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Field trip report

Rice husk gasification for electricity generation in Cambodia in December 2014

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Introductive summary

In 2014, the total rice production in Cambodia were approximately 9.3 million tons [1]. Rice husk accounted for approximately 20% of paddy production on a weight basis [2], meaning that 2 million tons of rice husk were produced. Only 10% of rice husk in Cambodia is utilized as fuel for household cooking and for brick kilns [3]. Rice mills have to throw the rest away or burn it out as a way of disposal. This creates environmental hazard and air pollution for the surroundings. Rice husk can become an interesting feedstock for electricity production. The conversion rate of rice husk to electricity is 1.6-1.8 kg per kilowatt-hour (kWh), equivalent to 1100 GWh of electricity [4][5].

Electricity price in Cambodia is among the highest in the region due to limited domestic fossil fuel resources. The state-owned electricity provider Electricité du Cambodia (EDC) provides electricity with cheapest tariffs, from $0.09 to $0.25 per kWh, but only 25% of Cambodians are having access to the EDC grid [6]. Other main domestic suppliers use Diesel/HFO as fuel and supply electricity at a tariff between $0.75 and $1 per kWh [7]. With such a high price, Cambodians living in areas without access to the EDC grid look for a way to produce electricity at a cheaper price. Recently, lots of rice mills and Rural Electricity Enterprises (REEs) have installed rice husk gasifiers (RHGs) to substitute diesel in the electricity production.

To learn more about the benefits and drawbacks of using rice-husk gasifiers, and to study about the sustainability challenges for deploying these technologies, the Clean energy and sustainable development lab (CleanED lab) of the University of Science

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and Technology of Hanoi (USTH), and the SNV Netherlands Development Organisation (SNV) have conducted a visit of several rice mills and rural electricity enterprises from 18th to 22nd December 2014.

Four rice mills, a REE and a rice husk power plant in Phnompenh, Siem Reap, Battambang and Kompong Thom were selected for the field trip. The rice mills were selected based on the difference of processing capacity: from micro (milling capacity inferior or equal to 1 ton/hour), small (between 1 and 3 ton/hour), medium (between 3 and 10 ton/hour) to big scale (superior to 10 ton/hour), and on the presence of RHGs. The REE was selected based on the presence of an imported RHG. The HAK SE power plant was selected as it is the Cambodia's first power plant using 100% RHG to supply power to the local grid [8]. This selection was designed in order to gather diverse types of information on the actual Cambodian rice milling sector and the actual status of RHGs.

Key lessons learned

1/ The gasification technology works in Cambodia. Rice mills, ice glace enterprises and rural electricity enterprises install the gasification system to substitute 60% - 80% of diesel consumption in order to generate electricity.

2/ Pollution is a problem. There is a cheap and dirty way to do it. Black waters containing high levels of polycyclic aromatic hydrocarbons (PAH) are produced, and current treatment technologies seem underperforming. The value of ashes (biochar) as fertilizer or soil amendment is not realized. Tars re-burning seems rare.

3/ There is no enforced standard from the government. Lack of institutional public policy. One closed last year because of peer pressure, not by policy.

4/ Technology has been transferred in two ways: formally and informally. Formal transfers include workshops to produce spare parts locally at more affordable costs and training. Informally, there are at least three local producers of gasifier competing with the Indian technology leader Ankur, imported by SME Renewable Energy. The system has been copied by local manufacturers without license from the Indian manufacturer.

5/ There is a correlation between the choice of local or imported system and the choices related to environmental quality control and management. Further work is needed to compare the efficiency and reliability of local and imported systems.

6/ Rice husk is now a commodity. A few years ago, in the West of Cambodia, it was a waste that rice millers had to pay farmers to come and pick up. Now, some is exported to Thailand. Further work is needed to look at this market.

7/ It is still profitable to continue operating an installed gasifier, but new investors consider grid first when available. Millers are traders. They invest first in paddy stock, second in milling machines. Energy production is an ancillary activity. Is rice husk gasification a temporary local development option before the grid arrives, or a sustainable plant integration option?

8/ The key factors determining if a gasification system should be operated or installed are: the (opportunity) price of husk, the price of diesel fuel (barrel of oil) and the price of available grid electricity. These three prices vary geographically within Cambodia, and historically since the first gasifier arrived in 2005. The government is going to reduce the price of electricity next year. Other key factors include the load factor of the milling plant, which depends on their market demand and ability to source paddy. Price of ash and environmental constraints were less important factors.

9/ The sector is concentrating. Some micro/small rice mills (without installing gasification system, or small system installed) loose their customers since they cannot compete with other rice mills having a bigger capacity and lower price. These mills are reconsidering their strategy: focus on local market; sell paddy for bigger mills. Investing in new gasifier capacity is hardly an option for these.

10/ It is hard for millers to find a finance source. In traditional mills, taking loans from financial institutions is not as usual as taking loans from family. There is a gap between expected rates of 7-9 %, and those offered by banks 10-12 %. Banks are more interested in collateral than in business plan. In many cases, miller's assets are insufficient to cover their risk, from the banker's point of view.

Data collected

Data collected during the visit include:
- Profiles of 353 rice mills on their operation in 2014 (updated 19th June 2014), from FCRMA;
- Business spreadsheet for a gasification installation from FCRMA;
- Interview notes from 24 gasifier users;
- 4 reports on the EU SWITCH-Asia funded project: “Waste to Energy (WtE) for the Rice Milling Sector in Cambodia”, EuropeAid/130830/C/ACT/CAI, from SNV and their partners;
- Digital assets: pictures and record files taken during the visit;

These data were analyzed and utilized for this report and also will be useful for other future research.

Future research ideas

1/ Statistically look at the variables explaining the adoption and the abandonment of the technology using FCRMA database of *n*=353.
2/ Check for uses of rice husk in Thailand, explore the market.
3/ Make back of the envelope calculation. We can make precise calculations. Ask Federation of rice millers for its business model spreadsheet.
4/ Look at the lifecycle analysis to account for all emissions. A baseline study has been conducted in 2013 by SNV.
5/ Increase the capacity of local manufacturers. Check data on performance and quality.
6/ See what is behind biochar's hype (Ongoing research, SNV will do experiments next year), discuss with CIRAD.

List of visited installations

1/ Ms. Savoeun's rice mill, Deum Pou village, Phnom Penh, Cambodia.
This is a small familly owned rice mill with the milling capacity of 1 ton/hour. A 250 kW downdraft Ankur gasifier from SME Renewable Energy Ltc has been installed in 2011, which substitutes for 2/3 of diesel fuel in generator. SME imports gasifiers from India, assembles and installs the systems. SME offers a loan of 13%/year for the mill, with the equipment taken as collateral.
The mill operates more than 10 hours/day, 22 days/month and 10 months/year. 30% of rice husk produced is consumed by the gasification system the rest is sold for $17/ton. The rice mill purchases paddy mostly in 2 seasons: Nov-Jan & May-June and then stores paddy to ensure having enough of paddy for the whole year. Mixed paddy is collected to produce 3rd-rice quality for local consumption.

Figure 1. Ankur gasifier Ms. Savoeun's rice mill, Deum Pou village, Phnom Penh, Cambodia, 2014 - 12 - 19

Rice husk milled from paddy is directly utilized for gasification system. The mills have 6 labors, 2 to take care of the gasification system. Some problem with the reactor and the bearing is experienced.

Figure 2: Solid and liquid wastes from the gasification system, 2014-12-19

The site is polluted by ash, black water, tar and char. Ash can be sold for $7/ton, people will come to take ash. The water is not treated and flows in the undeveloped field behind the mill. No measure is taken to dispose tar and char. The gas leakage can be seen in the gasification system.

2/ Golden Daun Keo rice mill in DaunTeav Village, Battambang, Cambodia.
This is a new plant, built and owned by the Canadia Bank PLC. with the milling capacity of 3 tons/hour. In 2013, a modern 600kW Ankur downdraft gasifier has been installed and can replace 60% of diesel consumption.

Figure 3: 600kW Gasifier at Golden Daun Keo rice mill, Battambang, Cambodia, 2014-12-20

4 persons are needed for the gasification system, salary $120/month with bonus, saturday and sunday $3/h. This system operates for 10h/day but just in some period. The system is operating for 1 496h but will have to relocate because of the paddy supply issues (we have been told that the road to the mill is too small and tracks are hard to enter).

3/ Yam Chan rice mill, Songke Village, Battambang, Cambodia.
This is a modernized mill of Ms. Yam Chan, with a milling capacity of 6 tons/hour. The mill operates 10 hours/day, 22 days/month and for the whole year.

Figure 4: Yam Chan rice mill, Battambang province, Cambodia, KH. 2014 - 12 – 20

A downdraft gasifier of 600 kW from the local manufacturer Nouchanoith ($ 60 000 for the whole system) has been installed in 2012 to replace for the old 400 kW gasifier (installed in 2010). It is estimated that the new system replaces about 60% of diesel consumption, making a high profit rate in short term The rice husk is used in driers (3 driers 2x40 ton in China and 10 ton in Korea) and in the gasifier.

Figure 5: 600kW gasifier, local manufacturer at Yam Chan rice mill, Battambang province, Cambodia, 2014 - 12 – 20

The mill has big storage for paddy, the husk is left outside and transported to the gasifier by an excavator.

Figure 6: Solid and liquid wastes from the gasification system - Yam Chan rice mill, Battambang province, Cambodia, 2014 - 12 – 20

The mill has a very low pollution control. The black water flows in a big pond next to the installation. Ashes and tars are found on the ground; a high level of dust and noise is noticed.

4/ Baitang (Kampuchea) Plc., Battambang Province, Cambodia.

Baitang (Kampuchea) Plc. is a public limited company and was officially registered with the Ministry of Commerce in 2008, focusing on setting up Baitang community (Green Community), providing loan/ credit, supplying consumer goods and agro-input products to the community members, setting up paddy collection markets, milling and refining rice for the supply to both domestic and international markets [9].

They have a large rice mill with high-tech facilities, including:

- Dryer facility: 700 Tons/day (SUNCUE, Taiwan)
- Storage warehouse: 100,000Tons (Clean and well-managed)
- Milling facility: 480 Tons/day (SATAKE, Japan)
- Refining facility: 720 Tons/day (SATAKE, Japan)

Figure 7: Rice husk truck for Thailand. Baitang (Kampuchea) Plc, Battambang Province, Cambodia, 2014-12-20

Their production capacity is about 720 tons/day (refined rice), they only produce jasmine rice and export to 23 countries in 5 continents worldwide. Starting from 2014, they also trade rice husk to Thailand.

5/ **United Nations Industrial Development Organization (UNIDO)'s project: "*RURAL ENERGY FOR PRODUCTIVE USE AND INCOME GENERATION IN CAMBODIA*" (UNIDO Project Number: TFCMB04001), Charchouk Commune in Siem Riep Province, Angkorchum district, Cambodia.**

A 150kW rice husk gasifier system (downdraft gasifier from Ankur manufacturer) was installed in 2011 for local electrification, in order to substitute the old and costly diesel gensets.

The enterprise operates 24h/day for the whole year. The generators run with 100% producer gas from the biomass gasifier.

Figure 8: 150kW Ankur downdraft gasifier at UNIDO Project, Siem Siep Province, Cambodia, 2014-12-20

The system has operated for 14 685 hours, but will be relocated because the grid has arrived already, five years sooner than initially thought.

Figure 9: Morning glory growing on biochar from gasified rice husk, 2014-12-20

6/ SOMA Group's HAK SE Plant, Kompong Cham province, Cambodia

In 2012, the Hak Se plant installed 2x750 kW Ankur downdraft gasifiers to produce electricity. SOMA's project is the Cambodia's first fully-integrated biomass gasification-gas engine installation. When completed, the new plant will convert rice husk into biogas and feed it into two GE VHP 5904 Waukesha engines to produce electricity only [10]. Part of the electricity will be used to power the mills operations while the remaining power will be fed into the local grid. The plant was expected to operate on March 2013, but was delayed until now.

Figure 10: HAK SE Plant, Kompong Cham province, Cambodia, 2014-12-21

This plant is part of the SOMA Group's HAK SE MODERN RICE MILL (HSMRM) founded in 2007 by Mr. Hak Se. Its core business is producing quality rice to supply for both local and international market.

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