turning knowledge into practice

Codigestion for Backyard and Small Commercial Agriculture Operations

Lessons Learned from the Mekong Delta

RTI INTERNATIONAL

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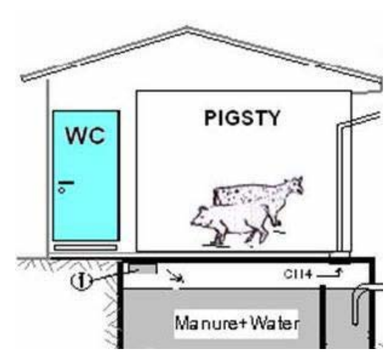
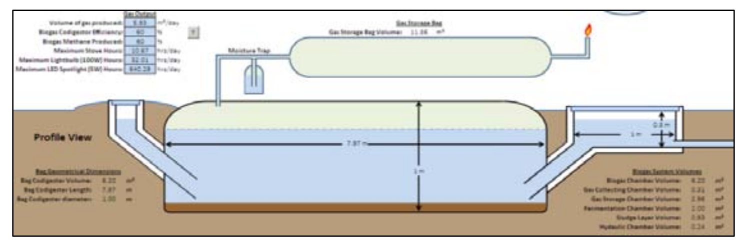
Presentation Outline

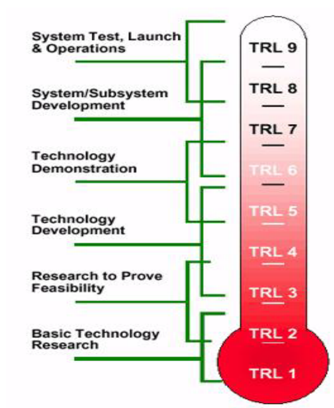
Introduction to Codigestion



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

Photo credit: http://www.unep.org/dewa/vitalwater/jpg/0283-mekong-EN.jpg

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/)

The VACVINA

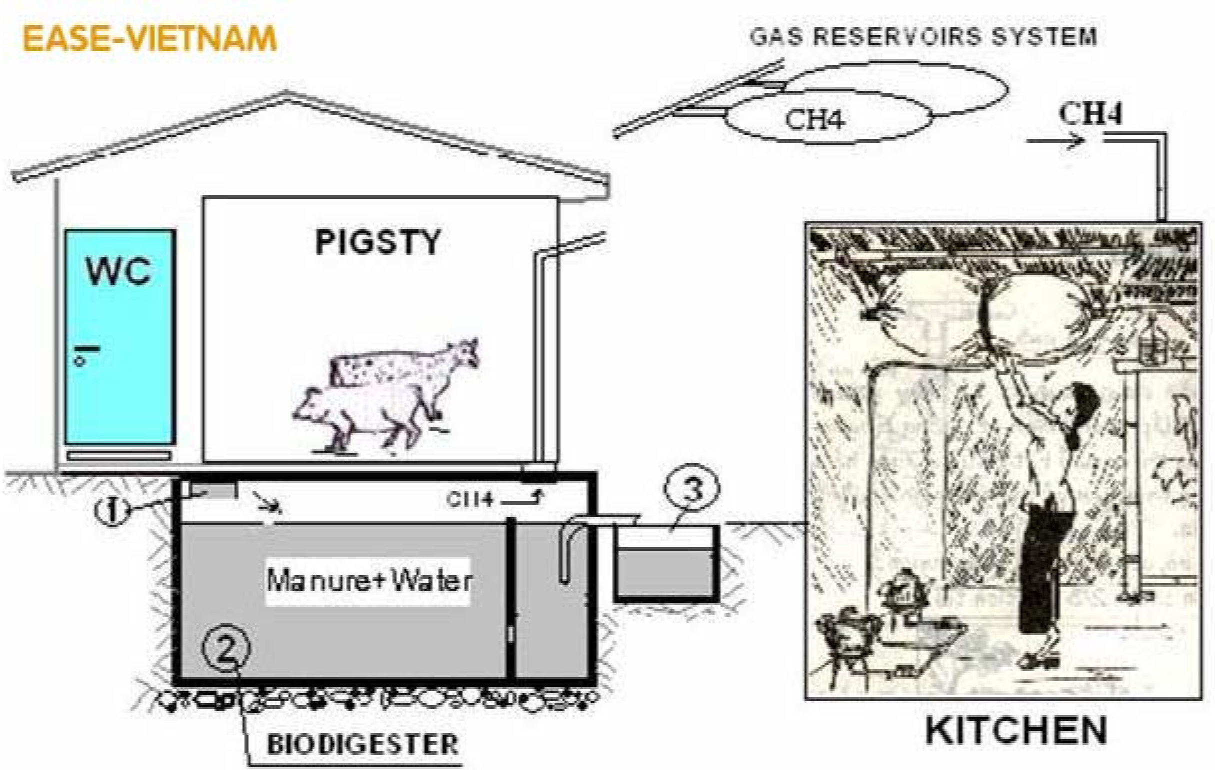
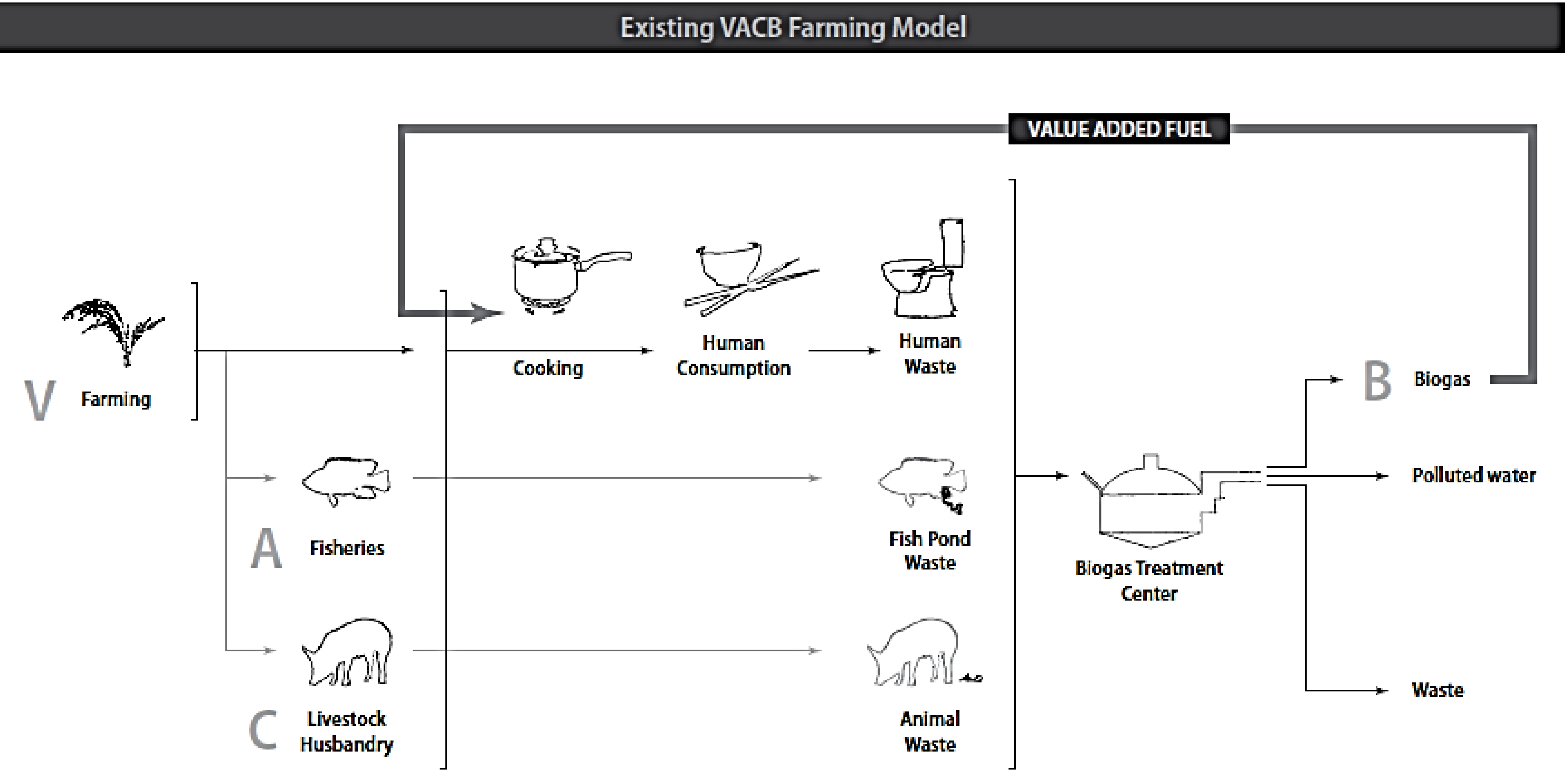


Image courtesy of: **Research Center for Energy & Environment (RCEE)** Address: No. 33, Trung Yen 9 Road, Yen Hoa ward, Cau Giay district, Hanoi, Vietnam Tel: (+84-4) 6291 2407, Fax: (+84-04) 3786 8593, email: rcee.ease@gmail.com

VACVINA (1986) – first attempt at codigestion in Vietnam

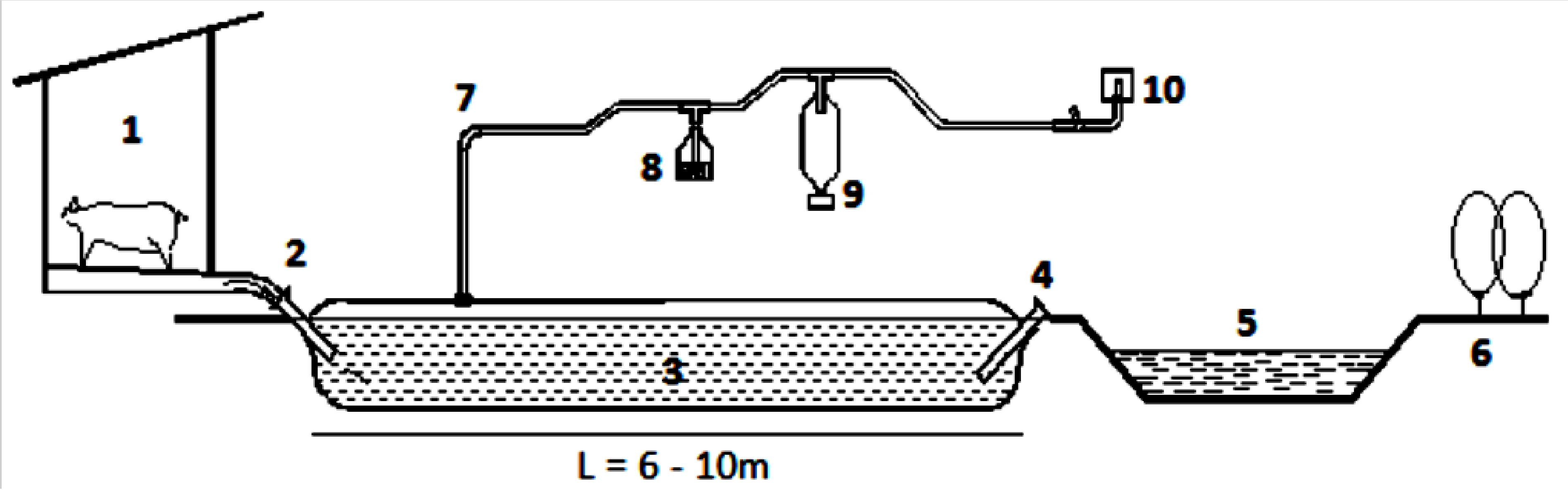
VAC ("Vuon"-Garden, "Ao"-Pond, "Chuong"-Stable) – Nat. policy promoted by National Association of Vietnamese Gardeners

VACB system —farming (V), fisheries (A), livestock (C), and biogas (B)



Integrated system for animal and human waste management - maximizes biogas output, and recycles nutrients and treated effluent to enhance agriculture.

The Polyethylene Digester:



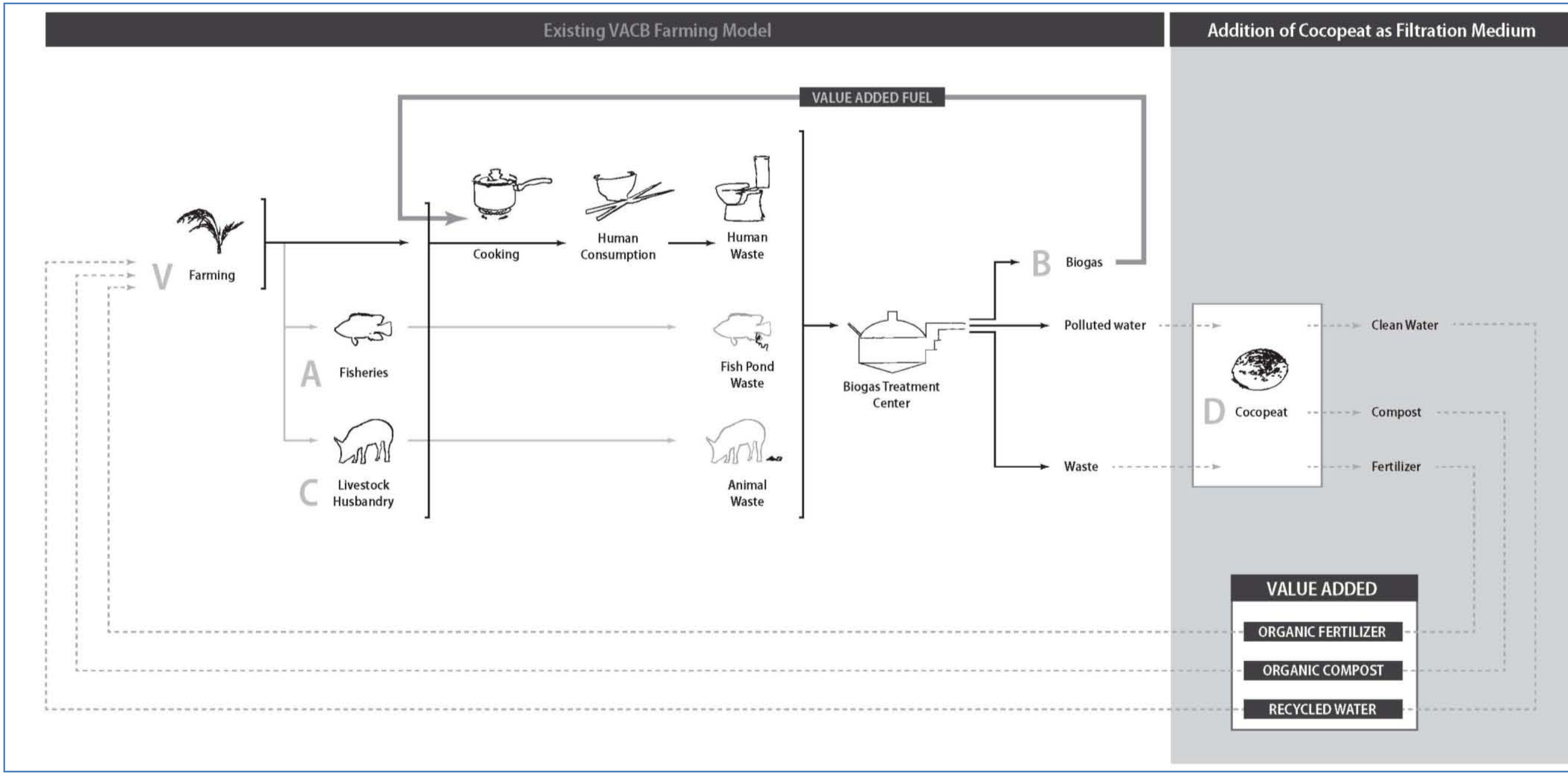
1. pig-pen
2. inlet pipe
3. digester
4. outlet pipe
5. discharge pond
6. garden
7. gas vent
8. security valve
9. polyethylene gas holder
10. stove

Images of VACB near Can Tho City

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

Enhanced treatment with ornamental plants

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.

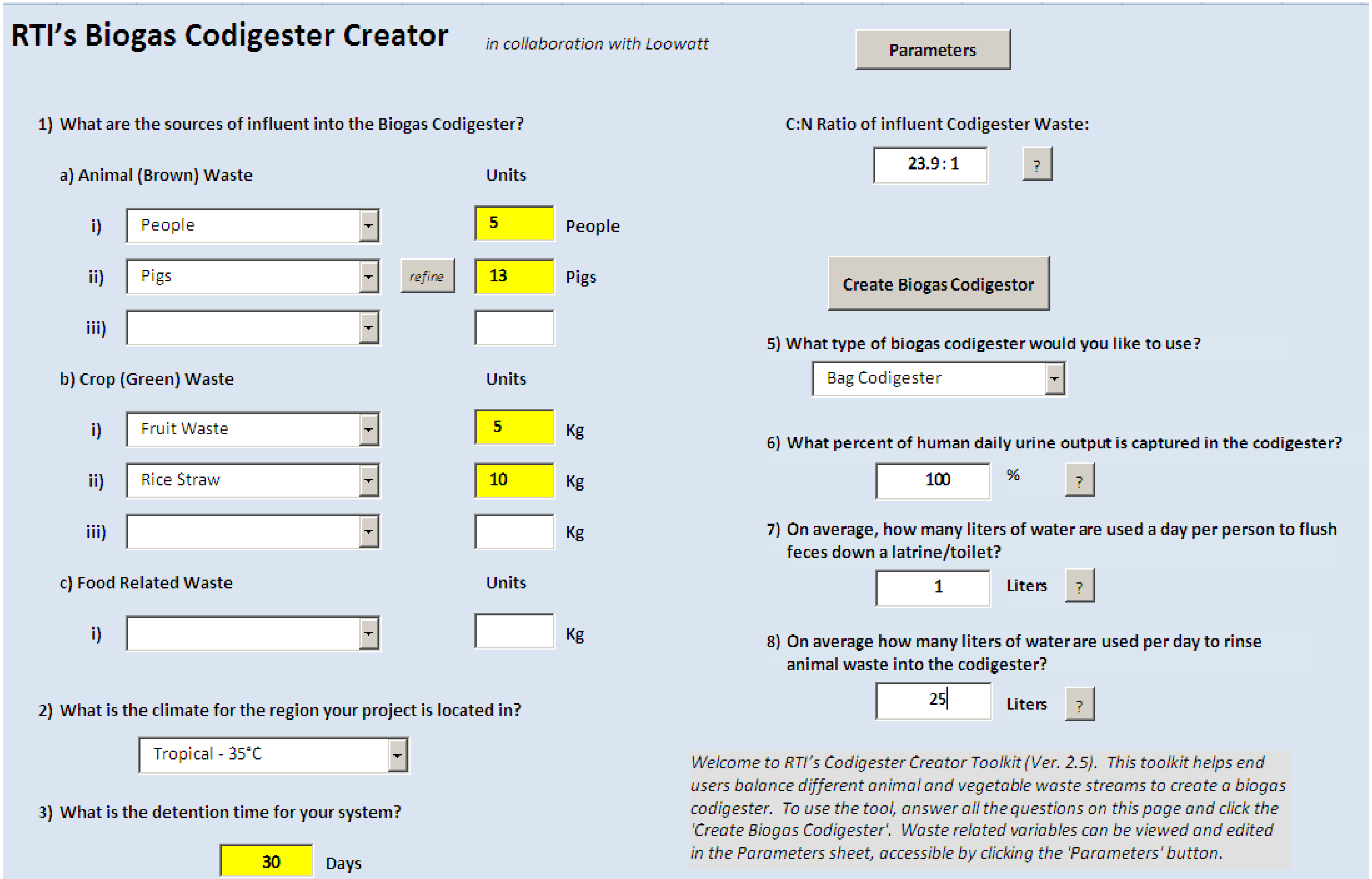
Carbon to Nitrogen Ratio

Brown waste feedstock	C:N	Green waste feedstock	C:N
Cattle	25:1	Corn straw	65:1
Pig	13:1	Fruit waste	40:1
Chicken	5:1 to 10:1	Rice straw	79:1
People	3:1	Wheat straw	127:1

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



Helps balance C:N ratio for multiple feedstocks

1) What are the sources of influent into the Biogas Codigester?

a) Animal (Brown) Waste — **Units**

		Units	
i)	Cows	2	Cows
ii)	Chickens	20	Chickens
iii)	People	5	People
iv)	Pigs (refine)	15	Pigs
v)			

b) Crop (Green) Waste — **Units**

		Units	
i)	Corn Straw	5	Kg
ii)	Fruit Waste		Kg
iii)	Rice Straw	15	Kg
iv)	Water Hyacinth		Kg
v)			Kg

c) Food Related Waste — **Units**

		Units	
i)	Fats, Oil and Grease		Kg
ii)	Food Waste		Kg

2) What is the climate for the region your project is located in?

Tropical - 35°C
Subtropical - 30°C
Temperate - 25°C

3) What is ... **ystem?**

40 **Days**

C:N Ratio of influent Codigester Waste:

25.4 : 1 ?

Create Biogas Codigestor

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?

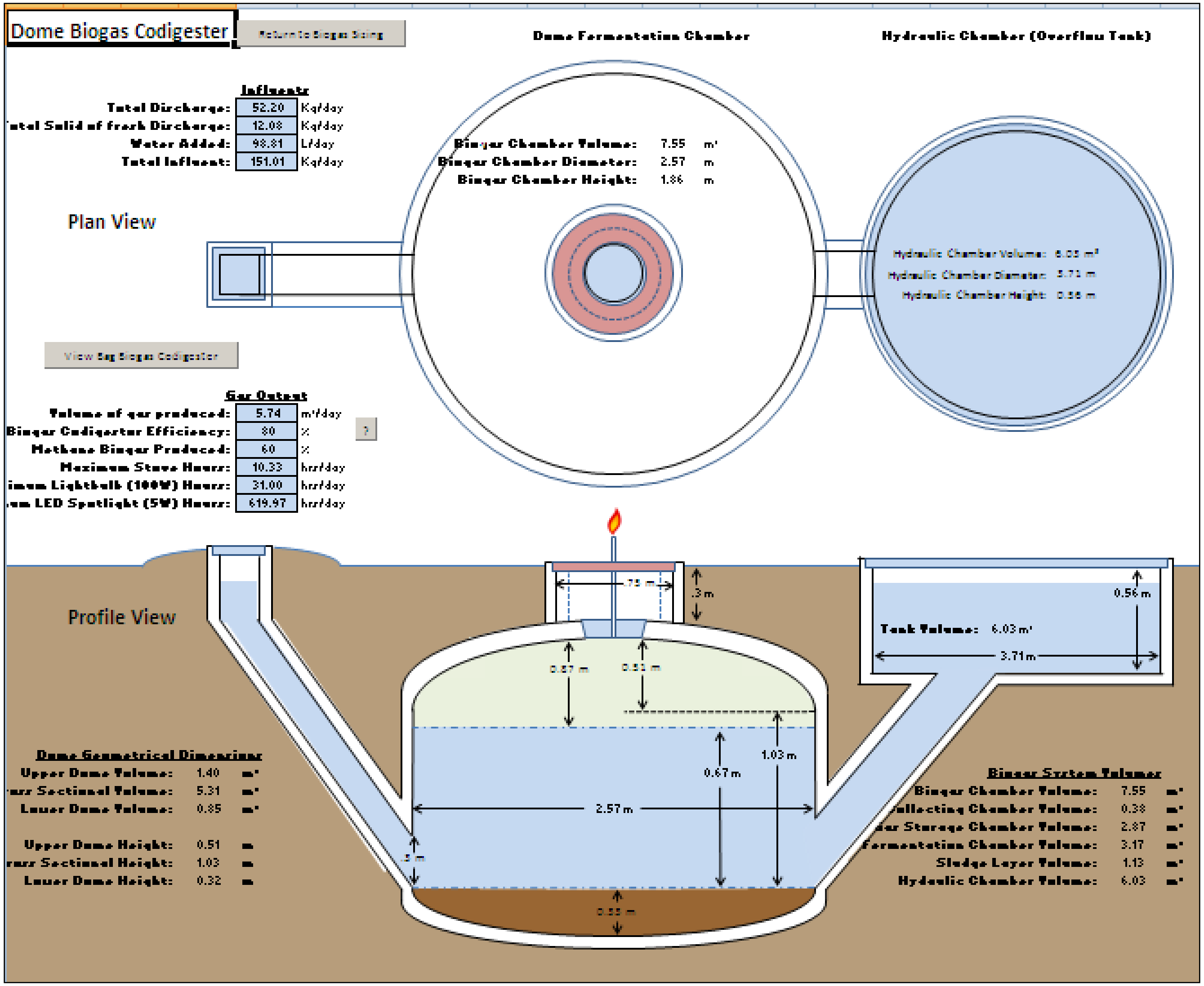
1 Liters ?

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

50 Liters ?

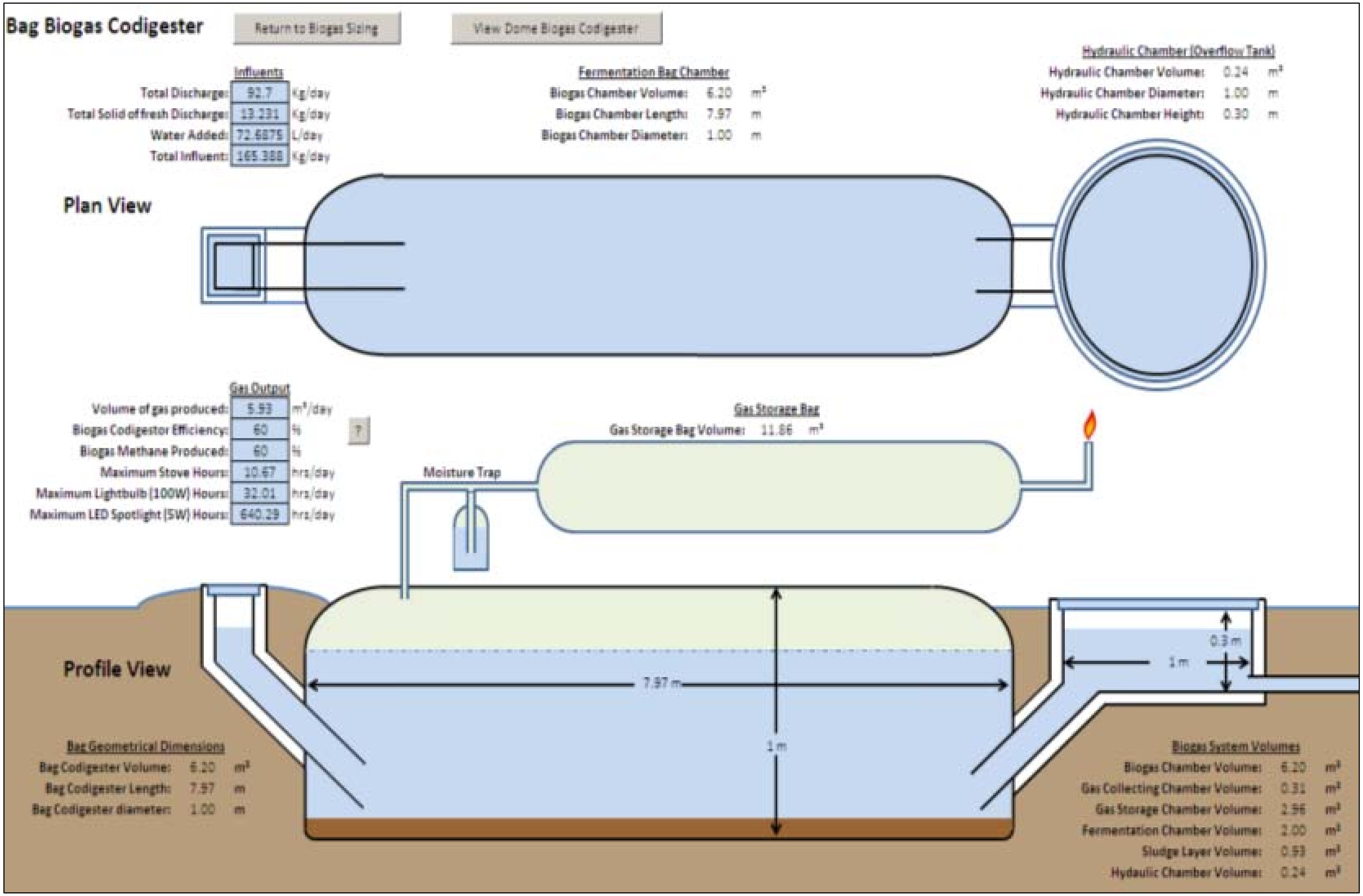
Welcome to RTI's Codigester Creator Toolkit (Ver. 2.5). This toolkit helps end users balance different animal and vegetable waste streams to create a biogas codigester. To use the tool, answer all the questions on this page and click the 'Create Biogas Codigester'. Waste related variables can be viewed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

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

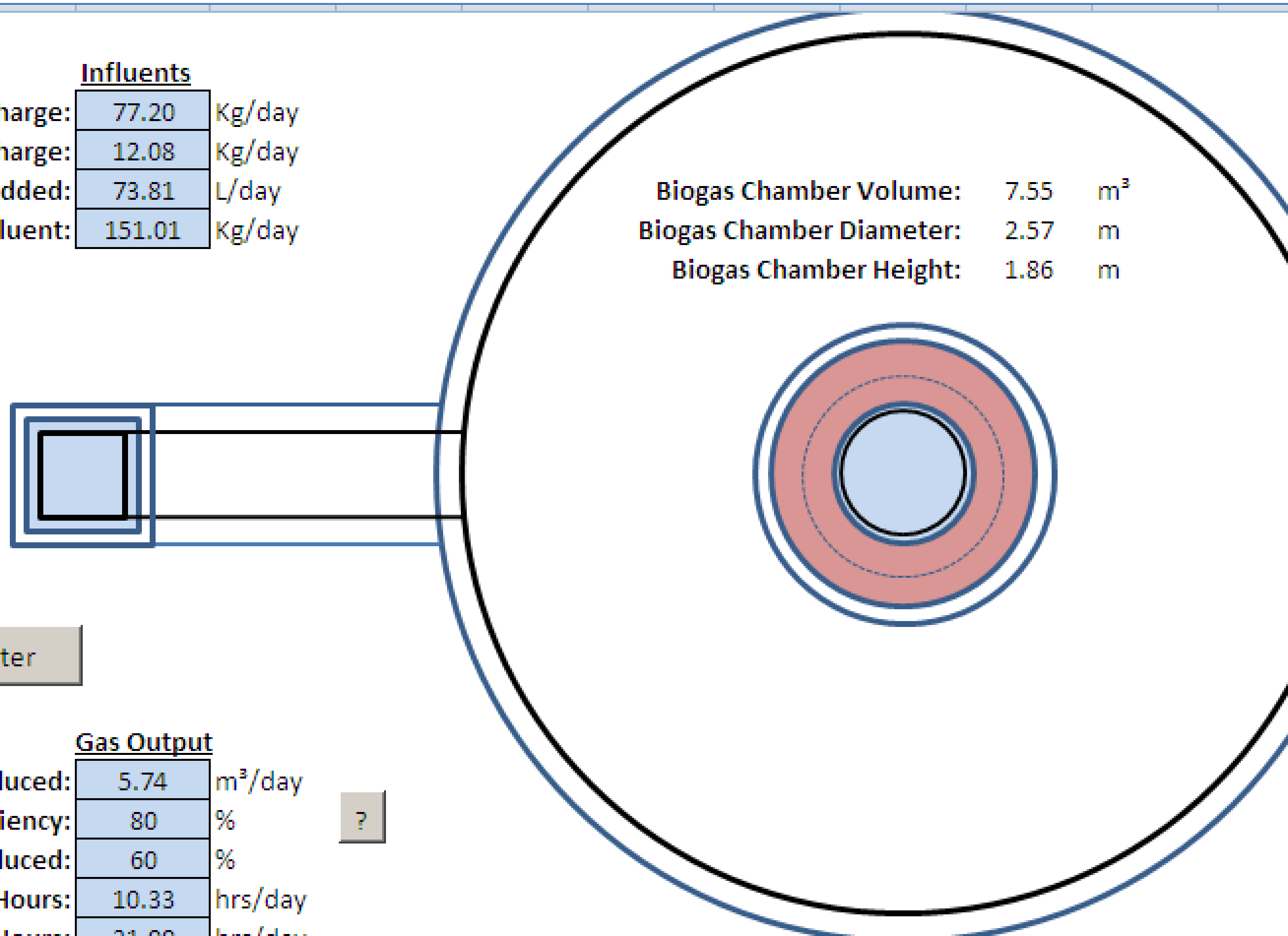
Codigestion Toolkit – Design and Outputs

Influents

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

Biogas Chamber Volume:	7.55	m^3
Biogas Chamber Diameter:	2.57	m
Biogas Chamber Height:	1.86	m

Plan View



View Bag Biogas Codigester

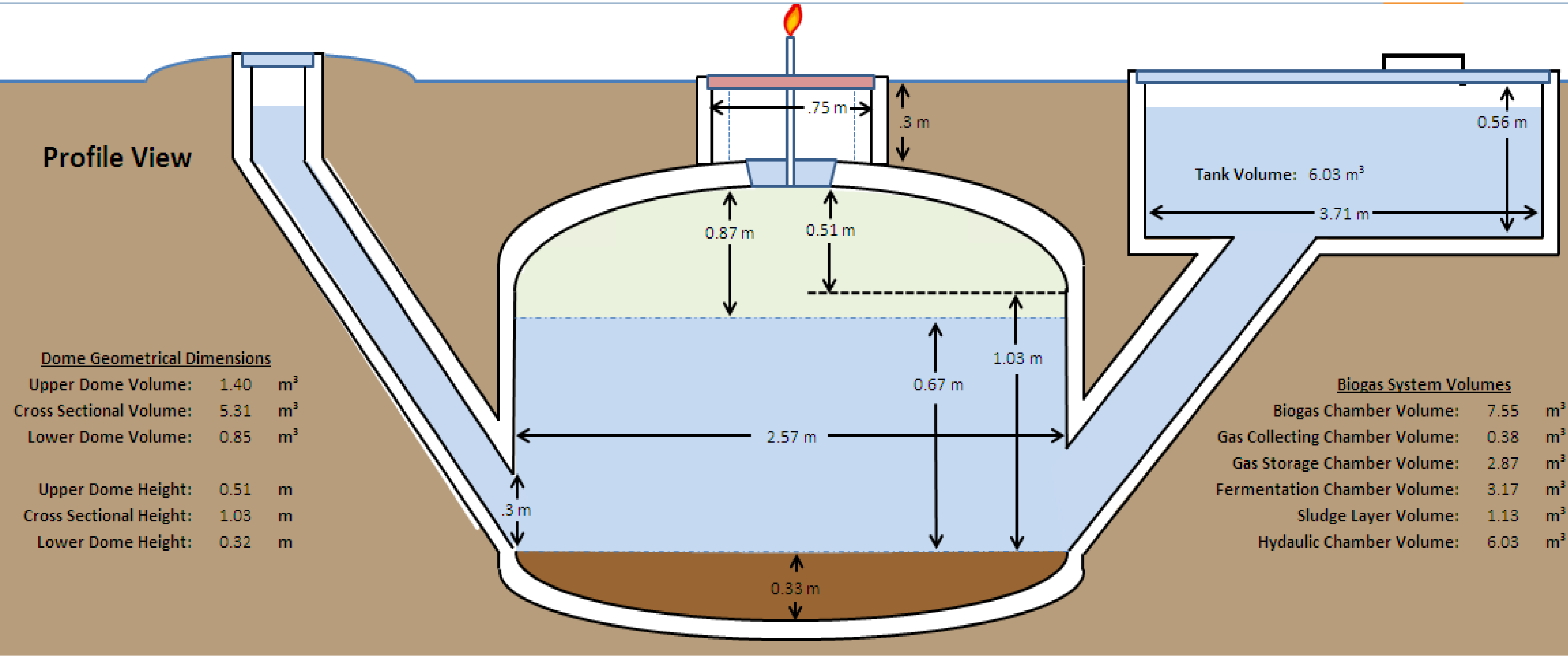
Gas Output

Volume of gas produced:	5.74	m^3/day
Biogas Codigestor 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

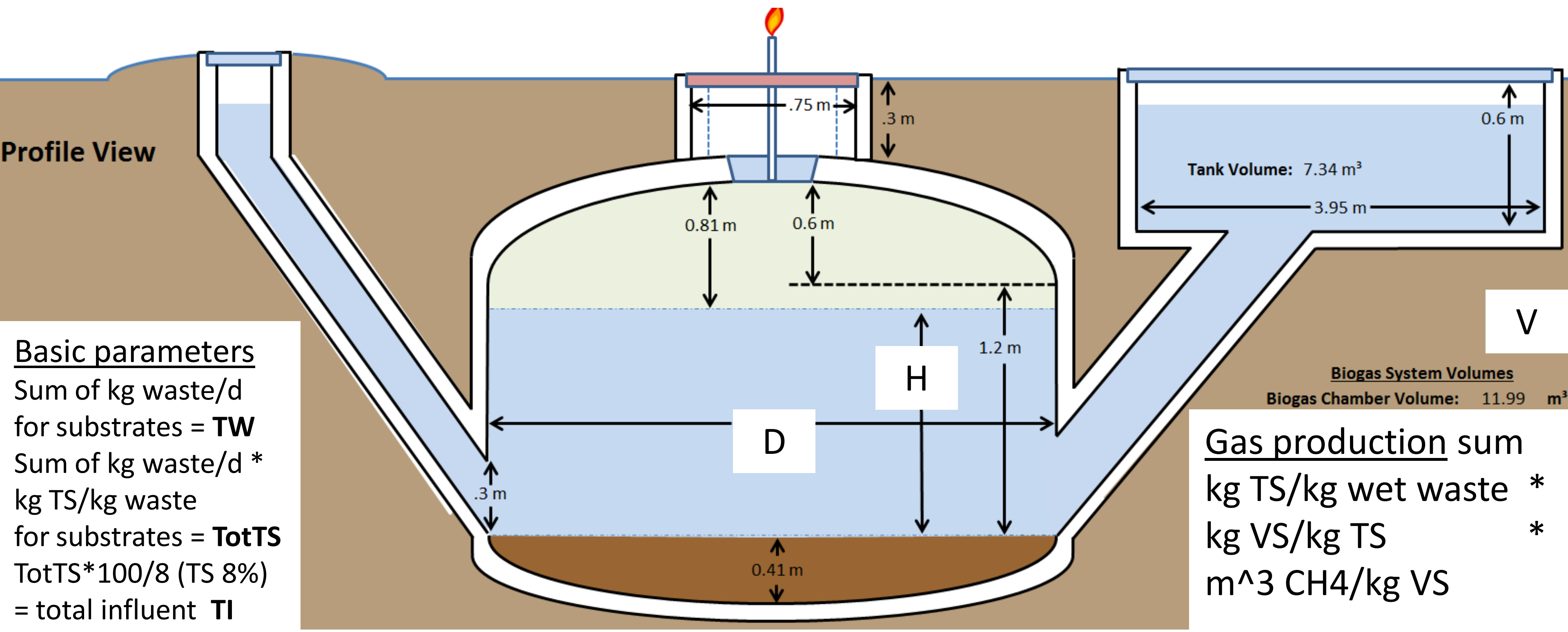


Toolkit provides sizing criteria for dome/bag & gas storage

Dome Digester Sizing and Gas Math

Using Chinese Biogas Research Training Center manual*

** Chengdu Biogas Research Institute (BIOMA) BIOMA 2006*



<u>Basic parameters</u>

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**

TI*det time/1000 = working volume **WV**

<u>Sizing parameters</u>

WV / 0.8 = real volume of unit, ‘V’.

1.3078*V^(1/3) = Diameter ‘D’

0.4*D= Height of main chamber ‘H’

<u>Gas production</u> sum

kg TS/kg wet waste *

kg VS/kg TS *

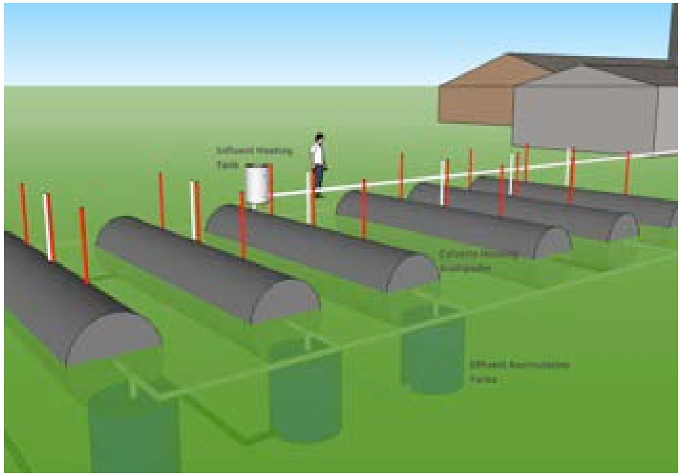
m^3 CH4/kg VS

<u>Example</u>: rice straw

0.914*0.815*0.236= 0.176m^3 CH4/kg for rice straw

Commercialization

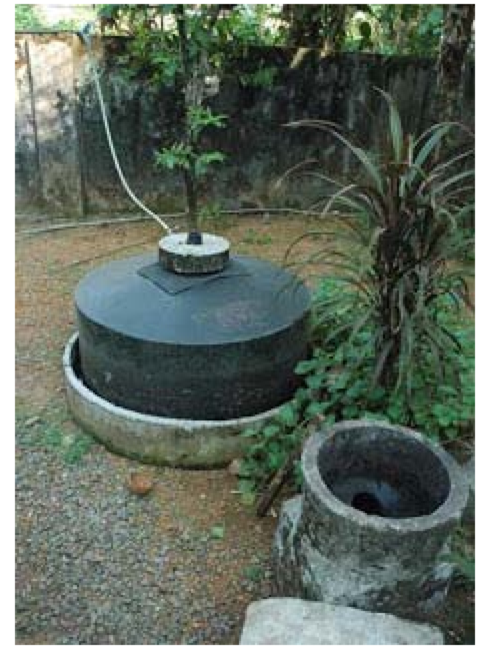
Image courtesy University of Maryland



- Better, more easily <u>scalable</u> digesters for quick installation and longer life;

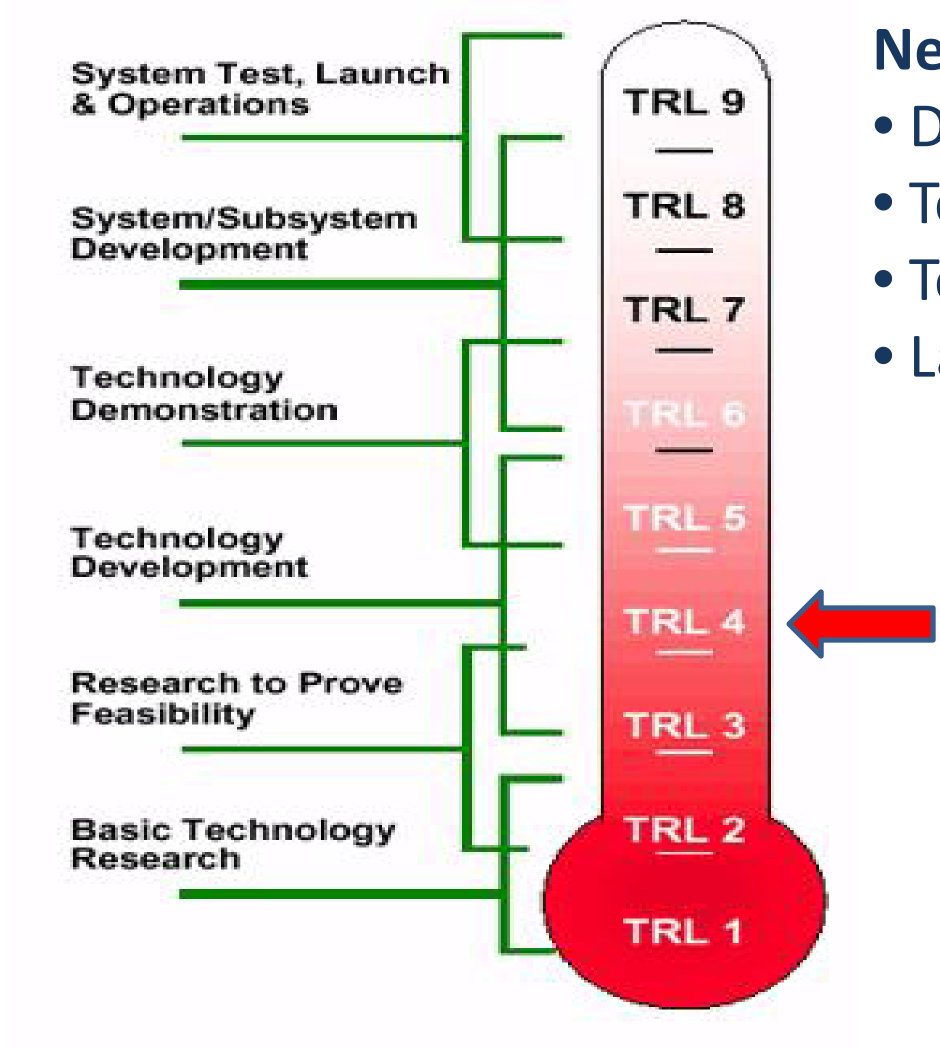
- Added equipment for shredding and mixing;

Smartphone apps for toolkit to empower service providers



Safer gas storage and delivery systems for increased gas production

Commercialization



Next Steps:

- Develop prototype
- Test in controlled settings
- Test in operational settings
- Launch at scale

Where we are now after Phase 1

Technology Readiness Level

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!

Dave Robbins

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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

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