Capturing Greenhouse Gases in China’s Countryside

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- Global warming potential
- $\text{CO}_2$ – 1
- Methane – 30
- Nitrous Oxide – 280
- CFCs – in the 1000s

https://www.epa.gov/ghgemissions/overview-greenhouse-gases
Methane

- 30 times the global warming potential of carbon dioxide
Methane 101
Methane is natural gas

• 2-step process
Methane

- No oxygen

Organic Matter + Acid forming bacteria → Organic acids
Methane

- No oxygen

\[ \text{Organic Matter} + \text{Acid forming bacteria} \rightarrow \text{Organic acids} \]

Smell Bad !!!
Methane

- No oxygen

Organic Matter

Organic acids

+ Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane

Natural Gas
Methane

- No oxygen

Organic Matter + Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane
Methane

- No oxygen

Organic Matter

Organic acids + Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane
Methane

• No oxygen

Organic Matter

+ Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane
Methane

- No oxygen

Organic Matter + Acid forming bacteria $\rightarrow$ Organic acids

Organic acids + Methane forming bacteria $\rightarrow$ Methane
Methane formers

• Sensitive
  • Warm
  • Near neutral pH
  • Low salt
Methane formers

• Too Cold

ZZZZZ
441 million livestock units
Other treatment option

Aerobic – with oxygen
Treatment

• With oxygen

[Diagram: Organic Matter + Heterotrophic bacteria → Carbon Dioxide]
Treatment

- With oxygen

[Diagram: Organic Matter + Heterotrophic bacteria → Carbon Dioxide]
Aerobic Digestion

- High electrical demand
- Infrastructure
Aerobic Digestion

- High electrical demand
- Infrastructure
Anaerobic Digestion

• No oxygen

Organic Matter + Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane
Natural Gas
Anaerobic Digestion
Methane capture policies

• Research
• Demonstration
• Training
• Subsidy
May 1979

National Archives
May 1979

National Archives

eia.gov/totalenergy/data/annual/archive/038406.pdf
Anaerobic Digestion Research - US

Published Agricultural AD Research

1986

eia.gov/totalenergy/data/annual/archive/038406.pdf
China?

https://advances.sciencemag.org/content/4/7/eaar8534
Replace wood and charcoal

- Biogas for cookstoves – 3 meals per day

aprovecho.org/cleaner-burning-technologies/aprovecho-newsletter-march-7th-2014/
HOUSEHOLD ENERGY SOURCES

- **Firewood**: 29%
- **Coal**: 35%
- **Straw**: 34%
- **Electricity**: 1%
- **Fuel oil**: 0%
- **Biogas**: 1%

**1982, Tongliang County, Sichuan Province**

University of Bristol - Historical Photographs of China reference number: Ru-s069
www.hpcbristol.net
China

• Biogas Institute Ministry of Agriculture
  • Opened 1979
  • Chengdu

• 7 million household digesters

http://biogas.caas.cn
China – 7 million digesters

Xia 2013 International Institute for Environment and Development
Digestor Failures – 1980s

**US**
- 85% shut down

**China**
- 30% underused or abandoned
Digestor Failures – 1980s

**US**
- 85% shut down

**China**
- 30% underused or abandoned
Digestor Failures – 1980s

**US**
- 85% shut down
- Low oil prices

**China**
- 30% underused or abandoned
Digestor Failures – 1980s

**US**
- 85% shut down

**China**
- 30% underused or abandoned
- Not enough biogas
- Not enough feedstock
China

• Renewable Energy Law 2006
  • Goal – 40 million digesters
  • by 2010

http://biogas.caas.cn
China – 40 million digesters
Biogas digesters

- 40 million household
- By 2012
  - 24,000 small
  - 3690 medium and large
AgSTAR - 2000

- USDA
  - 107 project grants
- US EPA
  - Promotes biogas systems
  - Reduce methane emissions
US - 254 digesters
125,000 hog & dairy farms
China Biogas Institute Training Program

• 1981
  • Asia-Pacific training center
• 2018
  • 55 countries
China Subsidy per Household (2011)

- 1300-3500 RMB
- About ½ cost

• West gets more

SAAS, 2010
China investment
One – plus – three renovation

• Biogas digester
• Livestock pen
• Toilet
• Kitchen

MoA (2008), Technology criterion on rural biogas digester and three renovations [农村沼气一池三改技术规范], Ministry of Agriculture, Beijing.
Indoor air quality
Waste Treatment
Waste Treatment

- Odor
- Pathogen
- Volume

- Retain fertilizer value
Cost / Benefit

• Biogas is not pure natural gas

Cost of Anaerobic $>$ Value of Gas Digestion
Cost / Benefit

Cost of Anaerobic Digestion <

GHG reduction
Waste treatment
Air quality
Forest preservation
Value of gas
Goal – gas for 3 meals per day

Yes - Sichuan

GHG mitigation per household
6.3 MT CO$_2$ eq/year
X
40 million

https://advances.sciencemag.org/content/4/7/eaar8534
Goal – gas for 3 meals per day

Yes - Sichuan

GHG mitigation per household
6.3 MT CO$_2$ eq/year
\( \times \)
40 million

= 

Burning
28.5 billion gallons of gasoline

https://advances.sciencemag.org/content/4/7/eaar8534
Goal – gas for 3 meals per day

Yes - Sichuan

No - Shandong

https://advances.sciencemag.org/content/4/7/eaar8534
Methane formers

• Sensitive - need
  • Warm temperatures
  • Near neutral pH
  • Low salt content
Methane

- No oxygen

Organic Matter

Organic acids

+ Acid forming bacteria → Organic acids

Organic acids

+ Methane forming bacteria → Methane
Methane – too cold

• No oxygen

Organic Matter + Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane Natural Gas

Smell Bad !!!
Cold weather research

- Shandong Academy of Agricultural Science, 2010
Cold weather research

• SAAS, 2010
Anaerobic digester research worldwide

Published Agricultural AD Research

- 0
- 50
- 100
- 150
- 200
Capturing methane in agriculture

- Sensitive process
- Temperature

- Fuel value
- Not enough

SAAS, 2010
Successful program

• Consistent
• Comprehensive
• Multiple benefits
Opportunities for technology transfer