

# Estimation of ethanol production potential from rice straw and bagasse in Asian countries

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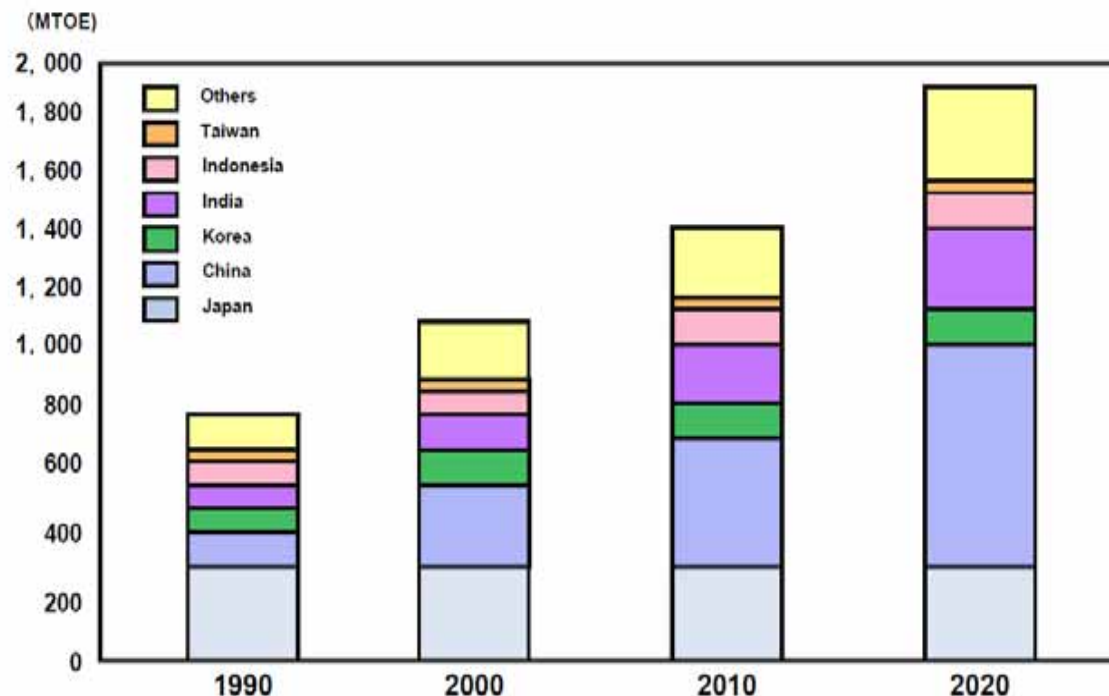
# Fuel ethanol in Asia

## Asian region

Large population, high economic growth

Increase of energy demand,

Increase of CO2 emissions



Estimation of petroleum demand in Asia

S. Yokoyama 5<sup>th</sup> Biomass-Asia Workshop (2008)

The use of ethanol as a substitute for gasoline can be an effective measure to the problems, but.....

The present feedstock is food resources like sugars from sugarcane, starch from corn or cassava.



The use of non-food resources like agricultural residues is expected.

# Practical estimation of ethanol production potential

- 1 . Based on actual sugar recoveries from experiments
- 2 . Based on the practical fermentation efficiency (85%) and consideration of process recovery (90%)
- 3 . Exclusion of xylose utilization
- 4 . Estimation considering resource availability is also studied (Case 2)

## Estimation of resource amounts :

by Product-Residue Ratio (RPR)

Rice straw (dry wt.) / Paddy rice (dry wt.) = 1.0

Bagasse (dry wt.) / Sugarcane (fresh wt.) = 0.15

## Availability of resources : by literature

Rice straw            20%

Bagasse              15%

# Enzymatic saccharification with AIST procedures

## Pretreatment:

Pulverization with planetary ball-mill



## Enzymatic saccharification:

Acremonium cellulase (Meiji Seika)

4 or 40 Filter Paper Unit (FPU) / g substrate

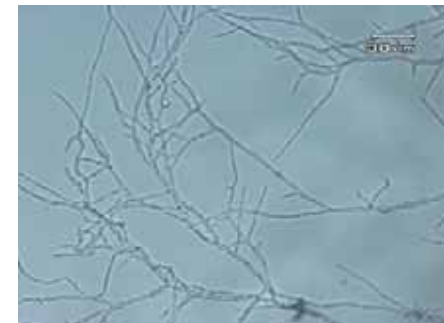
+

Optimash BG (Genencore)

0.02 ml / g substrate

in 0.05 M NaAc buffer (pH 5.0)

incubate at 45 °C for 72 h



Cellulase-producing fungus,  
*Acremonium cellulolyticus*  
(isolated by AIST researchers)

# Obtained sugar recoveries and estimation of ethanol production amounts

## Glucose

	Content (g/dry g)	Hydrolysis rates (%)	
		4 FPU	40 FPU
Rice Straw	0.289	88.2	91.7
Bagasse	0.404	84.8	91.7

## Xylose

	Content (g/dry g)	Hydrolysis rates (%)	
		4 FPU	40 FPU
Rice Straw	0.148	70.1	78.3
Bagasse	0.207	74.2	84.0

**Ethanol(L) = Resource amount (kg) × Glucose content × Sugar recovery with 4 FPU cellulase × Fermentation efficiency (0.85) × Theoretical ethanol yield (0.51) × Process recovery (0.9) / Specific gravity of ethanol (0.79 kg / L)**

# Ethanol production potential from rice straw

Country	Rice Production (10 <sup>6</sup> t)	Total Straw Amount (10 <sup>6</sup> t)	Straw Amount considering Availability (10 <sup>6</sup> t)	Ethanol Production Potential (10 <sup>6</sup> L)	
				Case1	Case2
China	184.1	138.1	27.6	17,422	3,484
India	139.1	104.4	20.9	13,165	2,633
Vietnam	35.8	26.9	5.4	3,390	678
Cambodia	6.3	4.7	0.9	592	118
Laos	2.7	2.0	0.4	252	50
Thailand	29.3	22.0	4.4	2,769	554
Myanmar	30.6	23.0	4.6	2,895	579
Malaysia	2.2	1.6	0.3	203	41
Indonesia	54.5	40.8	8.2	5,152	1,030
Philippines	15.3	11.5	2.3	1,451	290
Sum of ASEAN	176.6	132.4	26.5	16,705	3,341

Case 1: Production from total straw

Case 2: Production from straw considering availability

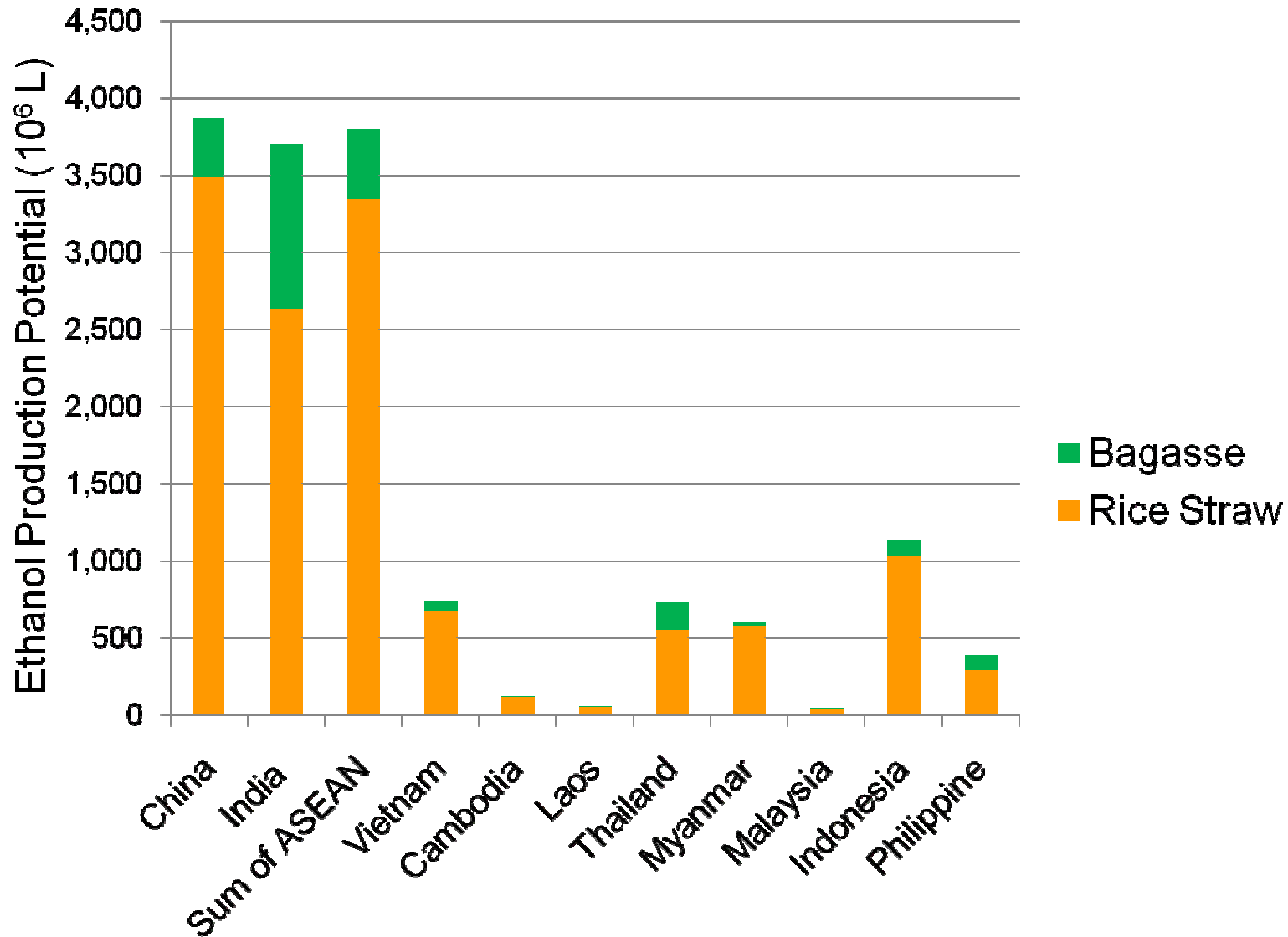
# Ethanol production potential from bagasse

Country	Sugarcane Production (10 <sup>6</sup> t)	Total Bagasse Amount (10 <sup>6</sup> t)	Bagasse Amount considering Availability (10 <sup>6</sup> t)	Ethanol Production Potential (10 <sup>6</sup> L)	
				Case1	Case2
China	100.4	15.1	2.26	2,555	383
India	281.2	42.2	6.33	7,151	1,073
Vietnam	15.7	2.4	0.35	399	60
Cambodia	0.1	0.0	0.00	4	1
Laos	0.2	0.0	0.00	6	1
Thailand	47.7	7.1	1.07	1,212	182
Myanmar	7.3	1.1	0.16	186	28
Malaysia	0.8	0.1	0.02	20	3
Indonesia	25.2	3.8	0.57	641	96
Philippines	24.4	3.7	0.55	619	93
Sum of ASEAN	121.3	18.2	2.73	3,086	463

Case 1: Production from total bagasse

Case 2: Production from bagasse considering availability

# Ethanol production potential from rice straw and bagasse (Case 2)



# Possible gasoline substitution with ethanol from rice straw and bagasse

Country	Gasoline consumption (10 <sup>6</sup> t)	Possible substitution by ethanol (%, Energy basis)	
		Case1	Case2
China	52.3	18.7	3.6
India	9.3	107.2	19.6
Vietnam	2.8	66.8	13.0
Cambodia	0.2	192.1	38.4
Laos	0.1	90.0	17.9
Thailand	5.4	36.5	6.7
Myanmar	0.4	418.1	82.4
Malaysia	7.9	1.4	0.3
Indonesia	13.1	21.7	4.2
Philippine	2.6	38.4	7.1
Sum of ASEAN	33.4	29.1	5.6
Korea	7.0	4.2	0.8
Japan	44.1	1.2	0.3

Case 1: Production from total resources

Case 2: Production from resources considering availability

# Summaries

Based on actual experiment data and modest assumption, ethanol production potential from rice straw, sugarcane bagasse, was estimated.

Possible ethanol production from rice straw and bagasse was estimated as 20 billion L (Case 1), and 4 billion L (Case 2) for China, India, and the sum of ASEAN, respectively.

Possible substitution of domestic gasoline consumption with ethanol from three kinds of residues is 18.7%, 107.2%, 29.1% (Case 1) and 3.6%, 19.6%, 5.6% (Case 2), for China, India, and the sum of ASEAN, respectively.

Asian countries in general have large ethanol production potential without utilizing food resources.