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Study of Current the Rice Straw Potential for a Small Power Plant Capacity in the Central Region of Thailand

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Abstract**—**The objective of this work was to study potential of rice straw for power plant in the Central region of Thailand. Provincial power plant capacity was studied. The results showed that provinces central region had potential for small power plants with a capacity of over 10 MW in 13 provinces, 1-10 MW in 6 provinces and less than 1 MW in 3 provinces.

Keywords**—**Rice straw, Power plant, Central region, Thailand.

I. Introduction

IN Thailand, the use of bio-energy from biomass would be promoted to substitute fossil fuel for power generation because Thailand is highly imported fossil fuel (e.g., natural gas). Nowadays, Thailand has thus actively supported an additional from 1,751.86 MW to 4,800 MW from biomass power plant by the year 2021[1].Rice straw is also one of the most residues available in Thailand. Mostly, the utilization of rice straw as animal feed and soil cover. However, the unused rice straw remains to be left in the field and then would be burnt. Rice straw could thus be a high potential biomass and may help partly substituted fossil energy for power generation [3], [7].

Although, there are many studies of utilization of rice straw residues for power generation in Thailand and other countries [2]-[5], [7], [8], the obtained information has considered for several plants capacities. However, for possible power plants, it is therefore desirable to develop for appropriate capacity power plants at provincial level. The purpose of this work was to study the potential of the rice straw to set up the small power plant in the Central region of Thailand (Fig. 1). The rice straw power plant capacity was evaluated based on the current quantity of rice straw. Provinces in the Central region were selected to the study areas in this work because these provinces could produce 2-4crops annually and easy to transport. Therefore, Central province shave highly potential and readiness to utilization for power production.

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II. Methods

A. Quantification of the Available Rice Straw

To evaluate the amount of rice straw that generated in the field was carried out using Straw to Grain Ratio (SGR). SGR of 0.75 and 0.43 were multiplied the three-year average rice production quantities for rainfed crop and Irrigated crop, respectively [2]. Three-year statistics (2011-2013) data was obtained from Thailand Office of Agricultural Economics (OAE) [6].

B. Quantification of the Surplus Rice Straw

To evaluate the rice straw residues were available as surplus (i.e., unused rice straw) for energy generation. The quantity of surplus rice straw residues availability was also defined as 29.5% of the rice straw availability occurred [9].

C. Evaluation of Power Plant Capacity

The rice straw power plant capacity could evaluate from the current quantity of surplus rice straw. The operating conditions of power plant capacity of 9.5 MW were used as assumptions for this evaluation. Plant efficiency was around 33%, which could be operated to 330 days per year. The plants thus required fuel biomass supply of 67,620 ton/year (LHV of 14 MJ/kg and moisture content of 12%w.b.).

Fig. 1 Map of Central region in Thailand

III. Results and Discussions

A. Rice Straw Availability

Provincial rice production and rice straw availability are shown in Table I. Central provinces annually produced around 2 crops.22 provinces are areas of interest to evaluate rice straw potential for power production. It is interesting to note that these provinces can be as the high potential areas for possible power plant from rice straw. Statistics data in 2010 - 2013 shows that the average quantity of rice straw generated was around 25% of the total annual rice production [7].

As expected, the average rice straw residues capacity tended to increase with the averages rice production in all provinces. Almost all provinces seem to be a high potential to produce rice straw, except three provinces were a lowest potential (Samut Prakarn, Samut Sakorn and Samut Songkhram). This is probably because rice was not economic crop of these provinces.

TABLEI
Rice Straw Availability in Some of Provinces in the Central Region of Thailand: 2010-2013

Province	Average rice production (tons)			Average rice straw residues (tons)		
	Rainfed Crop	Irrigated Crop	Total	Rainfed Crop	Irrigated Crop	Total
NakhonSawan	1,209,055	758,821	1,967,876	906,792	326,293	1,233,085
Phichit	979,817	697,736	1,677,553	734,863	300,027	1,034,889
SuphanBuri	869,151	881,718	1,750,869	651,863	379,139	**1,031,002**
Phitsanulok	850,978	771,974	1,622,953	638,234	331,949	970,183
KamphaengPhet	795,457	564,390	1,359,848	596,593	242,688	839,281
Sukhothai	642,001	512,734	1,154,735	481,501	220,475	701,976
Ayutthaya	543,908	609,289	1,153,197	407,931	261,994	669,925
Chai Nat	497,479	499,915	997,393	373,109	214,963	588,072
Phetchabun	586,033	86,759	672,792	439,525	37,307	476,831
Lop Buri	366,580	327,826	694,406	274,935	140,965	415,900
Nakhon Pathom	271,330	307,576	578,906	203,498	132,258	335,755
UthaiThani	323,779	193,762	517,541	242,835	83,318	326,152
Ang Thong	218,365	241,888	460,253	163,774	104,012	267,786
Pathumhani	219,663	236,279	455,942	164,747	101,600	266,347
Sing Buri	203,415	230,388	433,803	152,561	99,067	251,628
NakhonNayok	241,280	143,530	384,810	180,960	61,718	242,678
Saraburi	219,281	201,963	421,244	164,461	86,844	251,305
Nonthaburi	80,167	81,837	162,003	60,125	35,190	95,315
Bangkok	69,855	78,452	148,307	52,391	33,734	86,125
SamutPrakan	33,391	22,279	55,670	25,044	9,580	34,623
SamutSakhon	8,989	9,208	18,197	6,742	3,959	10,701
SamutSongkhram	2,412	2,209	4,620	1,809	950	2,758
Total	**9,232,386**	**7,460,532**	**16,692,918**	**6,924,290**	**3,208,029**	**10,132,318**

B. The Utilization of Rice Straw

Fig. 2 shows the proportional the utilization of the available rice straw residues. Rice straw is being used for animal feed and soil cover of around 29.8% and 20.7%, respectively. The rice straw residues of around 29.5% were available as surplus (the amount of straw residues left unused), which was often burned in the field after harvest. Surplus rice straw residues among 22 provinces are shown in Table II.

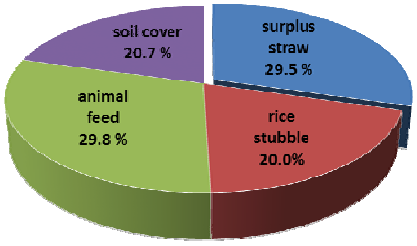

Fig. 2 The proportion of rice straw utilization

C. Potential Provincial Level

Table II shows the potential of rice straw available for energy use in the Central region in 2013. It was found that the total quantity of rice straw residues ofabout10.7million tons were surplus available of around 3.1 million tons. The equivalent energy of the amount of surplus rice straw was 43,514 TJ.

TABLE II
POTENTIAL OF RICE STRAW AVAILABILITY IN SOME OF PROVINCES IN THE CENTRAL REGION: 2013

	Province	Average rice production (ton/year)	Average rice straw residues (ton/year)	Surplus rice straw (ton/year)	Energy equivalent (TJ)	Energy equivalent (ktoe)	Plant Capacity (MW)
Group 1	NakhonSawan	2,087,238	1,337,098	394,444	5,443	129	55.4
	Phichit	1,761,267	1,102,848	325,340	4,490	106	45.7
	SuphanBuri	1,789,214	1,059,778	312,635	4,314	102	43.9
	Phitsanulok	1,624,539	997,334	294,213	4,060	96	41.3
	KamphaengPhet	1,392,043	869,254	256,430	3,539	84	36.0
	Sukhothai	1,217,439	743,550	219,347	3,027	72	30.8
	Ayutthaya	1,217,192	723,445	213,416	2,945	70	30.0
	Chai Nat	1,068,338	633,038	186,746	2,577	61	26.2
Group 2	Phetchabun	666,793	478,364	141,117	1,947	46	19.8
	Lop Buri	745,456	455,323	134,320	1,854	44	18.9
	NakhonPathom	612,366	359,146	105,948	1,462	35	14.9
	UthaiThani	510,130	323,843	95,534	1,318	31	13.4
	Ang Thong	489,503	287,438	84,794	1,170	28	11.9
	PathumThani	475,343	280,764	82,825	1,143	27	11.6
	Sing Buri	469,083	275,438	81,254	1,121	27	11.4
	NakhonNayok	406,586	257,754	76,037	1,049	25	10.7
	Saraburi	418,855	256,677	75,720	1,045	25	10.6
Group 3	Nonthaburi	174,731	103,997	30,679	423	10	4.3
	Bangkok	162,286	94,866	27,986	386	9	3.9
	SamutPrakan	53,544	34,782	10,261	142	3	1.4
Group 4	SamutSakhon	18,389	10,931	3,225	44	1	0.5
	SamutSongkhram	5,073	3,079	908	13	0	0.1
	total	**17,365,408**	**10,688,747**	**3,153,180**	**43,514**	**1,030**	**443**

Moreover, considering the potential of biomass-fueled power plants at the provincial level was evaluated in terms of provincial power plant capacity. The results showed that provincial potential is classified into 4groups. Group 1 (Nakhon Sawan, Phichit, SuphanBuri, Phitsanulok, Kamphaeng Phet, Sukhothai, Ayutthayaand Chai Nat), the provinces in this group had the highest potential for power plant capacity over 20 MW. The provinces in Group 2 (Phetchabun, Lop Buri, Nakhon Pathom, Uthai Thani, Ang Thong, Pathum Thani, Sing Buri, Nakhon Nayok and Saraburi) and Group 3 (Bangkok, Nonthaburi and Samut Prakan) had also the available rice straw potential for power plant with capacity of around 10-20 MWand1-10 MW, respectively. Those provinces in Group 4 (Samut Sakhon, and Samut Songkhram), the provinces in this group had rice straw potential for a small power plant with capacity less than 1 MW. The locations of these provinces are shown in Fig. 3.

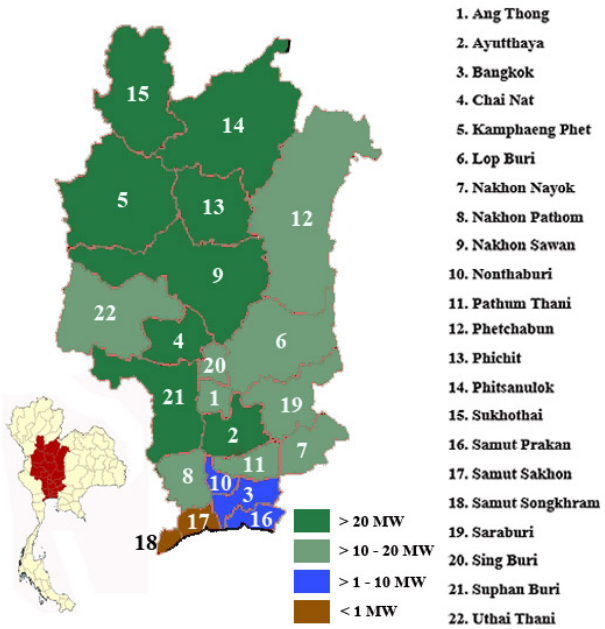

Fig. 3 Central provincial power plant capacity

IV. CONCLUSION

The surplus rice straw residue available for energy generation was evaluated in the Central region. The results

showed quantitative potential that the provinces in the central region had quite a high potential for rice straw power plant. Provincial power plant capacity could thus be classify into four groups. Future work should be made to consider economic analysis of rice straw power plant, which will be help to decide a power plant whether is achievable or not. Use of other evaluation techniques such as GIS should be attempted as well.

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