CHAPTER 5

SUMMARIES AND RECOMMENDATIONS FOR FUTURE WORKS

5.1 Summaries

- Very small decentralized biomass-fueled power plant is revisited in this research work as modeling to calculate unit cost of electricity generated from woody biomass is formulized along with its environmental impacts. It is suggested that the power plant is owned by the community or at least local authority to minimize the cost of facility and operations also maximize community benefit. Aimed to explore the potential in agriculture-based community, woody biomass are focused as primary feedstock, i.e. plantation of fast-growth wood and agriculture residues, and the capacity of the plant is kept under 1 MWe which is enlisted as VSPP (Very Small Power Producer) according to PEA (Provincial Electricity Authority), Thailand. As the model is simple enough to include either Rankine steam turbine system or gasification system as a conversion technology to be used for the power plant. The environmental impact assessment of the electrification is accomplished by the commercial software; "Sigma Pro". The externality cost is also shown in accordance with the environmental damage influenced by the system.
- Economic feasibility of such power plant is achieved for community-based power plant fueled by the woody feedstock from plantation surrounding the facility. Yield of fast-growth wood is taken to be 14 ton/rai (87.5 ton/ha) within 3 years and the low heating value the woody biomass is about 12.5 MJ/kg. The 50-kW Rankine steam system and 100-kW gasification technology are in comparison based on the previous study carried out at Chiang Mai University and Suranaree University of Technology. Suitable for small agriculture

community, size of required plantation is determined and management pattern is proposed such that woody biomass is in three-year rotation and there are three batches of plantation for the continuity of plant operation. As the total efficiency of the 50-kWe steam system is as small as 7.2%, it requires a consumption rate of woodchips at 4.78 kg/kWh with a plantation area of 359 rai(57 ha). With reported higher efficiency of 17.72%, the 100-kWe gasification system consumes less woodchips at 2.27 kg/kWh on required area of 340 rai(55ha). Life cycle costing reveals that the unit cost of electricity generated from steam system and gasification system is 5.78 baht/kWh and 4.17 baht/kWh, respectively. These are lower than the price that PEA can offer. Electrification alone is not sufficient for the project to be feasible unless extra benefit is available.

Life cycle assessment shows that the environmental impact of the both power plants is less than of the national grid by 5.3 times in gasification case and 4.7 times in steam system case. If economic is not only factor for the decision to establish the power plant, this environmental prospect should be factored in. In addition, decentralized power plant is essential to energy stability especially in the remote agricultural area. Central and local government should consider support the projects, at least partial if not full. It is also disclosed that environmental impacts from the gasification system is $8.02x10^{-4}$Pt/kWh which is 13% less than that from Rankine steam system since it releases less pollutant gas and consume less energy especially during the conversion process. The externality cost of both system agrees well with previous investigation at 0.57 baht/kWh for steam system and 0.436 baht/kWh of gasification system.

To convert the power plant to be more profitable without external investment, waste heat from the systems, especially from the steam system, can be recovered and utilized to generate income for the. It is purposed to that at least two drying units should be installed and used for the agriculture products as the local services earning more benefit as the combined heat and power facility. If 27% waste heat is utilized, the steam system will start to generate income. On the other hand, carbon is a co-product from the gasification system. It is proposed to be bound and compressed as charcoal briquette to be sold to the market. Some earning may be generated from tops and leaves of the fast-growth crop chosen for plantation as *Leucaena Leucocephala* is suggested as the viable option but generated income is not much substantial.

- As plantation is not quite an option for the resource of community-based power generation, wooden residue is considered. For small community, the sources may be scattered; therefore, the geographic information system (GIS) is integrated to evaluate the suitable location of the power plant to minimize the energy consumption due to logistic. Based on fast shortest path and multi-seed point theory, transport network analysis is achieved using ArcGIS. Supported with database of woody fuel and transport routes, wood-industry community in Chiang Mai–Lamphun area where there are 54 handicraft factories is studied as sample case. It is potential area for establish 400 kW_e gasification power plant. Optimized location for the power plant is suggested where the average fuel consumption cost is 39.25 Bath/ton resulting in a unit cost of electricity at 1.37 baht/kWh as the corresponding IRR is 31.11% with a payback period of 3.21 year. This is based on the assumption that woody residues are a contribution from the community; however, if fuel has to be purchased, it is found out that the price should not be more 1,105 baht/ton. While the externality cost is less than 0.19 baht/kWh, environmental impact of this power plant is found to be $4.11x10^{-4}$Pt/ kWh which is less than what is released from the national grid.

5.2 Recommendations for Future Works.

5.2.1 This analysis can be applied other potential areas as long as database of corresponding fuel and road network in the area is available.

5.2.2 There are more conversion technologies with potential to be used in the community-based power plant. Some of them are pilots and some of them might be simpler. If the cost of the system is not too high, it might yield high possibility to be deployed in the community, especially the remote area.

5.2.3 Similar Analysis should be done nationwide. As small power plant bears small efficiency, the local authority such as Sub-district Administration Organization might also be pursued to support the first investment of the project.

5.2.4 Externality costs in this study are calculated from the reference's value of environmental damage. Therefore, the value of environmental damage of Thailand should be scrupulously studied.