Capturing Greenhouse Gases in China’s Countryside

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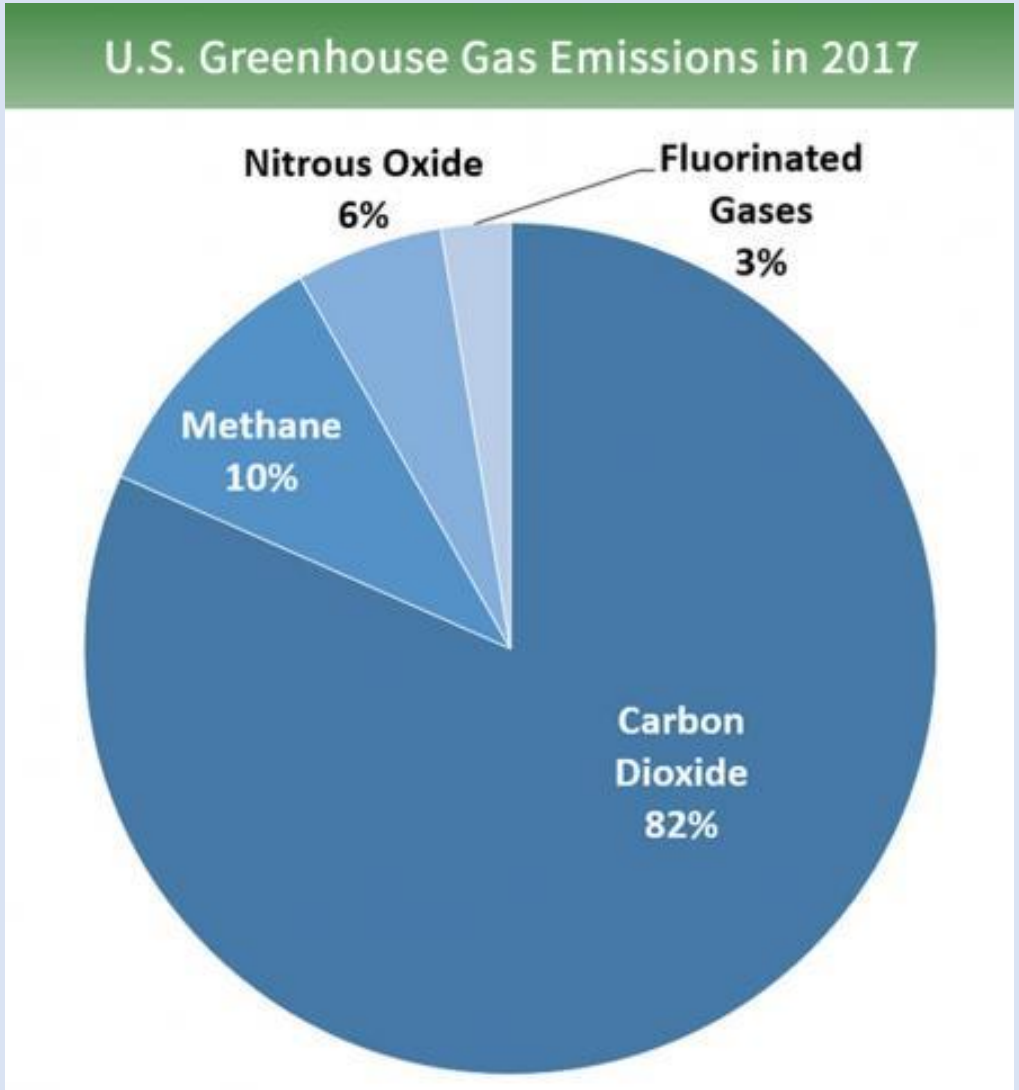
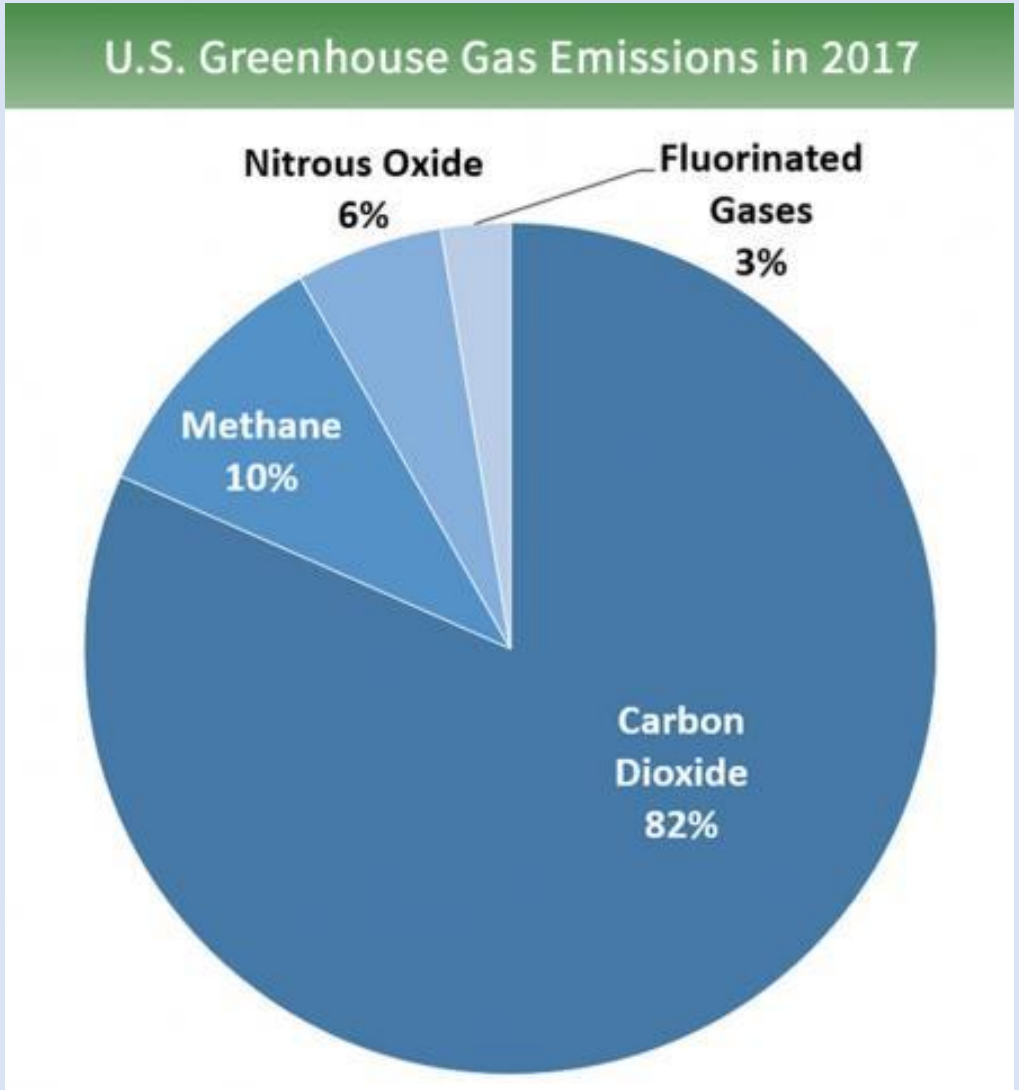


https://www.epa.gov/ghgemissions/overview-greenhouse-gases

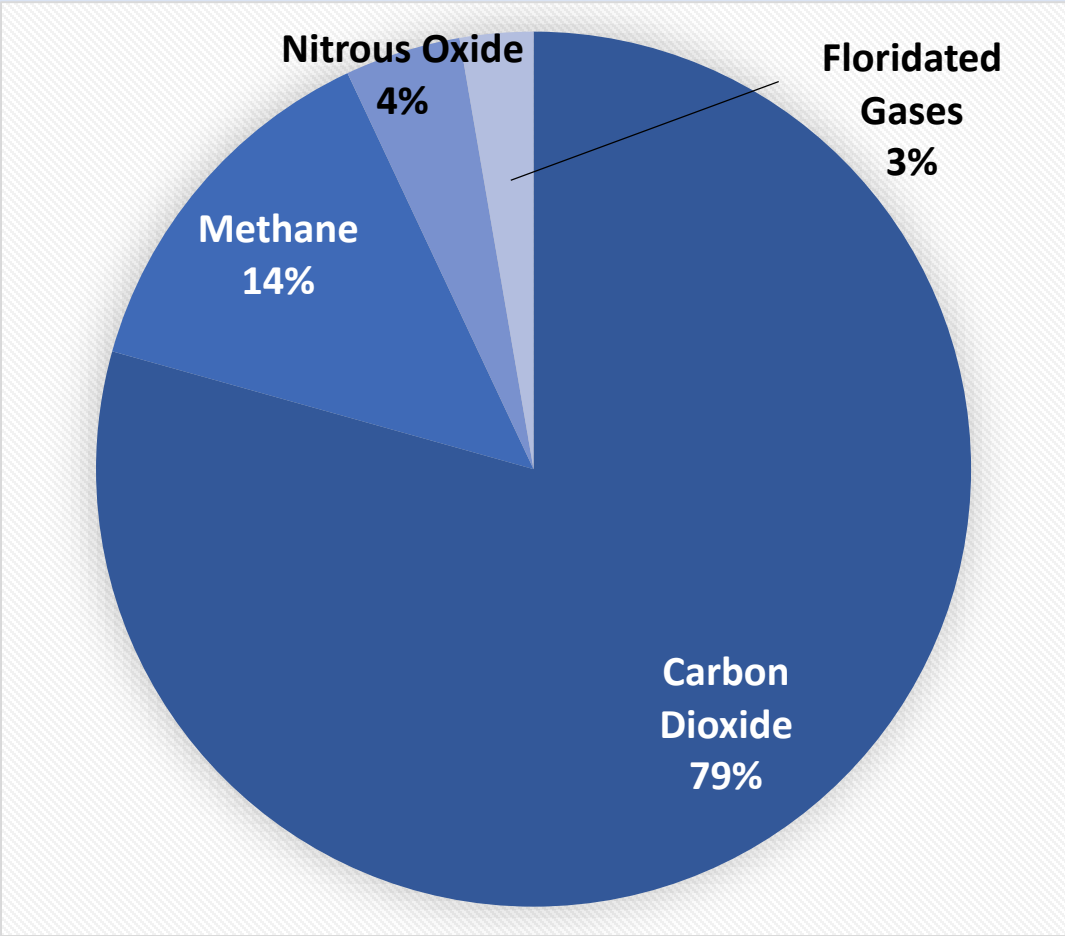
- Global warming potential

- CO_2 – 1
- Methane – 30
- Nitrous Oxide – 280
- CFCs – in the 1000s

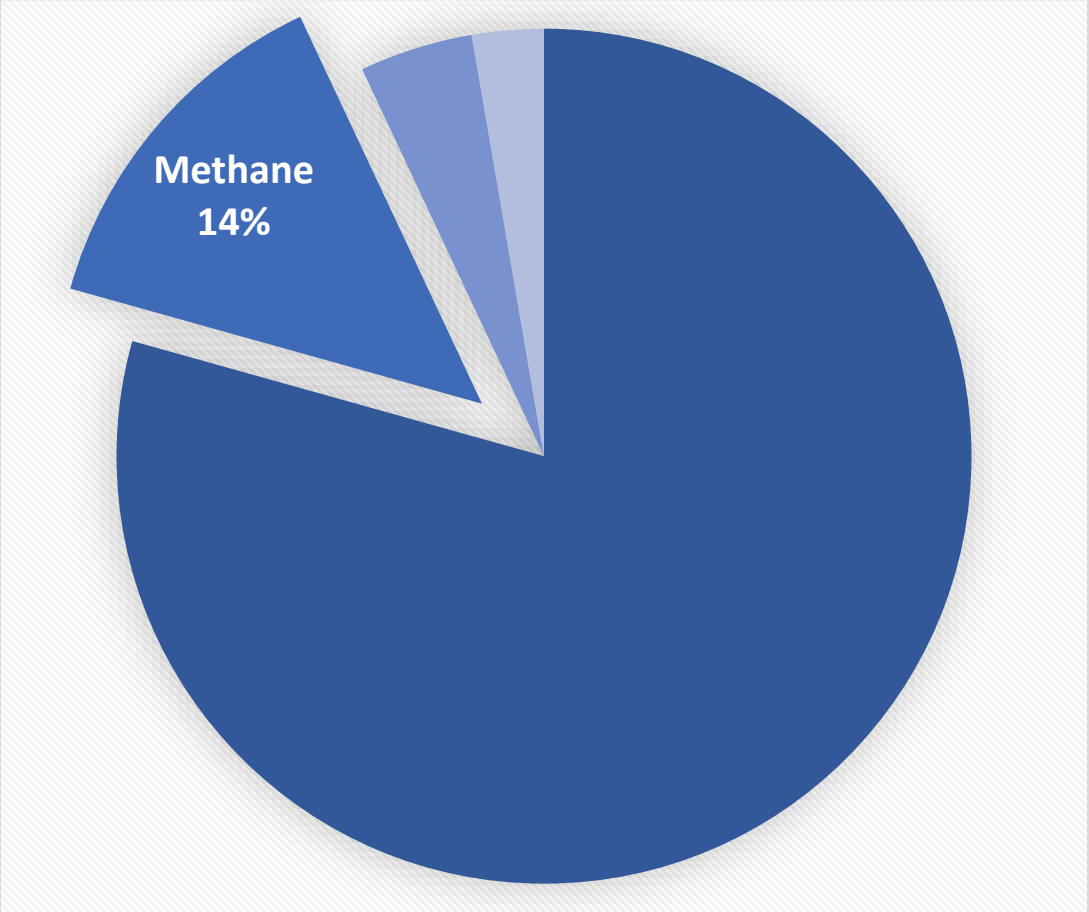


https://www.epa.gov/ghgemissions/overview-greenhouse-gases

China Emissions



Methane



- 30 times the global warming potential of carbon dioxide

Methane 101

Methane is natural gas

- 2 – step process

Methane

- No oxygen

+ Acid forming bacteria → Organic acids

Methane

- No oxygen

+ Acid forming bacteria → Organic acids

Smell Bad !!!

Methane

- No oxygen

+ Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → Methane

Natural Gas

Methane

- No oxygen

+ **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

+ 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 formers

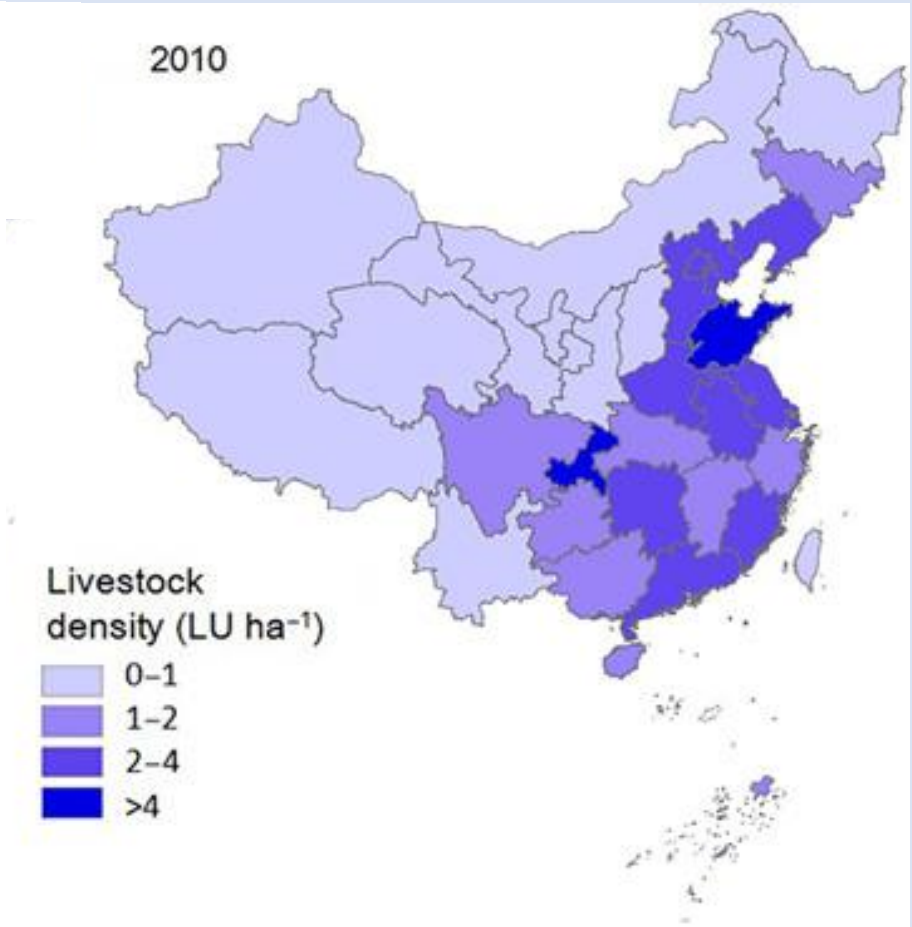
- Sensitive
  - Warm
  - Near neutral pH
  - Low salt

Methane formers

- Too Cold

ZZZZZ

441 million livestock units



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

Other treatment option

Aerobic – with oxygen

Treatment

- With oxygen

+ Heterotrophic bacteria → Carbon Dioxide

Treatment

- With oxygen

Organic Matter

+ Heterotrophic bacteria → Carbon Dioxide

Aerobic Digestion

- High electrical demand
- Infrastructure

Aerobic Digestion

- High electrical demand
- Infrastructure

Anaerobic Digestion

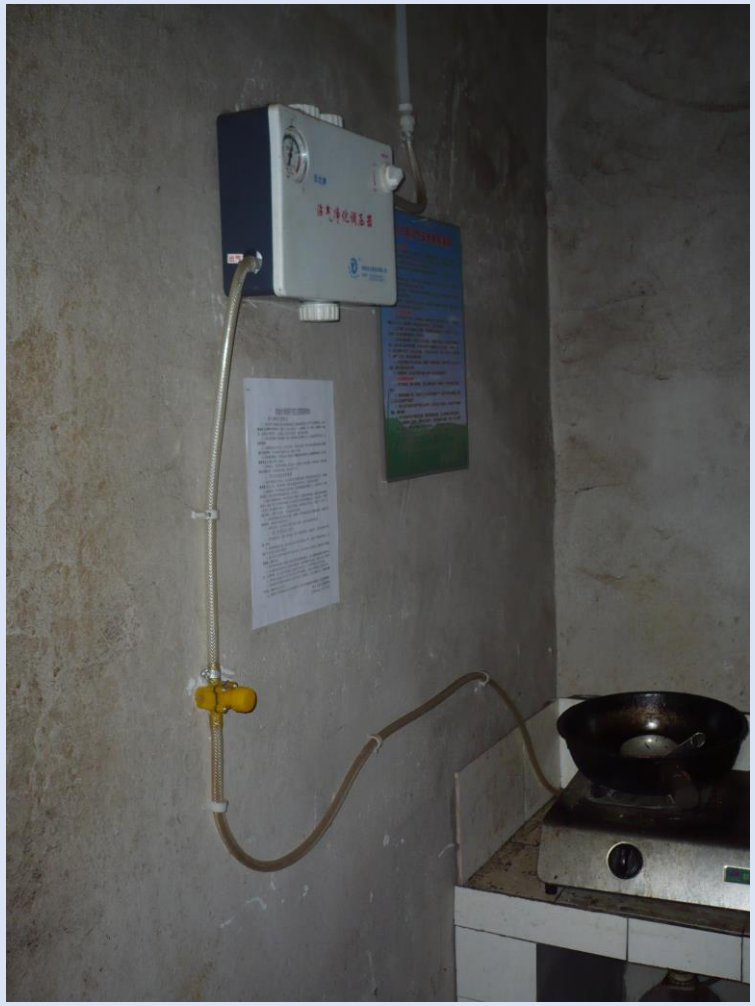
- No oxygen

+ Acid forming bacteria → Organic acids

Organic acids + Methane forming bacteria → **Methane**

Natural Gas

Anaerobic Digestion



Methane capture policies

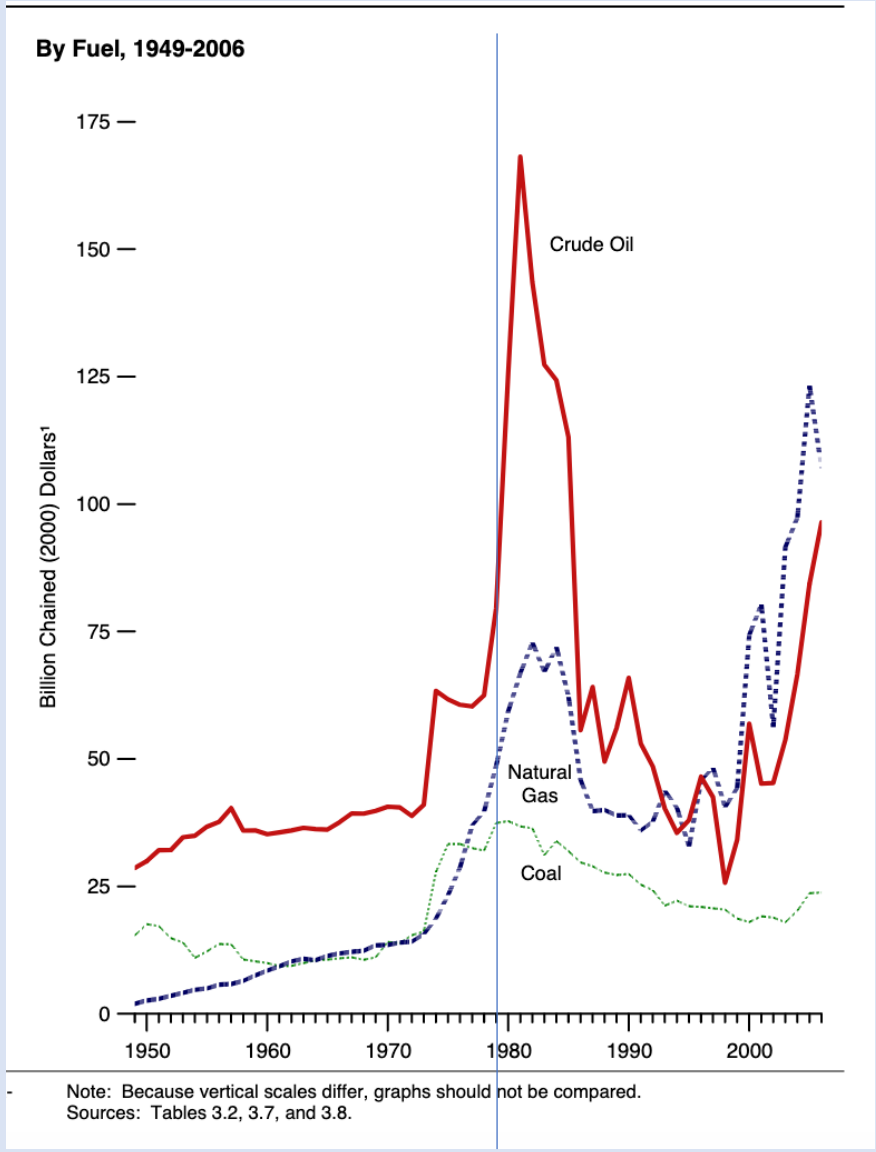
- Research
- Demonstration
- Training
- Subsidy

May 1979

National Archives

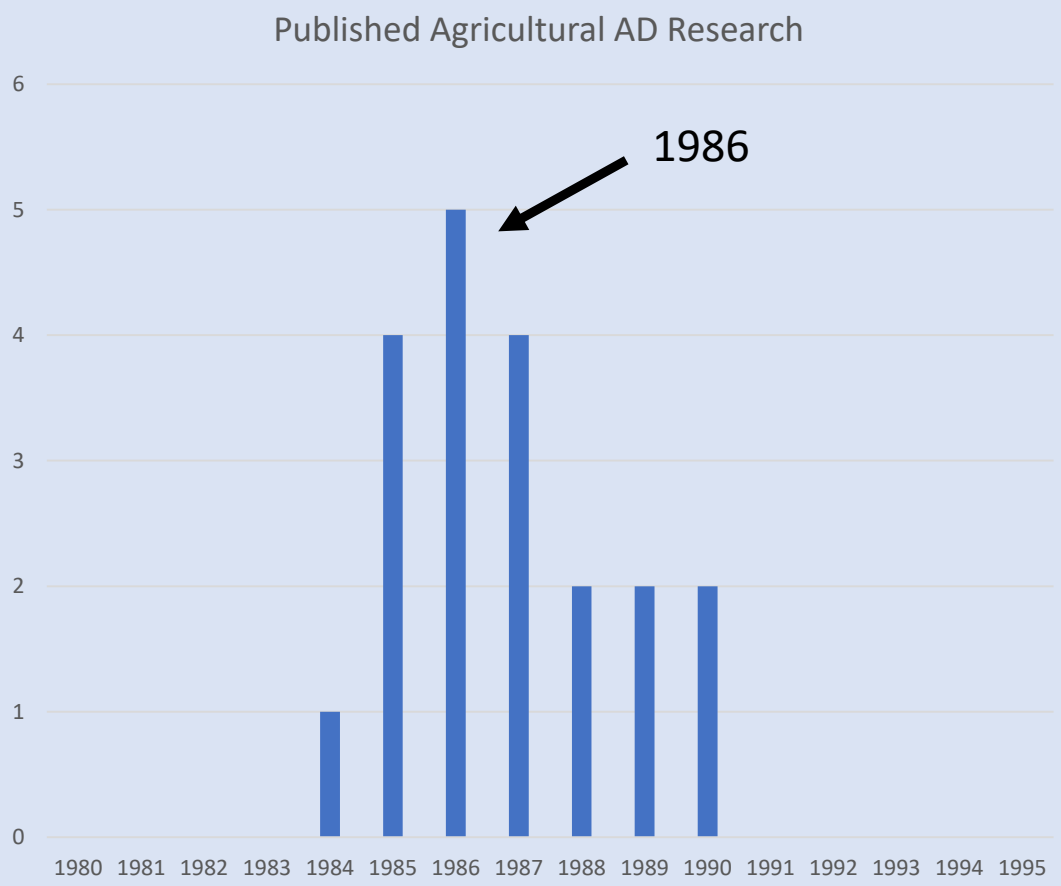
May 1979

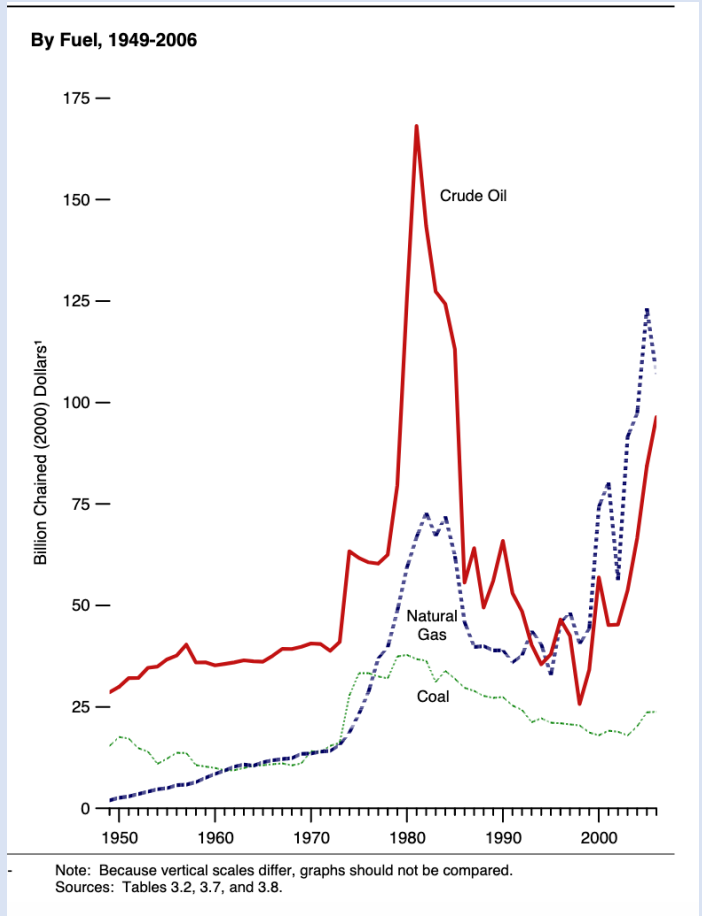
National Archives



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

Anaerobic Digestion Research - US





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

China?

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

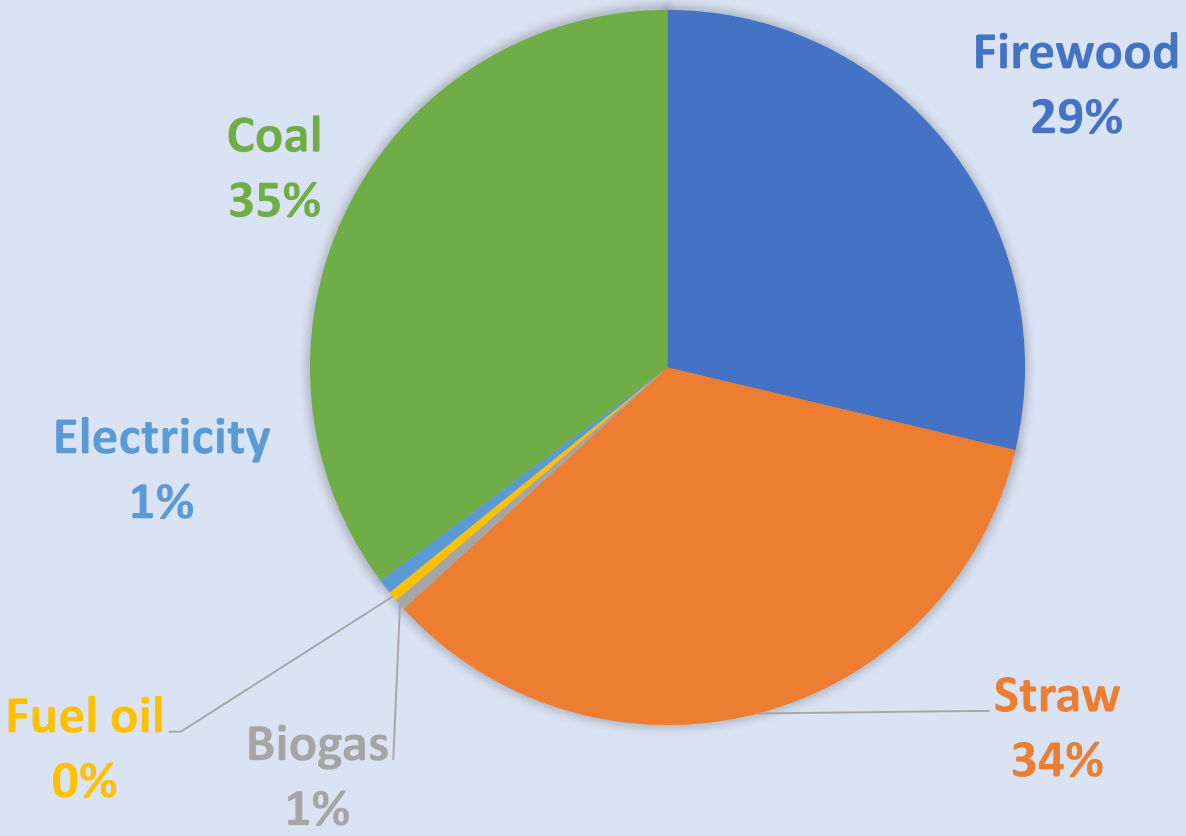
Replace wood and charcoal

- Biogas for cookstoves – 3 meals per day

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

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

HOUSEHOLD ENERGY SOURCES



1982, Tongliang County, Sichuan Province

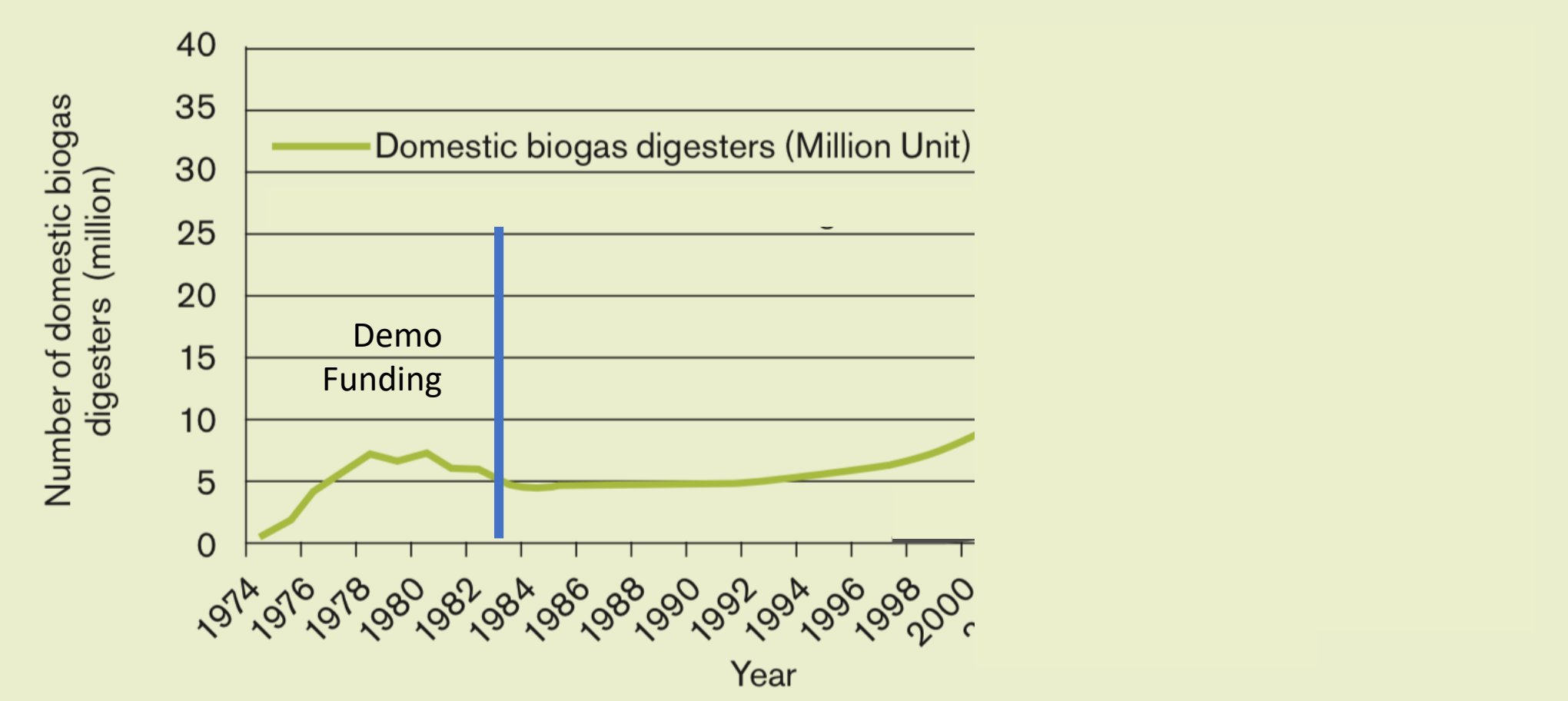
China

- 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

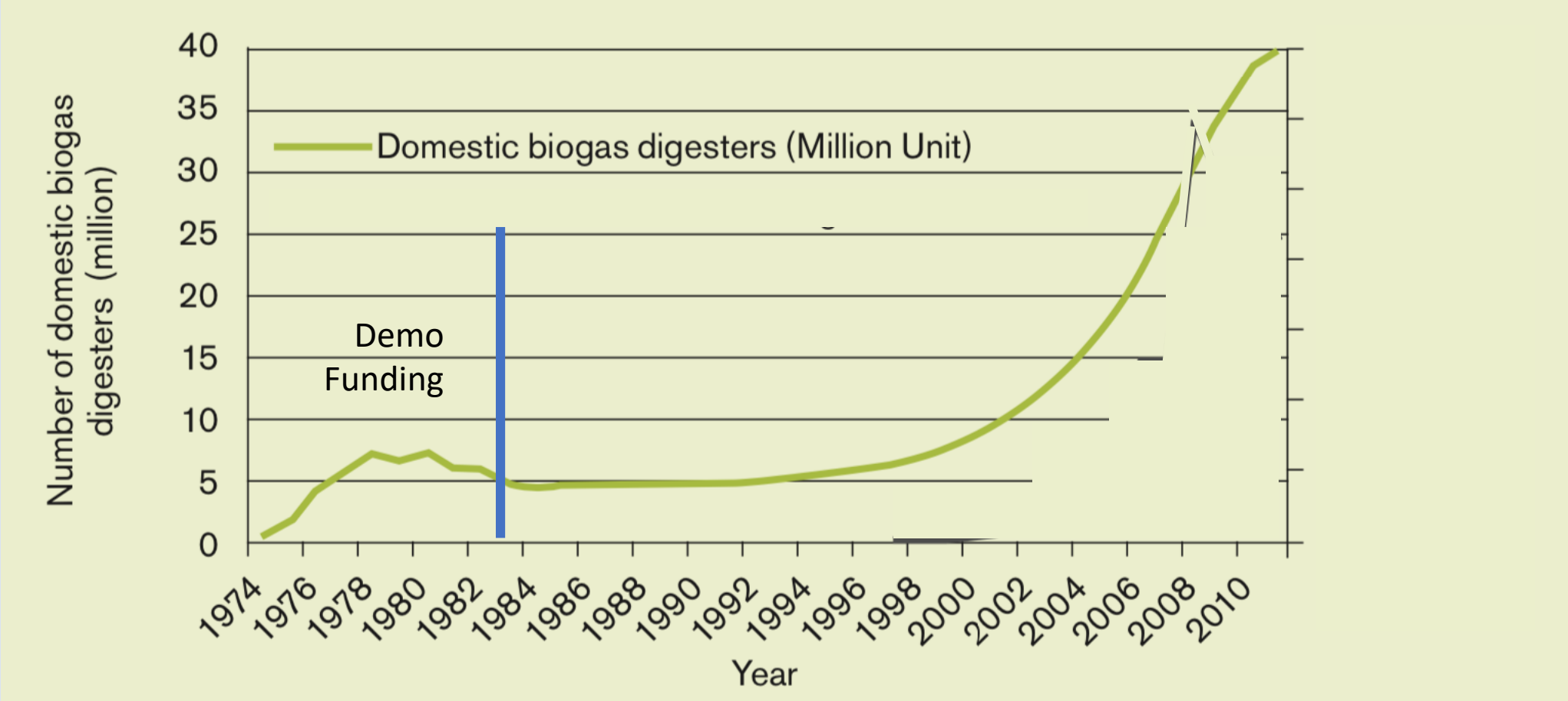
- Not enough biogas
- Not enough feedstock

China

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

http://biogas.caas.cn

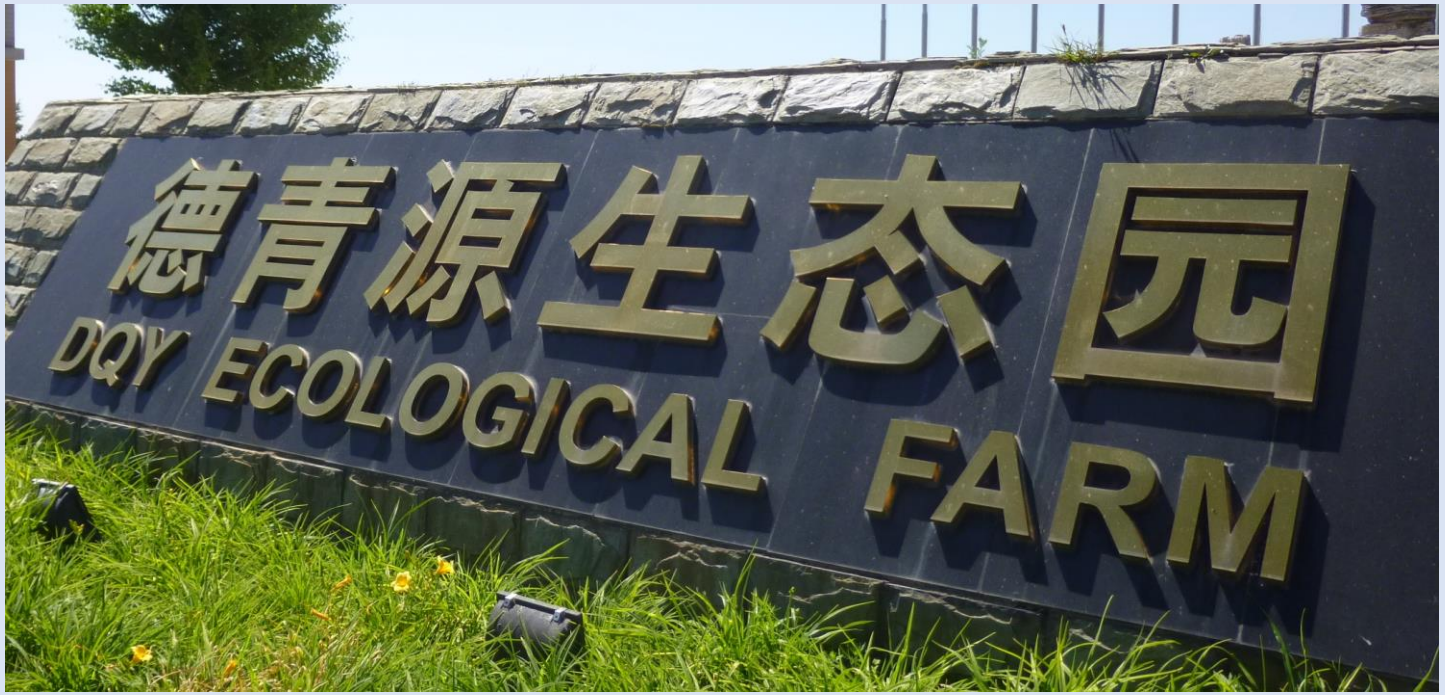
China – 40 million digesters



Xia 2013 International Institute for Environment and Development

Biogas digesters

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



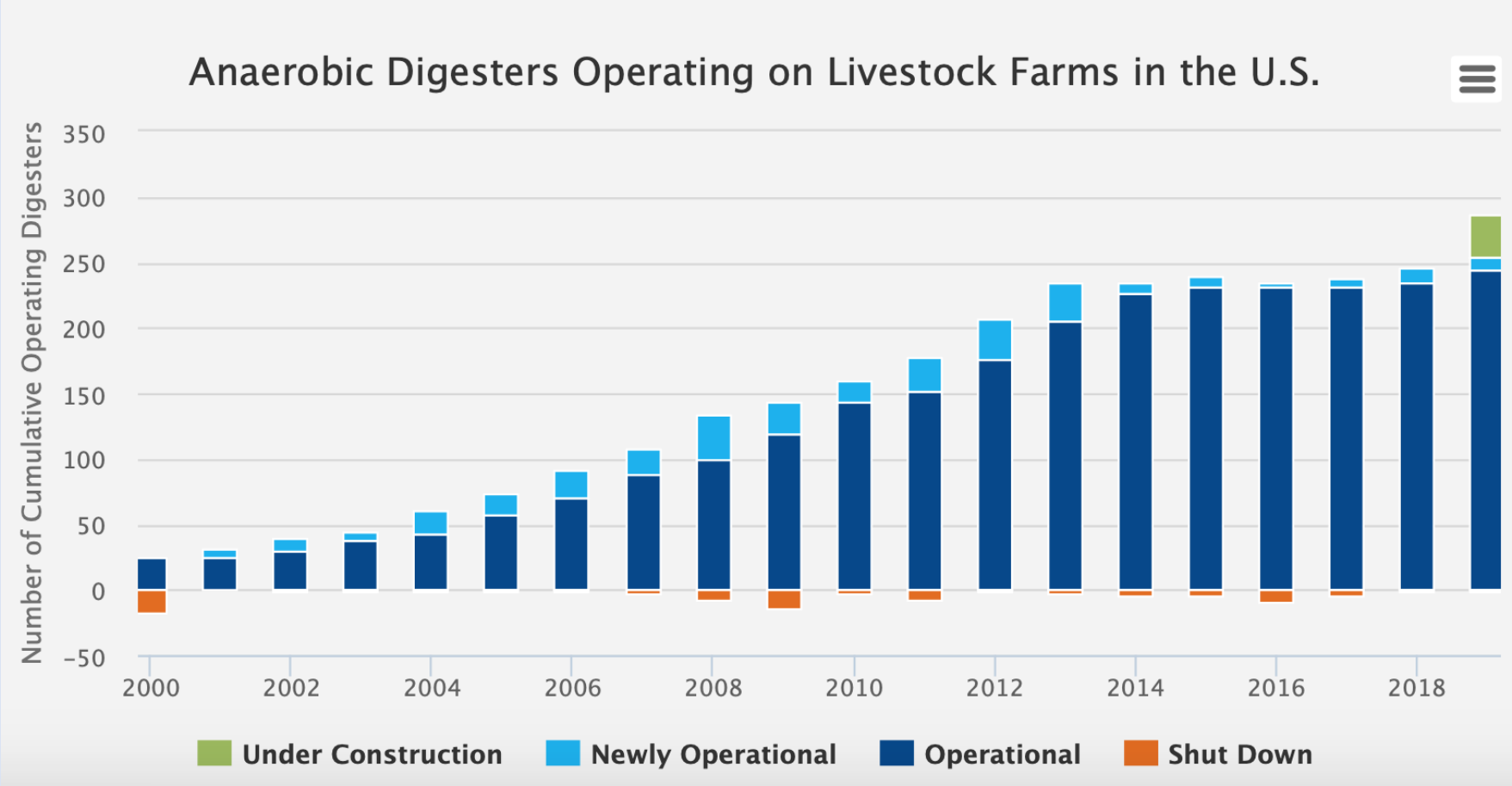
AgSTAR - 2000

- USDA
  - 107 project grants
- US EPA
  - Promotes biogas systems
  - Reduce methane emissions

agstar_trifold_bochure.pdf

US - 254 digesters

125,000 hog & dairy farms



US EPA AgSTAR Livestock Anaerobic Digester Database

China Biogas Institute Training Program

- 1981
  - Asia-Pacific training center
- 2018
  - 55 countries

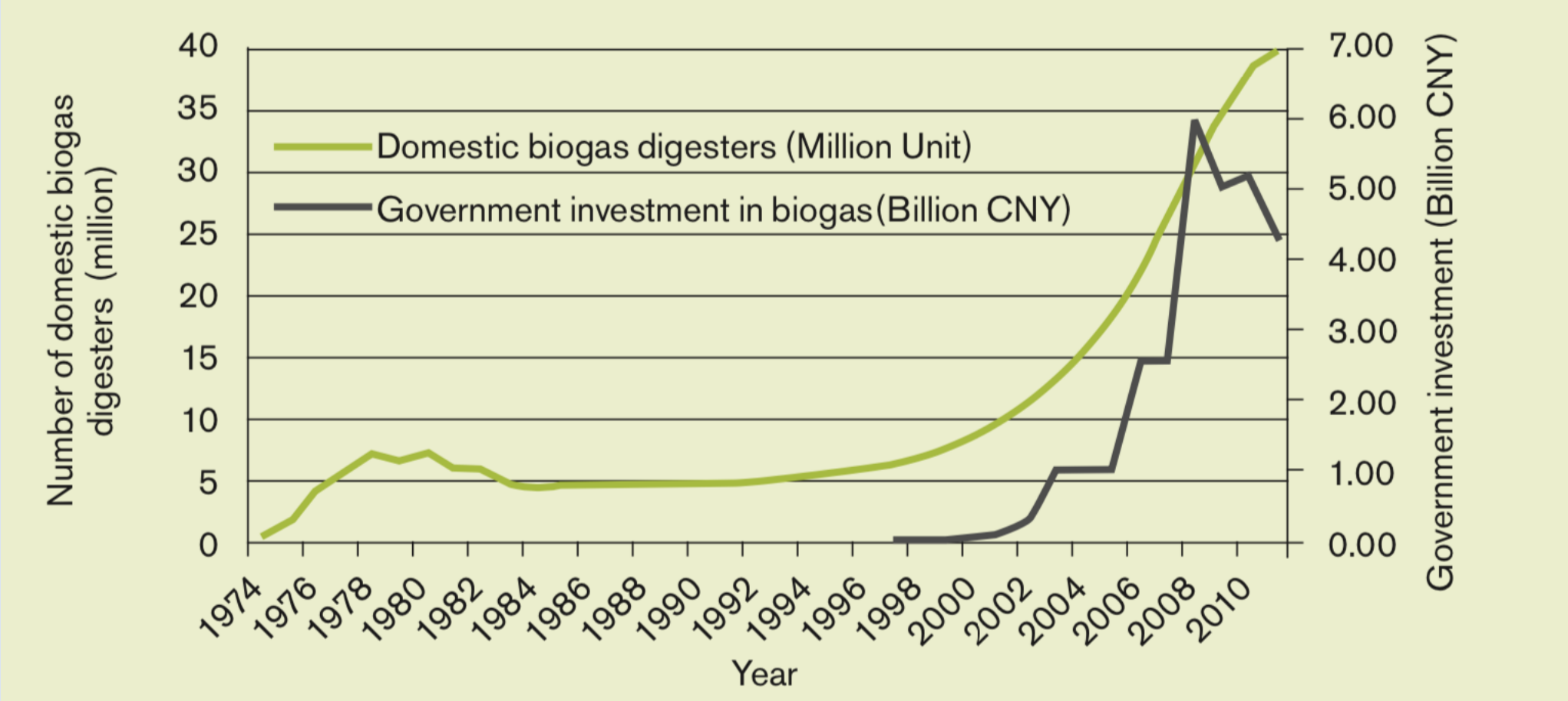
China Subsidy per Household (2011)

- 1300-3500 RMB
- About ½ cost

- West gets more

SAAS, 2010

China investment

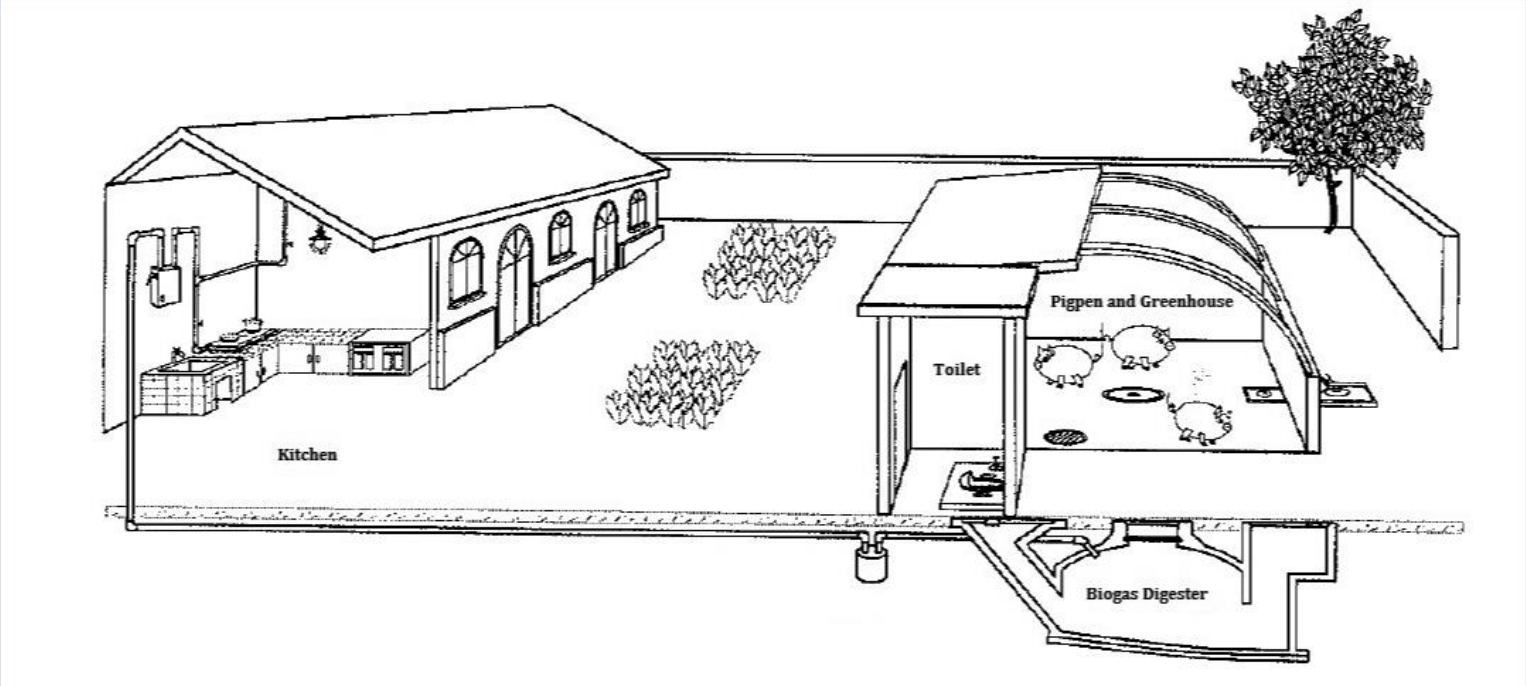


Xia 2013 International Institute for Environment and Development

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 Digestion > Value of Gas

Cost / Benefit

Cost of Anaerobic Digestion ? <

GHG reduction

Waste treatment

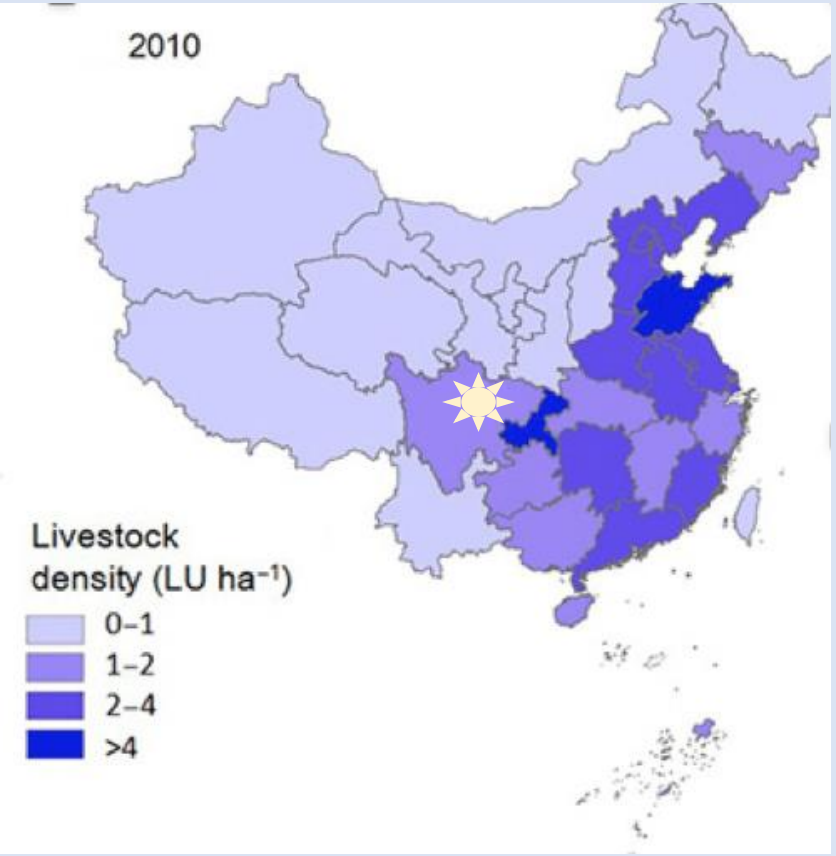
Air quality

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

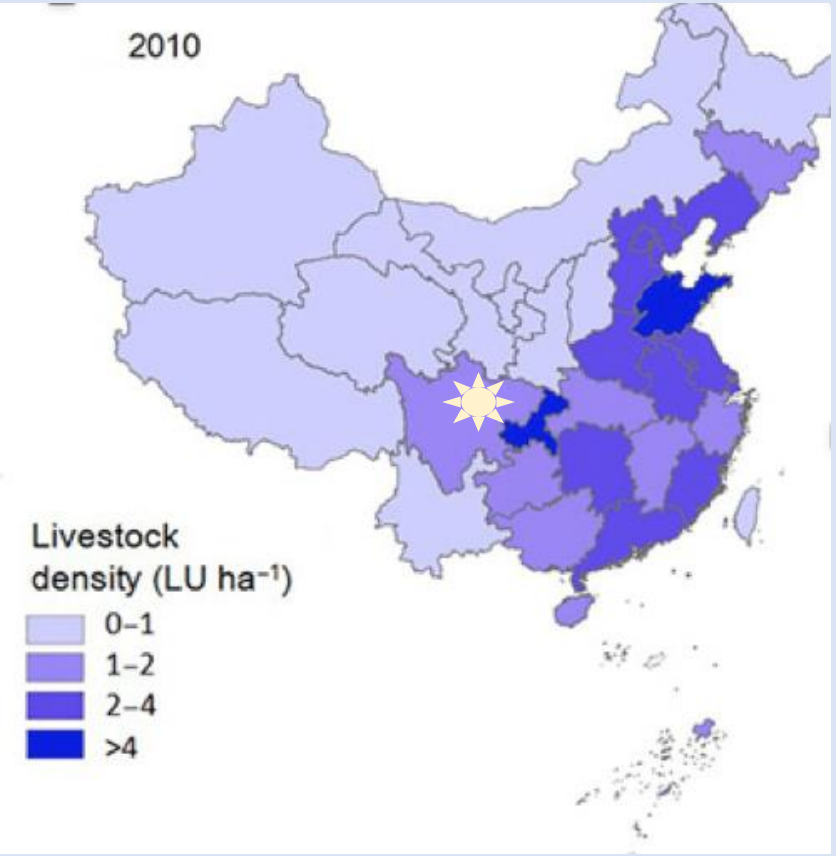
X

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
X
40 million

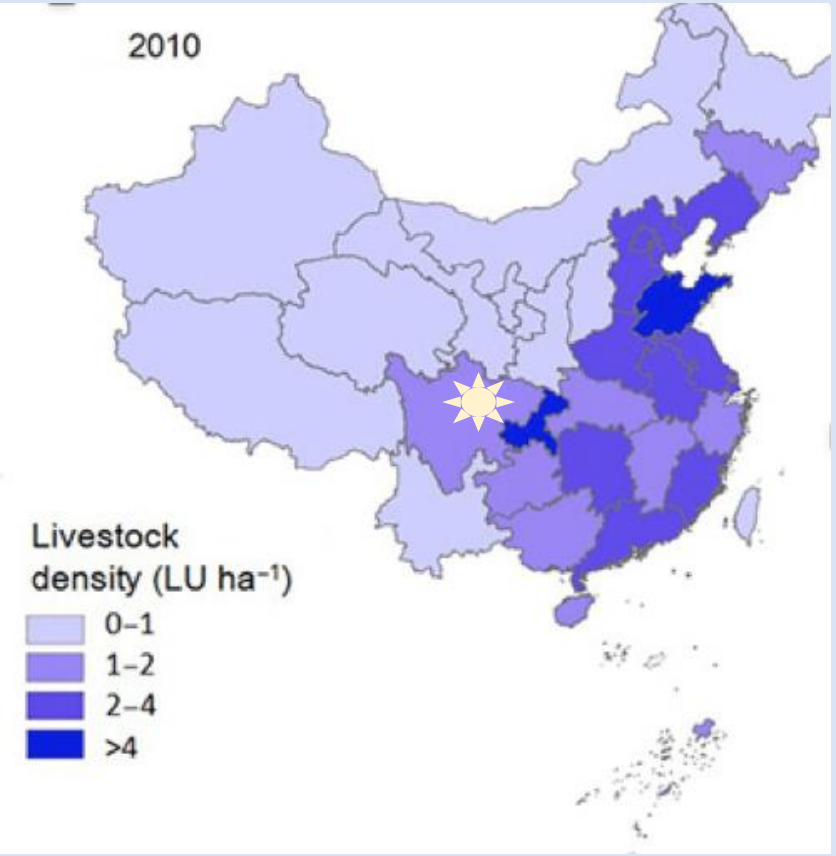
=

Burning
28.5 billion gallons of gasoline

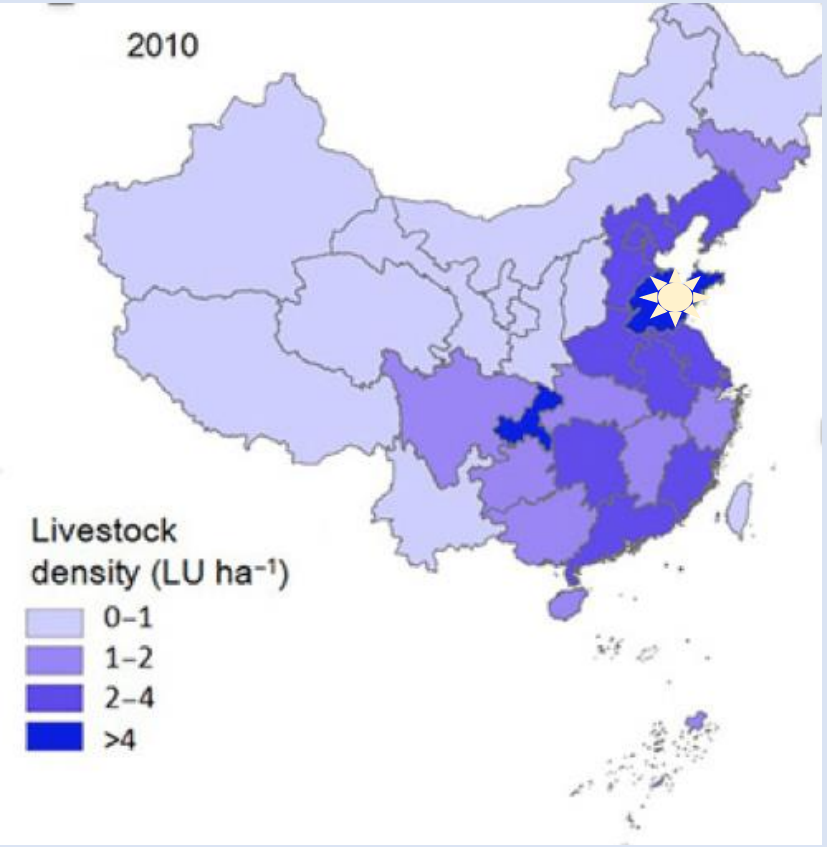
https://advances.sciencemag.org/content/4/7/eaar8534

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

ZZZZZ

Methane

- No oxygen

Organic Matter

\+ Acid forming bacteria → Organic acids

Organic acids + **Methane forming bacteria** → Methane

Methane – too cold

- No oxygen

Organic Matter + Acid forming bacteria → Organic acids

Smell Bad !!!

Organic acids + Methane forming bacteria → ~~Methane~~

~~**Natural Gas**~~

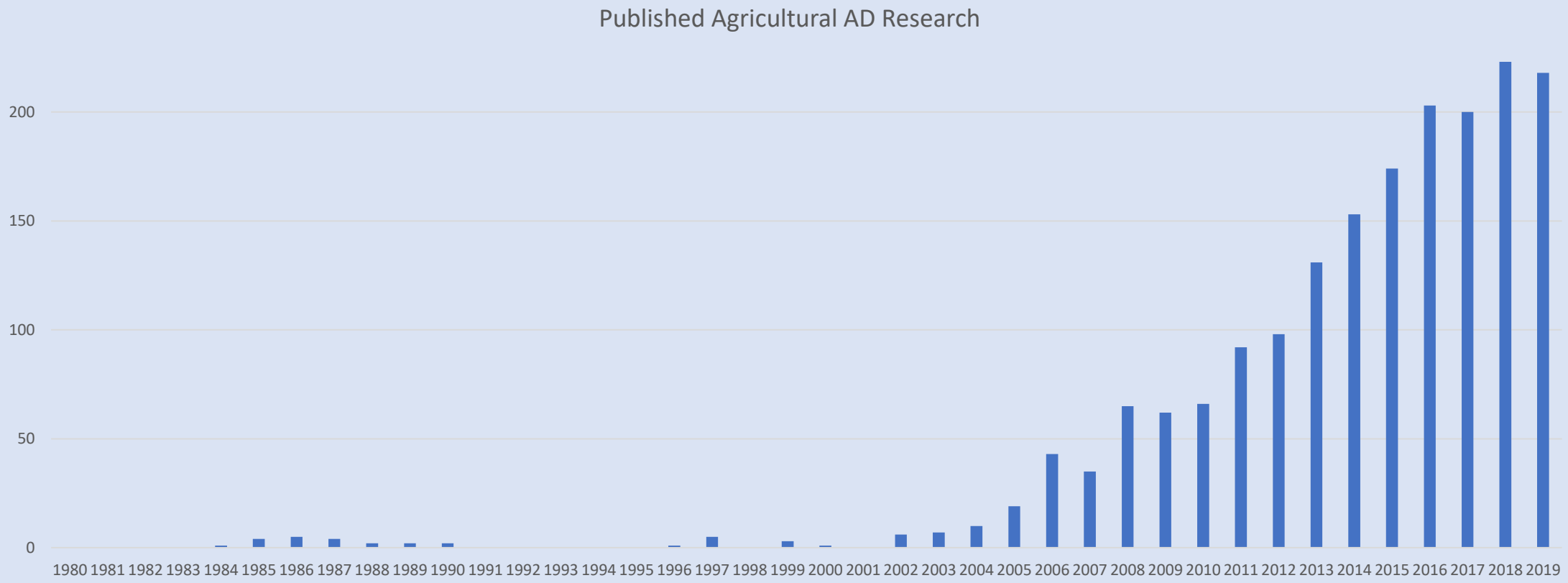
Cold weather research

- Shandong Academy of Agricultural Science, 2010

Cold weather research

- SAAS, 2010

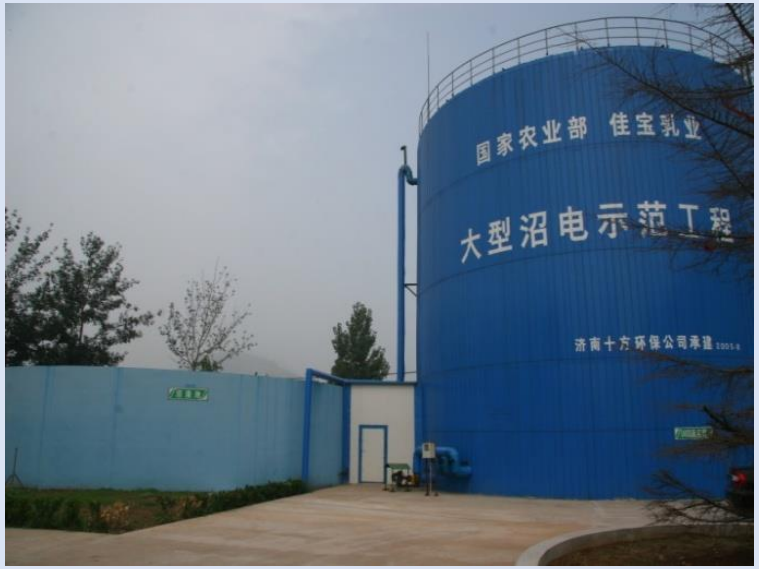
Anaerobic digester research worldwide



Capturing methane in agriculture

- Sensitive process
  - temperature

- Fuel value
  - not enough



SAAS, 2010

Successful program

- Consistent
- Comprehensive
- Multiple benefits

Opportunities for technology transfer

Setll.osu.edu