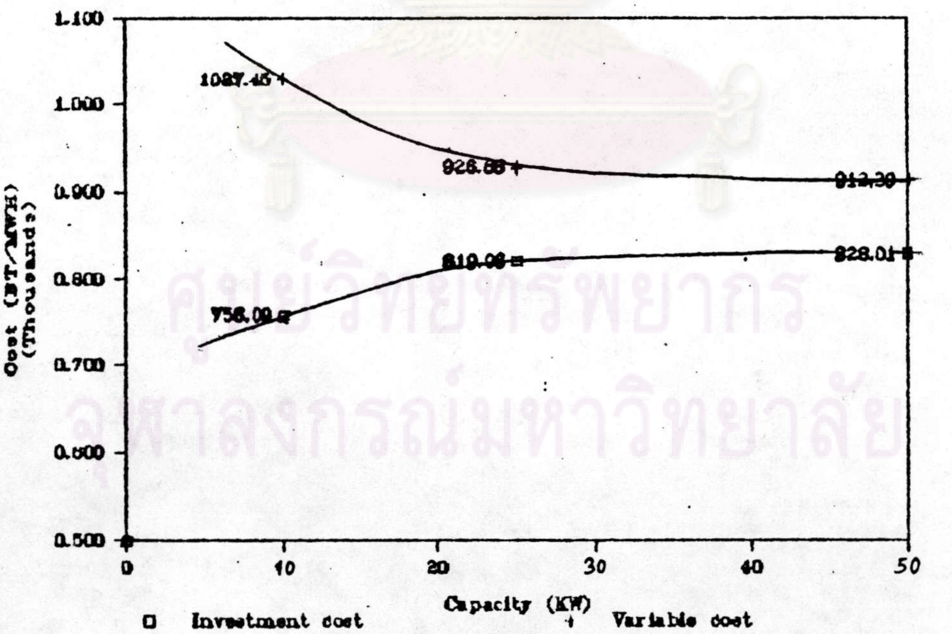

Fig. 6.4 Maximum investment and variable costs permissible for the rice husk gasifiers in different capacity for cost of rice husk up to 515 $^{BT}/_{TON}$, at a diesel price of 6.7 $^{BT}/_{LIT}$.

economically permissible for Nongwang at rice husk prices of up to 515 BT/TON which could be operated only about 86% of full utilization (2400 hours). The higher cost of rice husk requires more running time, that leads towards the maximum time available for the system or 2880 hours. Although these minimum operating hours are specific conditions for Nongwang, they should be common situations for most local communities. The income is maximized by importing more paddy to the mill driven with the gasifier-gasoline engine using the mill's own residues and imported rice husk from other villages nearby as fuel, and converting the paddy to rice or glutinous rice for exporting in excess of household consumption. From economic analysis, the maximum cost of rice husk for the gasification system to make it attractive over conventional diesel systems under the present conditions of diesel prices of 6.3 BT/LIT is 750 BT/TON of rice husk.

4. Electricity generation for self-use by the gasifier-diesel engine system for lighting is unlikely to be competitive with electricity from a central grid costing about 1.75 BT/KWH and even with utilization of kerosene lamps in households. In the case study of Nongwang, the model has shown that electricity self-generation from the dual-fuel engine at a charcoal price of 1.3 BT/KG and a diesel price of 6.3 BT/LIT costs 4.38 BT/KWH. Its use will therefore generally be limited to rural areas where grid electricity is expensive or unavailable and the villagers would like to replace the inconvenience of using kerosene lamps.

5. The larger the gasifier, the lower the investment and variable costs, and also the less labor time

for operation and maintenance per kilowatt-hour. This is one reason that economically deters each household from owning a small gasifier for generating electricity. In other words, this study reconfirms that centralized energy systems are more economic than distributed energy systems.

6. The gasifier-diesel engine systems for shaft power of irrigation pumps are economically feasible, under the present diesel fuel prices of 6.3 BT/LIT or above, especially where interruptions in diesel supplies are common. In general, irrigation requirements are seasonal, and irrigation systems will often be needed for only part of the year. The shaft power required to irrigate one rai of land depends on the pumping depth and the quantity of water applied. In the case of Nongwang, the shaft power of 36.6 KHPH is used for pumping about 920 kilo-cubicmeter of water in the wet season to irrigate 1500 Rai of lowland and increase crops yield by 66%. That is, a gasifier with a capacity of 13,33 W is required per rai of irrigated land.

7. It is quite dangerous to introduce gasifiers without regulations into areas of fuelwood scarcity. If high-priced wood can be tolerated by gasifier owners, the widespread use of gasifiers will tend to push up wood prices. While this might encourage replanting efforts in the longer term, it could also tend to accelerate depletion of wood resources and adversely affect domestic wood consumers. In Nongwang, for example, the introduction of gasification systems would require 64 tons per year of wood converted to charcoal (0.196 KG. of charcoal/KG. of wood) for low efficiency of the kiln or 41.4 tons per year for a higher efficiency of the kiln (0.303 KG. of charcoal/KG.of wood) to run a gasifier-powered generator of about 20

MWH/YEAR, and 26.7 tons of wood per year for irrigation pumping system driven with gasifier-diesel engine. Growing forest trees should be done to replace wood cut for gasification projects even in the abundance of forest areas as Nongwang.

8. In the locality where a rice mill exists, it is most attractive to introduce a gasifier-gasoline engine for shaft power for milling by utilizing rice husk as fuel instead of selling it at very low prices of normally 100-300 BT/TON, or burning it simply in the fields. The investment cost of the rice-husk gasification system at the first year will be paid back within 3-4 years.

9. All the conclusions obtained from the analysis of the gasification systems with RCDM in this study may be used by gasification engineers. First of all a knowledge of gasifier introduction in Nongwang has now been made although of limited use. However, the methodology could be used for application to other rural communities. Because people in different communities have different basic activities, a ordinary gasification system economic analysis is not enough for making a decision on the introduction of a system in a specific village. RCDM would be a generalized tool for engineers to analyze parameter sensitivities or various factors in the community which influence gasifier technology introduction ; using community income as criteria. In any other cases of energy technologies introduction in rural communities, RCDM may also be used as a prime tool to test effects of decisions in the same manner as the present simulation of gasification system introduction.

10. One problem about introduction of gasifiers to rural communities is rejection from the villagers due to various causes : difficulty of operation, difficulty of cleaning and maintaining the equipment, and the high investment cost of the systems. To lessen such problem, the RCDM results could conceivably be advertised and used to convince the villagers on how the gasifier systems introduction for some activities such as water pumping for irrigation or shaft power for rice milling could increase the overall community income.