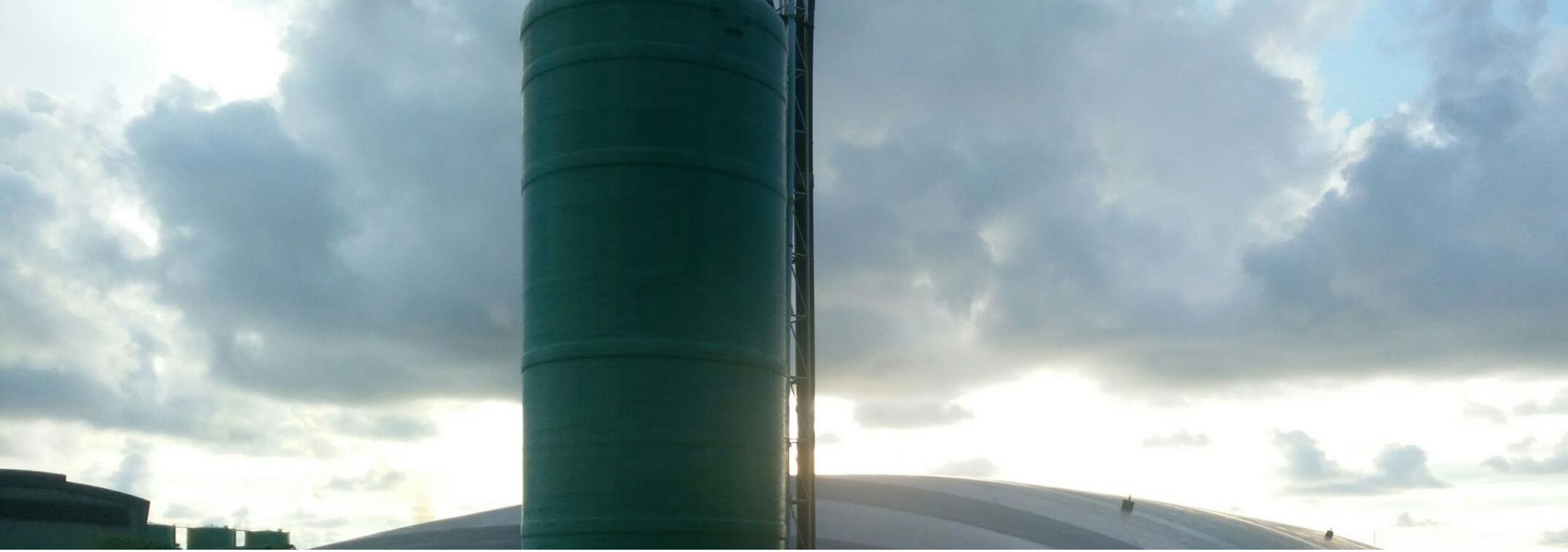

Biogas the Sustainable Choice for ASEAN

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Excellence in Biogas

Presentation to Asia Clean Energy Forum

5 June 2018

Overview

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- What is Biogas?
- How is Biogas Produced
  - Process
  - Example Substrates
- How biogas contributes to our sustainable future

Asia Biogas Projects in Numbers

10 Operating Projects

- Projects in Thailand, Laos and Indonesia
- Multiple winner of Thai and ASEAN Energy Awards

Revenue of US$7m

- Excluding TBEC 59% CAGR to June 2017
- Following TBEC acquisition revenue will grow from US$3m per annum to over US$7m

165 Staff

- Over 95% of staff are local
- Over 90% work in rural communities at project sites

24,196,000 Nm3 CH_4 in 2017

- 6% of gas is flared
- 127,000 kWh per day of electricity and
- 287,000 kWh per day of heat
- Enough gas to supply the household energy needs of 90,000 people*

15MWe Installed Capacity

- 75% revenue from electricity sales
- 25% from biogas sales for process heat

14,292,000 litres wastewater treated per day

- Enough to fill over 5 Olympic size swimming pools
- Approx. 102,200,000 kg of COD destroyed in 2016

350,000 tonnes of CO_2 Reductions per year

- >70% from registered Clean Development Mechanism projects
- Responsible for 24% of all CERs issued in Thailand or Laos
- Sold 68,200 CERs to Swedish Energy Agency in 2017 at USD7.5 per CER

90 Reference Plants

- Projects in Thailand, Philippines, Vietnam, Laos, Indonesia and Sweden

* Based upon 2013 Household Energy Survey – Thailand NSO
Figures based upon 2017, includes data for Asia Biogas Group, TBEC and affiliates

What is Biogas?

Cassava Waste to Energy Project
Active Lagoons Before Biogas Project

What is Biogas?

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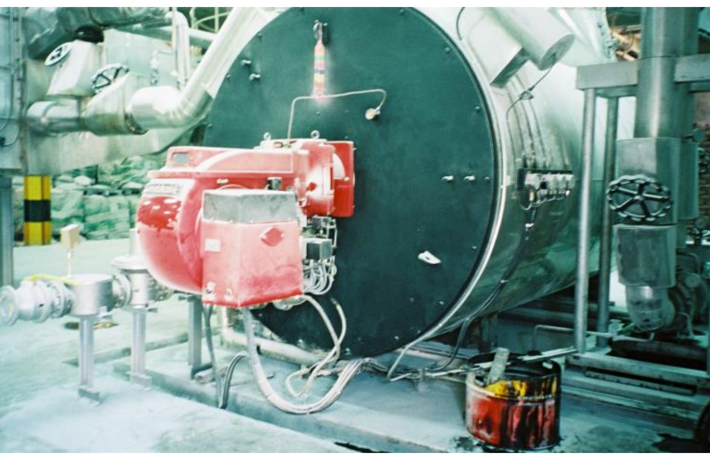
- Biogas is a **Renewable Fuel** produced through the microbial degradation of **organic solids (substrate)** under **anaerobic** conditions

- Typically in Southeast Asia the substrate used is agro industrial wastes such as:
  - Animal manure
  - Cassava starch processing wastes
  - Palm oil mill wastes
- Other sources:
  - Food waste / organic fraction MSW
  - Energy crops

- The process to create biogas is called **anaerobic digestion** and the residue left over after the process is **digestate**

Biogas Uses

- As a fuel biogas can be used in multiple applications:
  - **Dispatchable power production through engine generator set or microturbine**
  - **Heat production through combustion**
  - **Transport fuel**
  - **Cooking fuel**



Biogas Challenges

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- As a gaseous fuel biogas has some challenges:
  - Storage is expensive
  - Transportation is expensive
  - Safety is critical

- Storage and transportation can be improved by:
  - Compression – requires high pressure vessels
  - Liquifaction – expensive
- Both of these require Upgrading first

Biogas Composition

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BIOGAS

• Methane (CH_4)	50 – 80 %
• Carbon dioxide (CO_2)	20 – 50 %
• Hydrogen Sulfide (H_2S)	x00 – x000 ppm
• Water (H_2O)	Saturated

- Siloxanes, Ammonia (NH_3), Nitrogen (N_2)

- *CH4 is the component of biogas that delivers calorific value – energy*
- *CH4 concentration is a function of (i) the substrate and (ii) the design of the anaerobic digestion process*
- *A higher concentration of CH4 can mean less CH4!*

Biogas Composition

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UPGRADED BIOGAS (Biomethane / RNG)

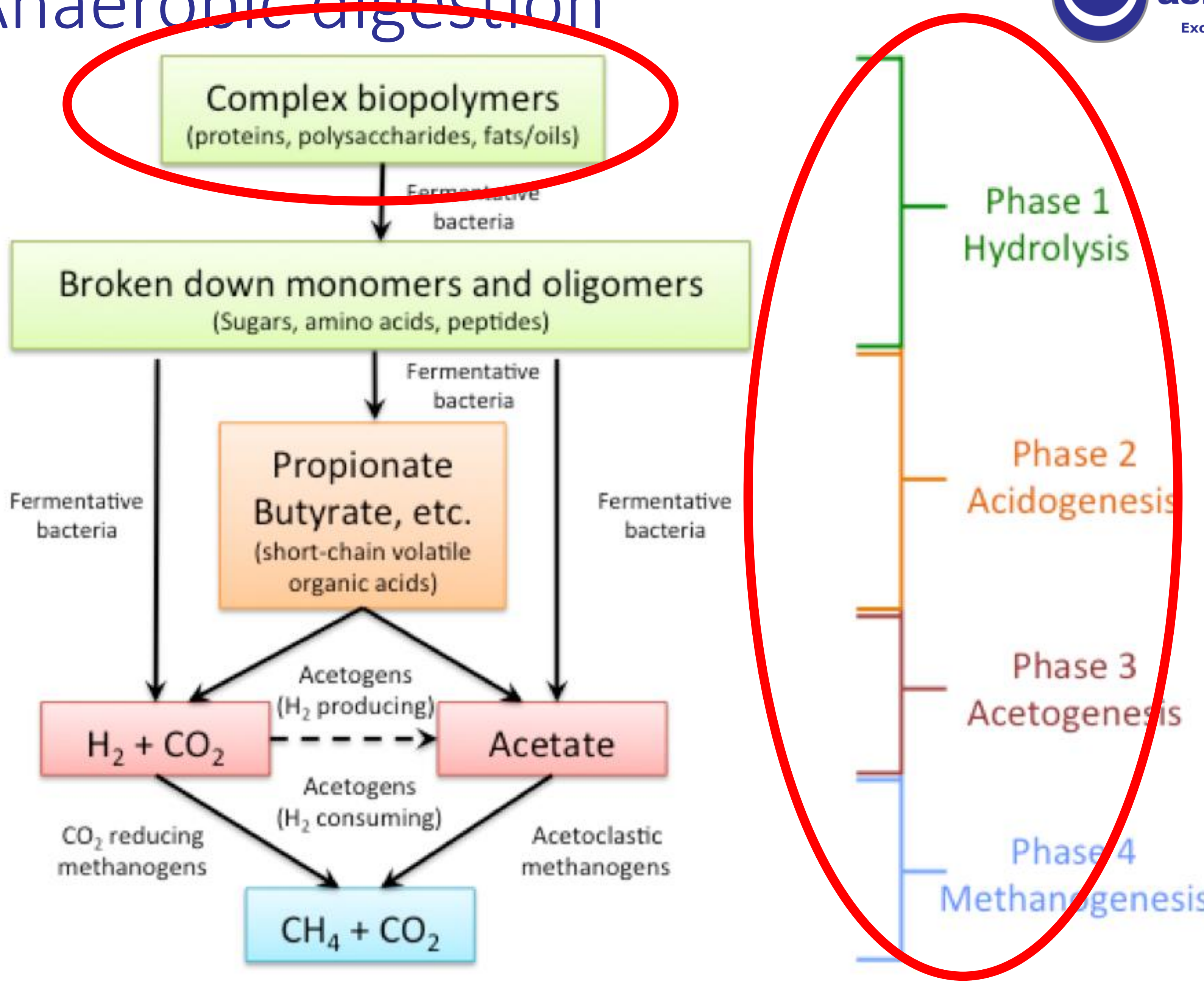
• Methane (CH_4)	80 – 99 %
• ~~Carbon dioxide (CO_2)~~	20 – 1 %
• ~~Hydrogen Sulfide (H_2S)~~	<10 ppm
• ~~Water (H_2O)~~	Dry
• ~~Siloxanes, Ammonia (NH~~$_3$), Nitrogen (N_2)	

- *CO2 is stripped from gas to increase CH4 concentration to match Natural Gas*
- *Impurities and water are removed*
- *Standards for Biomethane are being developed in Malaysia and Thailand, generally following European standard for impurities, but big difference in Wobbe Index / CH4 concentration to reflect local Natural Gas compositions*

Anaerobic Digestion

Tha Chang Biogas Projects 1 an

Anaerobic digestion



Complex process with multiple organisms involved – requiring different environments – from low pH to neutral pH etc.

Digester design needs to balance this complexity with simplicity

Digester Types - Upflow

Both systems rely upon the upward flow of wastewater to separate SRT and HRT

System in top photo is very robust due to huge volume of reactor – upflow prevents settling of solids

System in the bottom works well on high strength WW with low suspended solids

Digester Types - Plugflow

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Plugflow designs are often used for "dry" digestion, like in top photo (MSW digester).

But can also be used in wastewater systems, such as bottom photo.

Important that there is some way to recirculate / remove sludge that accumulates in the bottom of the reactor.

Digester Types - CSTR

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Typical reactor in Europe for digestion of solid substrates such as OFMSW or energy crops.

Can be inground, but impeller mixing to be optimal should be in circular tank with straight sides.

Flexible design, but moving parts inside reactor can be improved upon by using gas mixing

Anaerobic Digestion

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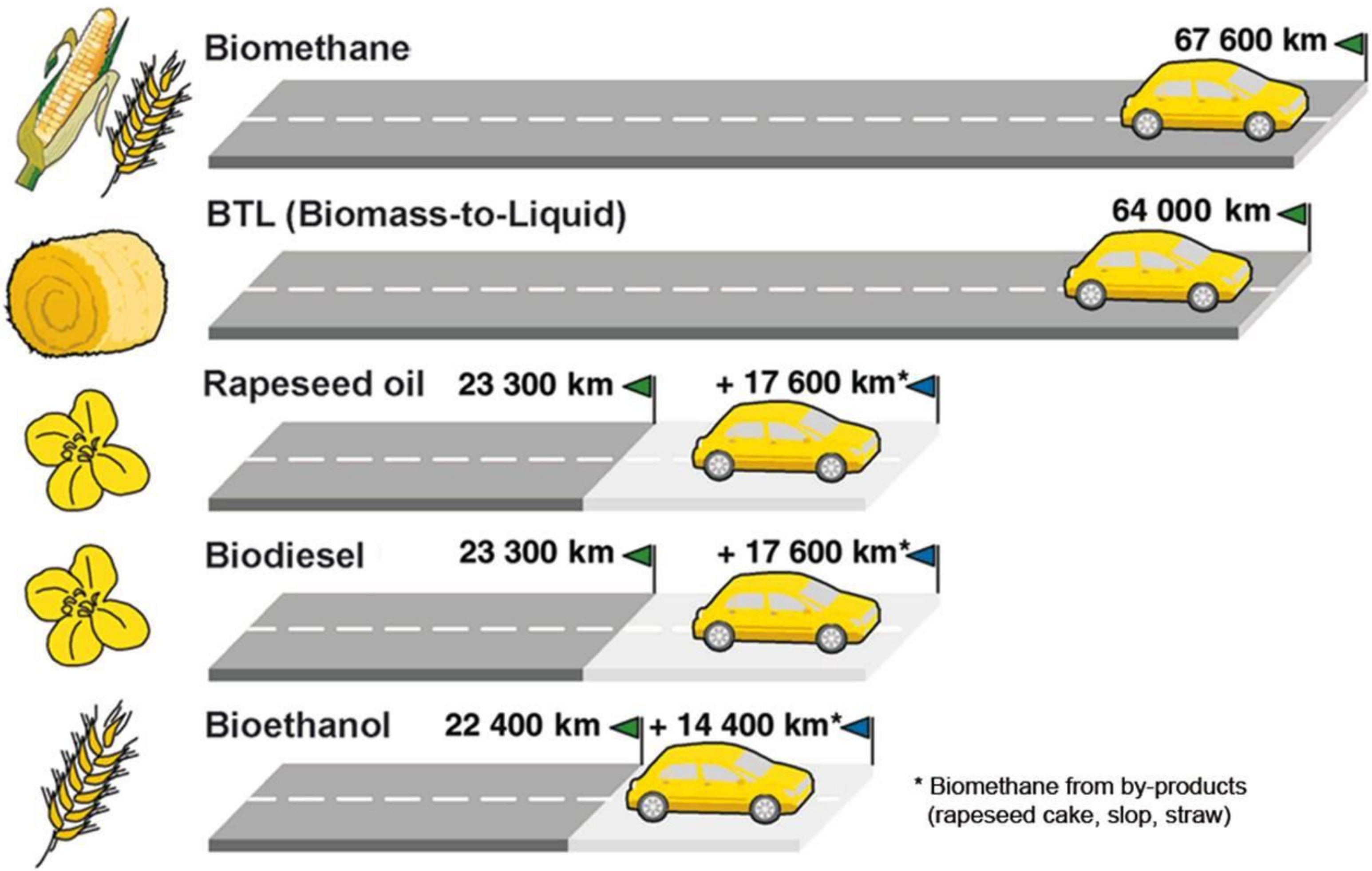
- Highly flexible process:
  - Most organic wastes can be digested
  - Moisture content not an issue – no need for drying
  - Digesters run typically as
    - wastewater digesters (low solids – easier to separate HRT and SRT)
    - Wet digesters (<c.15% solids – substrate still pumpable)
    - Dry digester >15% solids

- Digester Design needs to:
  - Ensure sufficient contact between the substrate and the microorganisms in the reactor
  - Ensure environment within reactor has correct temperature and pH
  - Safe – CH4 is explosive – H2S / CO2 are toxic
  - Appropriate to local situation
  - **Economically viable**

Anaerobic Digestion

Biogas is actually one of the most efficient ways we can produce fuels from energy crops

More so when using agricultural wastes



Source: Fachagentur Nachwachsende Rohstoffe e. V. (FNR)

Cassava Starch and Biogas

Cassava Starch and Biogas

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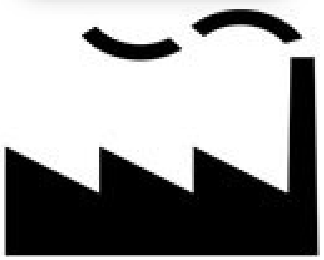
- Cassava starch sector in Thailand is a world leader in biogas production and use
- All large factories and most medium scale mills (>100 tpd starch production) have biogas plants
- Factories without biogas cannot compete
- Biogas is used for:
    - Drying – process heat
    - Power – electricity generation
- Excess biogas can be produced with co-digestion of pulp - export power to grid or upgrading

200 TPD Starch Factory

Starch
200 TPD



WASTEWATER
3,820 m³/day
COD: 15,000 mg/L

Methane
13,110 m³/day
Power
2.2 MWe

PULP
280 ton/day
20 % TS
95 % VS of TS

Methane
15,960 m³/day
Power
2.7 MWe

TOTAL COMBINED:

Methane
29,070 m³/day
Power
4.9 MWe

Palm Oil and Biogas

Tha Chang Biogas Projects 1 an

45 TPH POM Waste

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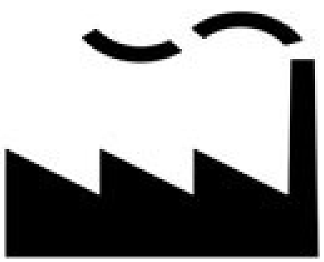
FFB
45 TPH

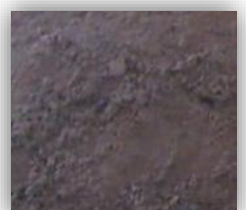


POME
27 m3/h
COD: 65,000 mg/L

Methane
438 m3/h
Power
1.8 MWe

EFB
10 ton/h
35 % TS
90 % VS of TS

Methane
787 m3/h
Power
3.2 MWe



Decanter cake
1.6 ton/h
20 % TS
85 % VS of TS

Methane
67 m3/h
Power
0.3 MWe

Wastes from Palm Oil Plantations

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- Biogas production from plantation wastes
  - Oil Palm Trunks and Fronds

- Example case oil palm tree replanting to biogas
  - **1,500 ha/year** removed trunks
  - 210,000 trunks/year
  - Shredding and pressing of the trunk (350 L/trunk)
  - Trunk press liquid → biogas plant
  - 1,885,000 m3 CH_4/year
  - **973 kW-e** (330 days/year; 24 hours/day)

- Can be applied to other palm based agriculture such as coconut

Sap photo credit: JIRCAS

Energy production from EFB

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- Biogas offers the only truly sustainable solution for Empty Fruit Bunches

	Energy	Nutrients	Structure material to soil
Return to plantation	No	Yes	Yes
Composting	No	Yes	Yes
Incineration	Yes	No?	No
Pellet production	Yes, indirect	No	No
Biogas	Yes	Yes	Yes

Biogas to Natural Gas

Biogas Train Sweden

Biogas Upgrading

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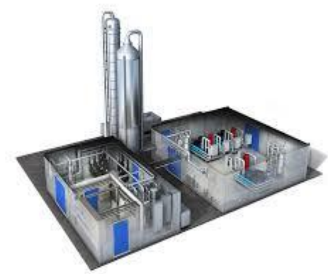
RAW BIOGAS

Biogas Production 2,000 m3 per hour

(equivalent to 1,100 m3 methane)

BIOGAS UPGRADING



Upgrading to set CH4 concentration as per appropriate standard

COMPRESSION
1,130 m3/h
to 200 - 250 bar

OR

LIQUEFACTION
1,100 m3/h
Chilled to less than – 155° C

bioCNG
940 kg/h
@90% CH4 conc

bioLNG
37 mmBTU/h
1,865 Litres/h
@99.5% CH4

bioCO2
1,780 kg / h
> 99.5% CO2

Biogas / Biogas Upgrading to bioCNG/CBG

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Technology	Ad/absorption media	Regeneration method	Potential CH4 Conc	Working pressure (bar)	
Pressure Swing Adsorption (PSA)	Dry medium, e.g. Activated Carbon	Depressurisation	>97%	4 – 7	Pretreatment, high power, no chemicals, high slip
Water Scrubber	Water	Depressurisation + air stripping, or None	>98%	5 – 10	High power, cooling in tropical conditions, high slip, no pretreatment needed
Amine Scrubber	Amine solvent, e.g. Mono Ethanol Amine (MEA)	Heat	>99.9%	Ambient	Highest performance, heat required, minimal slip, chemical needed
Membrane	Pressure gradient for gas separation across membrane	None	>96%	10 - 40	High power, pretreatment essential, concerns over life of membranes persist

CBG production from EFB

Upgrading Unit

@2,000 Nm^3 Biogas/Hr

Amount of Biogas

45,000 Nm^3 Biogas/day

CBG produced meet Thailand National Standard @85% CH_4 concentration

CBG Production

18,870 kg CBG/day

Amount of Vehicles can be fill up

Light Duty Vehicle – 1,250 Vehicles/day

or

Heavy Duty Vehicle - 75 Vehicles/day

Biogas leading on UN SDG

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SUSTAINABLE
DEVELOPMENT
GOALS

The Sustainable Development Goals

What: On September 25th 2015 the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, which sets out 17 Sustainable Development Goals (SDGs) and 169 targets as part of a global partnership to:

1. End poverty and hunger in all its forms
2. Mitigate the effects of climate change, and
3. Ensure prosperous, fulfilling, and peaceful lives for all

By whom: Endorsed by 192 Heads of State

When: 2016 to 2030

Resolution adopted by the General Assembly on 25 September 2015

[*without reference to a Main Committee (A/70/L.1)*]

70/1. Transforming our world: the 2030 Agenda for Sustainable Development

The General Assembly

Adopts the following outcome document of the United Nations summit for the adoption of the post-2015 development agenda:

Biogas and the UNSDGs

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Asia Biogas believes biogas can help solve the challenges related to **15 of 17** SDGs – can any other renewable energy come close?

2 ZERO HUNGER

Restores soils by recycling nutrients

3 GOOD HEALTH AND WELL-BEING

Manages waste responsibly cuts air pollution, odours & disease

4 QUALITY EDUCATION

School & university visits enable students to see science-in-action in their local community

5 GENDER EQUALITY

Provides quality jobs for women with technical & science degrees in rural areas

6 CLEAN WATER AND SANITATION

Treats bio solids & wastewater. Cuts COD in POME By >90%

7 AFFORDABLE AND CLEAN ENERGY

Biogas cuts fossil fuel use; it is easily upgraded to compressed biomethane (fuel) or a source of clean electricity. It is reliable and can be stored

Biogas and the UNSDGs

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8 DECENT WORK AND ECONOMIC GROWTH

12-15 jobs per plant in rural areas. Plus local investment. Decouples growth from environmental degradation

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Industry produces energy from its own waste and collaborates with farmers in circular economy

10 REDUCED INEQUALITIES

Rural areas where we work are much poorer and less developed than big cities

11 SUSTAINABLE CITIES AND COMMUNITIES

Improves sanitation and hygiene; cuts air pollution from coal, diesel and biomass

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Manage waste responsibly. Sustainable and efficient use of natural resources

13 CLIMATE ACTION

Cuts CO_2 and methane (25x global warming potential) emissions; generates local energy for local use

Biogas and the UNSDGs

Reduces pollution of surface water bodies, especially from land-based nutrient runoff.

Promotes sustainable use of terrestrial and inland freshwater resources. Recycles nutrients in digestate fertilizer and irrigation water

Biogas in Asia took off thanks to Kyoto Protocol CDM – a highly successful global partnership. US$724 million investment in biogas in S.E.A. in 2006-12

Support available?

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- Previously carbon credit support
- Now only FiT (limited) for power
- What future support will there be?
    - Needs to recognise co-beneits of biogas
    - Needs to be long term and escalating to cover opex
    - Needs to be simple

Conclusion

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Anaerobic digestion (AD) is a natural process in which microbes digest organic material in sealed lagoons or tanks and produce biogas which can be used for cooking, heating and electricity production or upgraded for use as vehicle fuel or gas-grid injection

In our tropical Southeast Asian climate, biogas plants cut waste, reduce water pollution and odours from agricultural processing, dramatically reduce greenhouse gas emissions, produce reliable clean energy locally and can produce bio-fertiliser from biogas reactor digestate

The biogas industry is uniquely positioned to help achieve the Sustainable Development Goals. Asia Biogas believes its biogas plants can help solve the challenges related to 15 of 17 SDGs. *No other renewable energy comes close*

SUSTAINABLE DEVELOPMENT GOALS

Biogas delivers the greatest environmental, social and economic benefits of any renewable energy in Asia.

Now where is the support?