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Feasibility Study of Potential and Economic of Rice Straw VSPP Power Plant in Thailand

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Abstract**—**The potential feasibility of a 9.5 MW_e capacity rice straw power plant project in Thailand was studied by evaluating the rice straw resource. The result showed that Thailand had a high rice straw biomass potential at the provincial level, especially, the provinces in the central, northeastern and western Thailand, which could feasibly develop plants. The economic feasibility of project was also investigated. The financial feasibility is also evaluated based on two important factors in the project, i.e., NPV $\geq$ 0 and IRR $\geq$ 11%. It was found that the rice straw power plant project at 9.5 MW_e was financially feasible with the cost of fuel in the range of 30.6-47.7 USD/t.

Keywords**—**Power plant, Project feasibility, Rice straw, Thailand.

I. Introduction

BIOMASS is one of the targeted fuels expected to substitute natural gas for power generation in Thailand. Presently, Renewable and Alternative Energy Development Plan for calls for 25% usage within 10 years (AEDP 2012-2021) and has targeted an additional 4,800 MW_e from biomass power plants by the year 2021 [1]. Moreover, the Thai government has promoted the biomass power projects, i.e., the Small Power Producer (SPP) and Very Small Power Producer (VSPP), to support the national grid as well [2]-[3]. SPP capacity is 10-90 MW_e, while the capacity of VSPP is less than 10 MW_e [4]. Rice straw has been especially evaluated to be a high potential biomass fuel for electricity generation in Thailand because surplus rice straw residues (i.e., the unused rice straw) still exist in fields [2], [3], [5]-[7]. However, the large amounts of surplus rice straw residues have not been considered as biomass fuel for possible small power plants.

This aim of this work was to study the feasibility of the biomass power plant project, using rice straw, at scale of 9.5 MW_e for the whole country. In addition, the rice straw power plant capacity of 9.5 MW_e was selected to be considered in this study instead of the power plant capacities of 10 MW_e or more. This is because a biomass power plant less than about 10 MW_e could not be regulated by Thai environmental law; whereas, those of 10 MW_e or more require HIA or EIA reports [8]. To avoid the environmental law impact; it is of interest to assess the feasibility of a biomass power plant with the capacity of less than 10 MW_e project and if it would be possible to develop. The project feasibility is assessed in terms of rice straw potential as a fuel supply for electricity generation and furthermore, the economic criteria, i.e., Net Present Values (NPV), Internal Rate of Returns (IRR) and Pay Back (PB) periods, had been evaluated over plant capacity of 9.5 MW_e. These economic data would help partly to decide whether a power plant project is feasible or not.

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II. Methods

A. Potential of Rice Straw for Power Plant

Potential of rice straw power generation was assessed in terms of rice straw power plant capacity [3]. The power plant capacity was evaluated based on a current amount of rice straw residues, as described [2]. Briefly, the available rice straw for the whole country was quantified using the Straw to Grain Ratio (SGR) [9]. SGR were then multiplied for the three-year statistics data (2011-2013) for average rice production [10]. The obtained data were based on rice straw availability. The available surplus rice straw residues for power generation were subsequently evaluated. They were defined as 29.5% of the rice straw availability [11]. Finally, the rice straw power plant capacity could be assessed from the amount of current surplus rice straw.

B. Project Costs Analysis

The economic parameters, i.e., NPV, IRR and PB periods, were analyzed with the assumption that the rice straw power plant capacity of 9.5 MW_e (or less than 10 MW_e) was operated. Its overall power plant efficiency and the project life-time were around 33% and 20 years, respectively. The cost data for plant capacity of 9.5 MW_e is also referred to the situation in March 2014 (1 USD = 32.7 THB) [5].

The economic evaluation of the plant capacity was assessed based on the capital cost, the operating cost and the selling price of the generated electricity. The plant project feasibility was assessed based on localized conditions in the regions studied as well [5], [6], [12].

1. Power Plant Capital Cost

The price of capital cost was commonly based on the size and technology for all plant capacities. In this work, a vibrating grate boiler was provided for combustion technology. The plant capital cost was also found to correlate well with rice straw combustion using grate boiler at various plant capacities as detailed [5]. Therefore, the estimated plant capital cost of 9.5 MW_e was about 2,000 USD/kW_e.

2. Operating Cost

The operating cost was assessed for evaluating the economic feasibility of plant project. These total operating costs of rice straw system were thus determined by local factors such as fuel cost, and maintenance cost. Generally, the cost of rice straw baling is dependent on local conditions, i.e., harvest seasonal and regions of the country, which directly affected the total operating cost for the generated electricity. The rice straw bale size was about 35×47×100 cm and its weight was 15-18 kg [3]. The average cost of rice straw baling in March 2014 was approximately 30.6-48.9 USD/t. In addition, the maintenance cost was reported between 4 to 5% of the capital cost for the combustion plants. The maintenance cost of 2.5% was used in this work [5], [13].

3. Income Conditions

Incomes from selling the generated electricity into the Provincial Electricity Authority (PEA) of Thailand were considered. The purchasing price of electricity was based on Feed-in Tariff of the Thailand Energy Policy and Planning Office (EPPO) [14]; that is 0.11-0.14 USD/kWh over the project lifetime of 20 years for plant capacity of 9.5 MW_e.

4. Economic Evaluation of the Power Plant Capacity

The economic profitability of the rice straw power plant project was evaluated in terms of NPV over the plant project lifetime of 20 years. NPV is the sum of the total capital cost and the present value of all future cash flows at a specific discount rate of 7% for Thailand.

IRR of the plant project is a specific discount rate, which is made to the total NPV of the plant project equal to zero.

A minimum required rate of return of 11% for private investors is therefore used as an assumption to benefit in the market, which was taken by the Thailand Department of Alternative Energy Development and Efficiency (DEDE) [1], [5]. Finally, PB is defined as the period of time required to recover the cost of an investment. The secondary evaluation measure is used to appraisal PB of an attractiveness of investment cost.

III. Results and Discussions

A. Surplus Rice Straw Residue and Power Potential

Fig. 1 shows an overall evaluation of the average rice straw availability, surplus rice straw residue for electricity generation and the rice straw power plant capacity in Thailand. The average rice straw availability for utilization is firstly quantified from rice straw production after harvest as detail in [2]. Provinces in Thailand usually can produce 1-4 crops annually; this is dependent on the location, i.e., rainfed areas and irrigated areas and readiness to utilization [3]. The results showed that the rice straw is being used for animal feed and soil cover at 29.8% and 20.7%, respectively, indicating that rice straw residues of around 29.5% were available as surplus which was often left and burned in the field after harvest [2]. Surplus rice straw residues available for electricity generation were subsequently evaluated. Finally, potential of rice straw power generation in Thailand is assessed from rice straw power plant capacity, which is also evaluated from available surplus rice straw. In addition, the rice straw power plant capacity is assessed based on the current quantity of surplus rice straw availability. The total 1,062 MW_e of power electricity were generated. It is interesting to note that Thailand has a high potential of rice straw biomass for power generation.

As mention earlier, the rice straw power plant capacity of 9.5 MW_e was selected to the optimum plant capacity under the economics of scale and environmental law conditions, which could feasibly be developed. In addition, the potential areas for rice straw power plant capacity of 9.5 MW_e at the provincial level in Thailand were assessed as shown in Fig. 2. The provincial potential for the availability of rice straw resources suitable to energy utilization were mostly found in central, northeastern, western and some parts of provinces in the northern regions of Thailand.

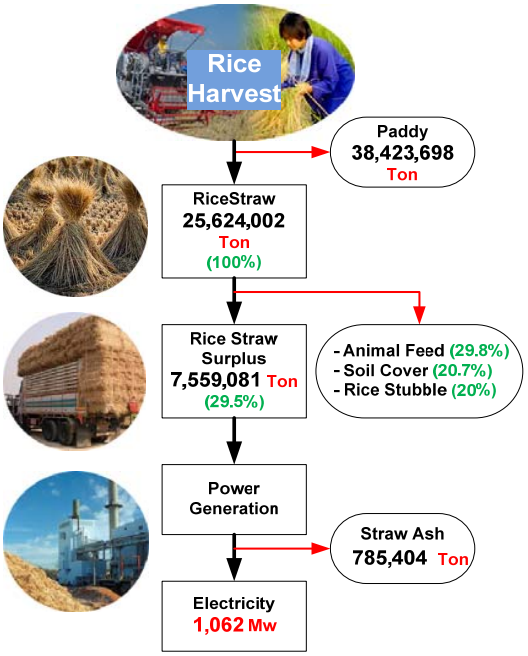

Fig. 1 An overview of the potential of rice straw available for electricity generation in the Thailand in 2013

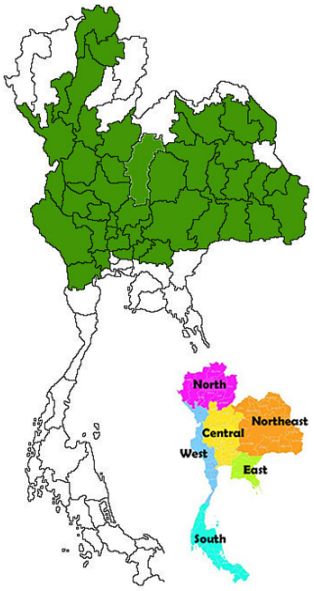

Fig. 2 Provincial potential areas for power plant capacity of 9.5 MW_e in Thailand

B. Project Costs Analysis Results

The financial evaluation of the project is represented in terms of NPV, IRR and PB as shown in Table I. It was observed that fuel costs have changed in the range of 30.6 - 47.7 USD/t and then relating the obtained results. The results showed the positive NPV (NPV > 0) and the IRR value was more than 11%, indicating that under assumption, the 9.5 MW_e power plant was financially feasible. However, when considering a higher fuel cost (fuel cost > 47.7 USD/t), the NPV yield of power plant remained positive value, but the IRR percentage of this project would not be attractive to the private investors. This is because it might result in less than the minimum pre-requisite rate of return, which is defined to be at least 11% [5].

TABLE I
PROJECT FINANCIAL EVALUATION OF THE POWER PLANT CAPACITY OF 9.5 MW_e

Fuel cost	Criteria		
(USD/t)	NPV (10^6 USD)	IRR (%)	Simple PB (yr)
30.6	19.9	18.8%	6.2
36.7	14.8	16.2%	6.8
42.8	9.6	13.3%	7.7
47.4	5.7	11.0%	8.6

IV. CONCLUSION

The potential and economic feasibility of the rice straw power plant with a capacity of 9.5 MW_e in Thailand were studied based on the current quantity of surplus rice straw residues availability. The result showed that the potential areas for a rice straw power plant at the provincial level were found in the central, northeastern, western and some part of provinces of northern Thailand. The results also show this could be a suitable resource to generate electricity. Electricity of around 1,062 MW_e was generated. It was of note that Thailand has a high potential of rice straw biomass for power generation. In addition, the financial feasibility was also evaluated based on two important factors in the project, i.e., NPV and IRR. The results showed that the rice straw power plant capacity of 9.5 MW_e was financially feasible with the cost of fuel in the range of 30.6 - 47.7 USD/t. Future work should be made to evaluate the potential of rice straw power plant using the GIS technique.

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