Codigestion for Backyard and Small Commercial Agriculture Operations

Lessons Learned from the Mekong Delta
Presentation Outline

Introduction to Codigestion

Brief history of biogas in Vietnam

RTI’s codigestion toolkit

Utilizing lessons learned for commercialization
The Mekong Delta:

- 17 million Vietnamese
- 2.5 million farm families
- 40,000 commercial farms

-Rice
-Aquaculture
-Animal husbandry

The project study area
The Project

- Investigate the applicability of codigestion for backyard and small commercial farms;
- Identify technology limitations;
- Suggest technology improvements;
- Develop strategies for commercialization;
- Utilize lessons learned for application to new markets.
Factors to Consider in Codigestion

- Carbon to Nitrogen ratio (C:N)
- TS:VS of feedstocks
- Temperature
- Moisture content
- pH
- Retention time & mixing
- Solids content
- Substances that interfere with fermentation
- Dimensions of the digester
- Other influent wastewater characteristics

- Codigestion: anaerobic biodigestion of multiple feedstocks in one digester
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Vietnam National Biogas Program

• Vietnam & Dutch Governments;

• Promoting Biogas and Training of local masons & Commercialization Programs led by SNV;

• 124,000 biogas systems since 2006.

Fixed dome biodigester – SNV
(For more information on SNV’s Biogas Program: [http://www.snvworld.org/](http://www.snvworld.org/))
The VACVINA

VACVINA (1986) – first attempt at codigestion in Vietnam

VAC ("Vuon"-Garden, "Ao"-Pond, "Chuong"-Stable) – Nat. policy promoted by National Association of Vietnamese Gardeners

Image courtesy of: Research Center for Energy & Environment (RCEE)
Address: No. 33, Trung Yen 9 Road, Yen Hoa ward, Cau Giay district, Hanoi, Vietnam Tel: (+84-4) 6291 2407, Fax: (+84-04) 3786 8593, email: rcee.ease@gmail.com
Integrated system for animal and human waste management - maximizes biogas output, and recycles nutrients and treated effluent to enhance agriculture.
The Polyethylene Digester:

1. pig-pen
2. inlet pipe
3. digester
4. outlet pipe
5. discharge pond
6. garden
7. gas vent
8. security valve
9. polyethylene gas holder
10. stove
Waste from toilets and hog pens co digested in common reactor. Nutrient rich effluent discharges to fish pond, and biogas collected for cooking.
Bag digester (blue) and gas storage bags (white). Polyethylene is low cost construction material.
VACB-D — For enhanced Environmental Protection*

Utilizes cocopeat biofilters for treating digester effluent

Initiated by Can Tho University and RTI in 2011

*Initial funding by the Bill & Melinda Gates Foundation
VACB-D — For Improved Performance

-2012. Program expands through Vietnam Government funding of 200 systems in:
  • Tra Vinh,
  • An Giang and
  • Kien Giang

Purpose: to determine if the VACB system can be improved through:

• More accurate system sizing;
• Technology improvements; and
• Codigestion practices based on better engineering, science and practices.

Enhanced treatment with ornamental plants
Carbon to Nitrogen Ratio

<table>
<thead>
<tr>
<th>Brown waste feedstock</th>
<th>C:N</th>
<th>Green waste feedstock</th>
<th>C:N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>25:1</td>
<td>Corn straw</td>
<td>65:1</td>
</tr>
<tr>
<td>Pig</td>
<td>13:1</td>
<td>Fruit waste</td>
<td>40:1</td>
</tr>
<tr>
<td>Chicken</td>
<td>5:1 to 10:1</td>
<td>Rice straw</td>
<td>79:1</td>
</tr>
<tr>
<td>People</td>
<td>3:1</td>
<td>Wheat straw</td>
<td>127:1</td>
</tr>
</tbody>
</table>

**Carbon** – mainly carbohydrate - green wastes.  
**Nitrogen** – mainly ammonia or nitrate - brown wastes.

The optimal C:N ratio **25:1 to 30:1**
Co-digestion Toolkit

RTI’s Biogas Codigester Creator in collaboration with Loowatt

1) What are the sources of influent into the Biogas Codigester?
   a) Animal (Brown) Waste
      i) People: 5 People
      ii) Pigs: 13 Pigs
   b) Crop (Green) Waste
      i) Fruit Waste: 5 Kg
      ii) Rice Straw: 10 Kg
   c) Food Related Waste
      i) (Blank)

C:N Ratio of influent Codigester Waste: 23.9:1

Create Biogas Codigester

5) What type of biogas codigester would you like to use?
   Bag Codigester

6) What percent of human daily urine output is captured in the codigester?
   100%

7) On average, how many liters of water are used a day per person to flush feces down a latrine/toilet?
   1 Liters

8) On average how many liters of water are used per day to rinse animal waste into the codigester?
   25 Liters

2) What is the climate for the region your project is located in?
   Tropical - 35°C

3) What is the detention time for your system?
   30 Days

Helps balance C:N ratio for multiple feedstocks

Welcome to RTI’s Codigester Creator Toolkit (Ver. 2.5). This toolkit helps end users balance different animal and vegetable waste streams to create a biogas codigester. To use the tool, answer all the questions on this page and click the ‘Create Biogas Codigester’. Waste related variables can be viewed and edited in the Parameters sheet, accessible by clicking the ‘Parameters’ button.
1) What are the sources of influent into the Biogas Codigester?

a) Animal (Brown) Waste
   - Cows: 2 cows
   - Chickens: 20 chickens
   - People: 5 people
   - Pigs: 15 pigs
   - [blank]

b) Crop (Green) Waste
   - Corn Straw: 5 kg
   - Fruit Waste: [blank] kg
   - Rice Straw: 15 kg
   - Water Hyacinth: [blank] kg
   - [blank] kg

c) Food Related Waste
   - Fats, Oil and Grease: [blank] kg
   - Food Waste: [blank] kg

C:N Ratio of influent Codigester Waste:
- 25.4:1
- [blank]

5) What type of biogas codigester would you like to use?
- Bag Codigester

6) What percent of human daily urine output is captured in the codigester?
- 0%

7) On average, how many liters of water are used a day per person to flush feces down a latrine/toilet?
- 1 liter

8) On average how many liters of water are used per day to rinse animal waste into the codigester?
- 50 liters

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2) What is the climate for the region your project is located in?
- Tropical - 35°C
- Subtropical - 30°C
- Temperate - 25°C
- [blank]

3) What is the expected system?
- 40 days
Codigestion Toolkit – Design and Outputs

Allows comparison between bag style and Chinese Dome digesters – Outputs in terms of energy production
Codigestion Toolkit – Design and Outputs

Allows comparison between bag style and Chinese Dome digesters – Outputs in terms of energy production
Codigestion Toolkit – Design and Outputs

Influent

- Total Discharge: 77.20 Kg/day
- Total Solid of fresh Discharge: 12.08 Kg/day
- Water Added: 73.81 L/day
- Total Influent: 151.01 Kg/day

Plan View

- Biogas Chamber Volume: 7.55 m³
- Biogas Chamber Diameter: 2.57 m
- Biogas Chamber Height: 1.86 m

Gas Output

- Volume of gas produced: 5.74 m³/day
- Biogas Digester Efficiency: 80%
- Methane Biogas Produced: 60%
- Maximum Stove Hours: 10.33 hrs/day
- Maximum Lightbulb (100W) Hours: 31.00 hrs/day

Toolkit provides sizing criteria and energy outputs
Codigestion Toolkit – Design and Outputs

**Dome Geometrical Dimensions**
- Upper Dome Volume: 1.40 m³
- Cross Sectional Volume: 5.31 m³
- Lower Dome Volume: 0.85 m³
- Upper Dome Height: 0.51 m
- Cross Sectional Height: 1.03 m
- Lower Dome Height: 0.32 m

**Biogas System Volumes**
- Biogas Chamber Volume: 7.55 m³
- Gas Collecting Chamber Volume: 0.38 m³
- Gas Storage Chamber Volume: 2.87 m³
- Fermentation Chamber Volume: 3.17 m³
- Sludge Layer Volume: 1.13 m³
- Hydraulic Chamber Volume: 6.03 m³

**Tank Volume:** 6.03 m³

Profile View

Toolkit provides sizing criteria for dome/bag & gas storage.
Dome Digester Sizing and Gas Math

Using Chinese Biogas Research Training Center manual*

* Chengdu Biogas Research Institute (BIOMA) BIOMA 2006

**Basic parameters**
- Sum of kg waste/d for substrates = TW
- Sum of kg waste/d * kg TS/kg waste for substrates = TotTS
- TotTS*100/8 (TS 8%) = total influent TI
- TI - TW = total water (L) needed = TotWat

**Sizing parameters**
- WV / 0.8 = real volume of unit, ‘V’.
- 1.3078*V^(1/3) = Diameter ‘D’
- 0.4*D = Height of main chamber ‘H’

**Gas production sum**
- kg TS/kg wet waste * kg VS/kg TS
- m^3 CH4/kg VS

**Example**: rice straw
- 0.914*0.815*0.236 = 0.176 m^3 CH4/kg for rice straw
Commercialization

• Better, more easily scalable digesters for quick installation and longer life;

• Added equipment for shredding and mixing;

Smartphone apps for toolkit to empower service providers

Safer gas storage and delivery systems for increased gas production

Image courtesy University of Maryland
Commercialization

Next Steps:
- Develop prototype
- Test in controlled settings
- Test in operational settings
- Launch at scale

Technology Readiness Level

Where we are now after Phase 1
Conclusions

Chau Thi Ret: “I love my biogas stove. I no longer have to spend my time gathering wood, and it is a lot cleaner too!”

Biogas Cook Stove with Flex Hose

Clean Cook Stoves  ➔  Reduced indoor air pollution  ➔  improved health
Lessons Learned

• People wont invest in waste management unless they have a good reason to do so;
• Biogas represents a powerful incentive for better waste management; and
• Continued production of biogas is an incentive for proper O&M.
• Codigestion in its simplest form (VACVINA, VACB) can increase methane production for small scale users,
• Carbon realities of implementation at scale can’t be ignored: 589,125 tons CO2eq in 2012 in Vietnam.

IMAGE BY: J. MARTIN GVOKUSAI – HTTP://BETWEENdraFTS.COM
Lessons Learned

• Toolkit must be customizable to account for local variability;
• COD of combined waste might be better indicator of gas production than VS;
• Adding crop wastes requires shredding, mixing and increased O&M;
• But the additional gas outputs may make this worth the effort;
• RTI’s Codigester Creator toolkit – medium or large family farms or small commercial enterprises.
Thank You!

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RTI’s Codigester Creator Toolkit is in the Beta Testing Stage. You may download the toolkit at www.watsanexp.ning.com