PURDUE EXTENSION | LOCAL FACES COUNTLESS CONNECTIONS

Anaerobic Digester Technology and Its Implementation in Indiana

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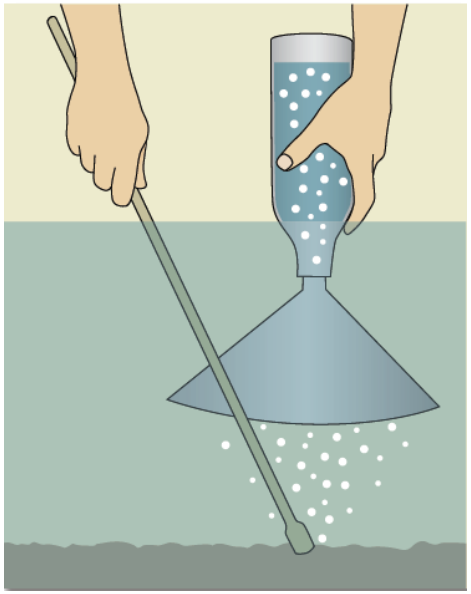
PURDUE UNIVERSITY

ANAEROBIC DIGESTION & BIOGAS

- Anaerobic digestion (AD): A microbiological process to degrade organic compounds in the absence of oxygen
- Biogas: A combustible mixture of gases (other names: manure gas, methane gas, marsh gas, etc.)

Compound	%
Methane (CH_4)	50–75
Carbon dioxide (CO_2)	25–50
Hydrogen sulfide (H_2S)	0–3
Hydrogen (H_2)	0–1
Nitrogen (N_2)	Trace
Ammonia (NH_3)	Trace
Oxygen (O_2)	Trace



Source: Jørgensen, 2009

ANAEROBIC DIGESTION APPLICATION

Digester Inputs

Digestate

Anaerobic digester system

Biogas Energy

Drawing adapted from: EPA AgStar digester_flow_diagram.pdf

Photos: HEEE and Ni

DIGESTER INPUTS

Choices:

- Animal manure
- Agro-industrial wastes
- Municipal wastes
- Crop residues
- Food wastes

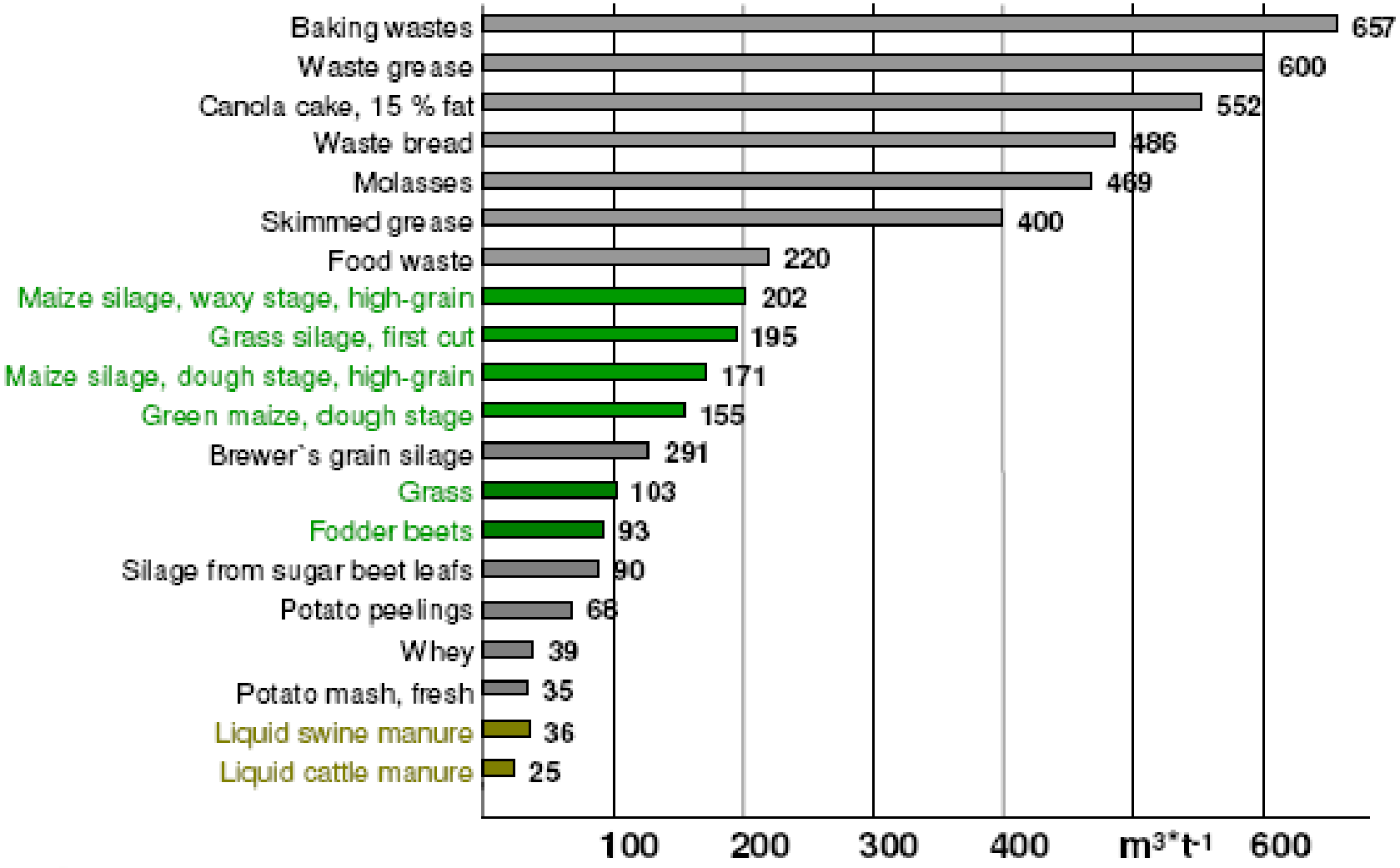
Must have:

- Enough quantity
- Long term stability
- Sufficient concentration



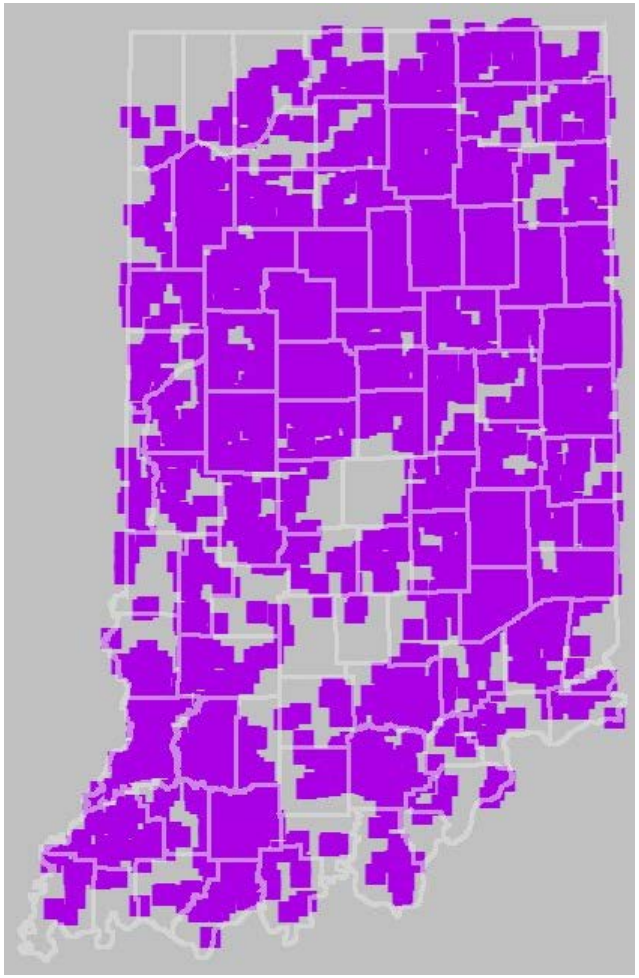

Photos: HEEE and Ni

POTENTIAL BIOGAS YIELDS



Source: Mathias Effenberger, 2006; Curt Gooch, 2009

ANIMAL AGRICULTURE IN INDIANA



Map from: www.Indianamap.org

- $1.7 to 2.4 billion annual sales
- 2012 CFO and CAFO in Jan. 2012
- Manure: ~ 9.1 million tons/yr

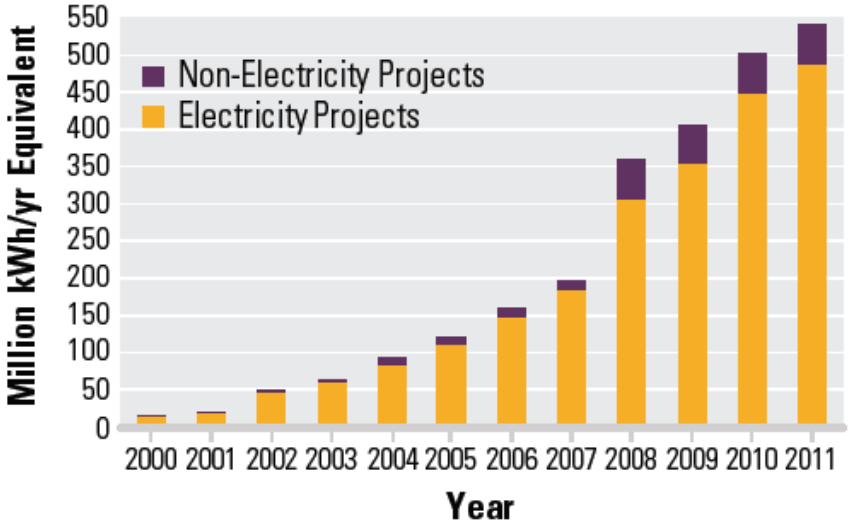
  (1.5 tons/person-yr)

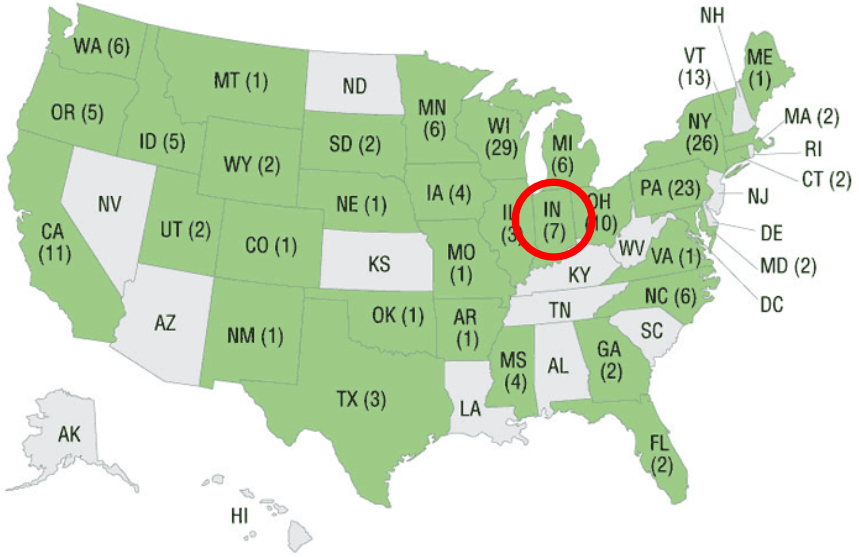
MANURE DIGESTERS IN USA

2011 by the Numbers

- **176** digesters in operation
- **15** new digesters brought on line
- **541 million** kWh of energy generated
- **1.2 million** metric tons of CO_2e destroyed
- **301,000** metric tons of CO_2e avoided

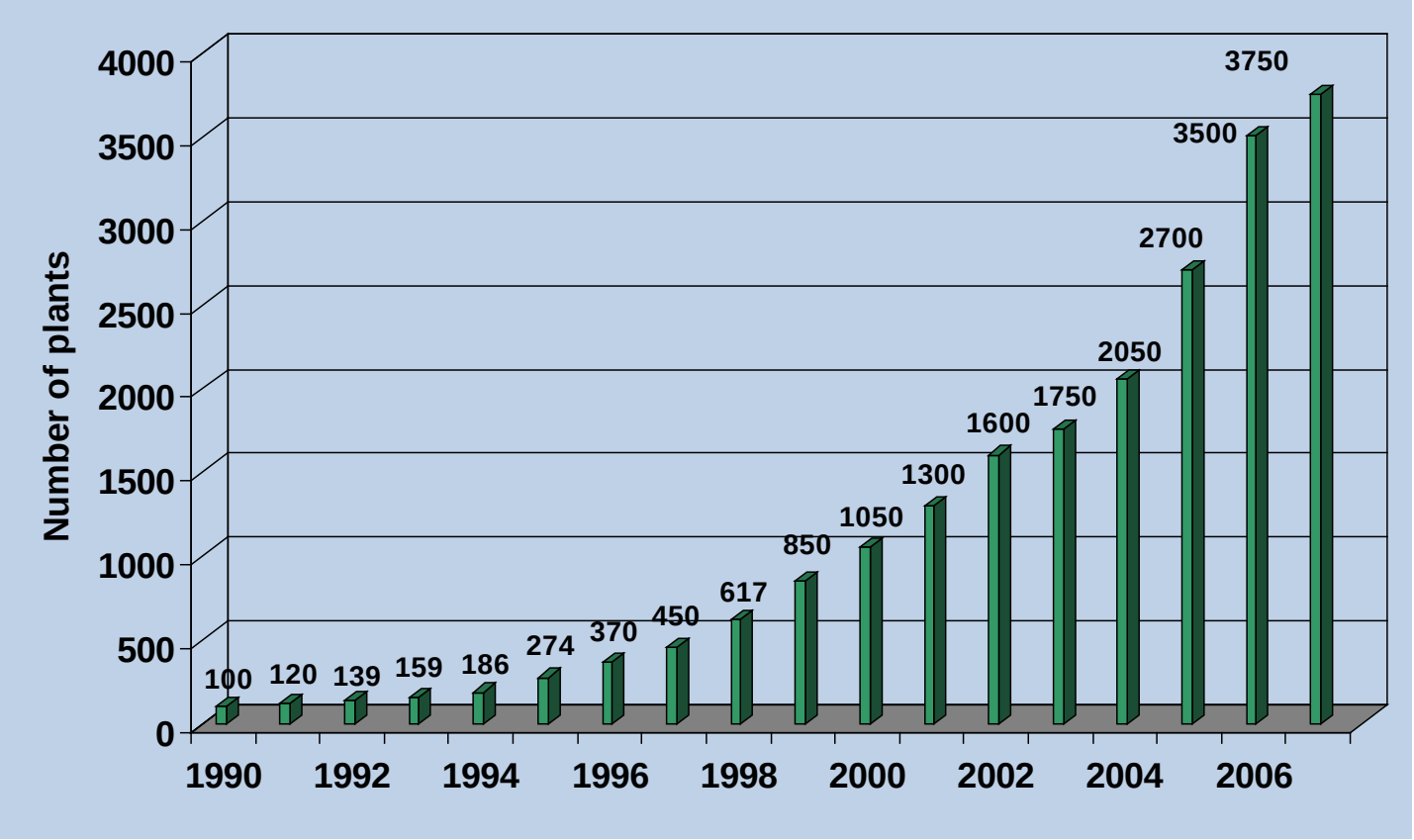
As of September 2012:
192 operating at commercial livestock farms





Source: U.S. EPA AgSTAR

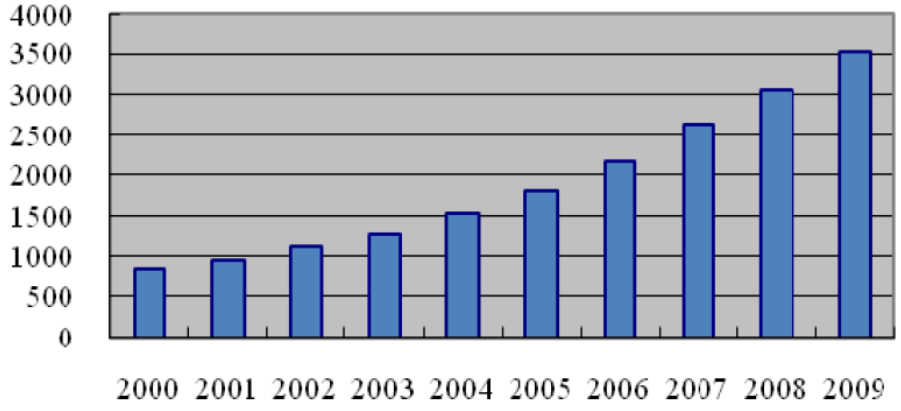
BIOGAS DEVELOPMENT IN GERMANY



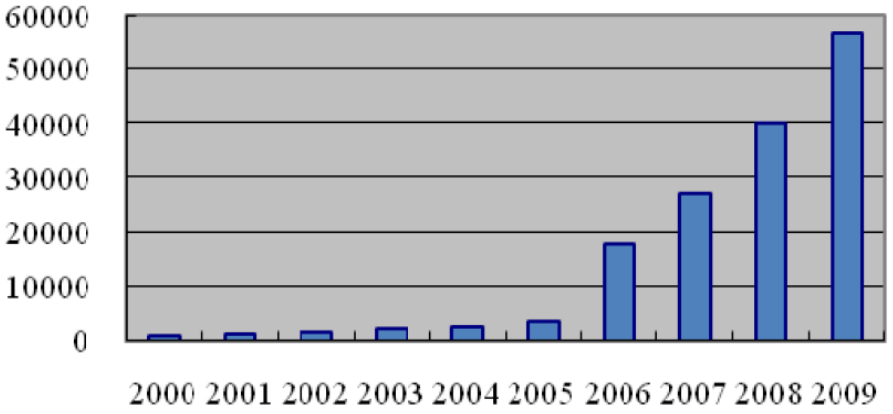
Source: Weiland, 2008

BIOGAS IN CHINA

- Late 1920s: First commercial biogas system
- 1930s: Several systems developed
- 1960s – 1970s: Rapid dissemination
- By 1978: 3 million working
- 1990s - now: New wave of biogas development



Household digesters (x10,000)



Large digester systems

Charts from: Liu, 2011

INCREASING INTERESTS IN INDIANA

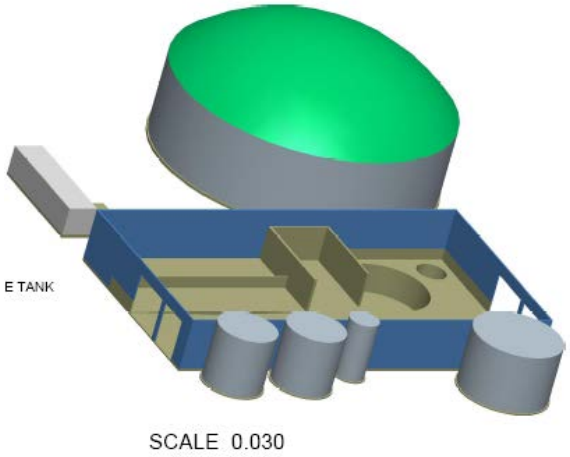
Monticello: Waste No Energy LLC (planning)

- 1.3 M gallon digester

Plymouth: Dairy farm (in progress)

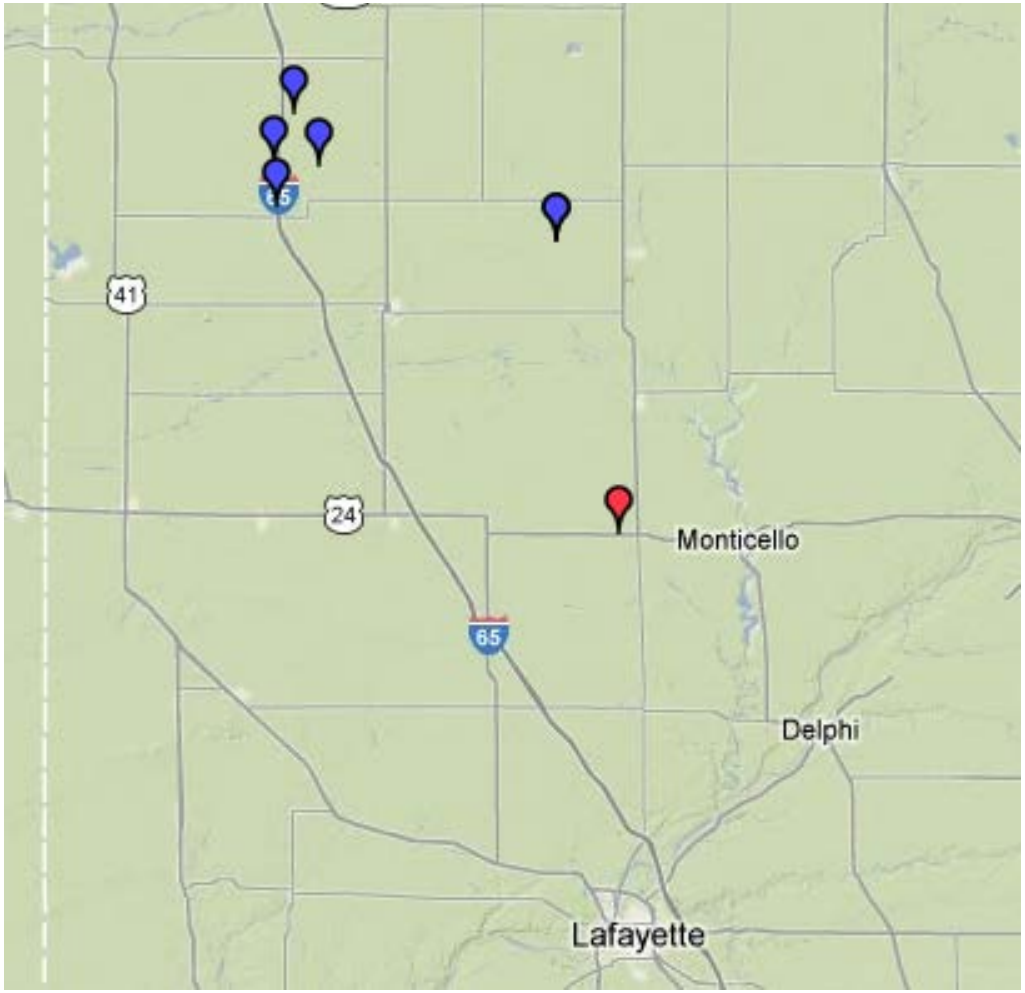
Others interested in:

- Jay and Randolph Counties (various wastes)
- Lebanon (dairy manure)
- Zionsville (duck slurry)
- Sharpsville (swine manure)
- Student groups



Source: Waste No Energy LLC

MANURE DIGESTERS IN INDIANA



- Bio Town Ag, Inc: 3300 kW
- Herrema Dairy: 800 kW
- Fair Oaks Dairy: 1050 kW
- Bos Dairy: 1050 kW
- Hidden View Dairy: 950 kW
- Windy Ridge Dairy: Flared

Source: www.epa.gov/agstar/projects/index.html

AGRO-INDUSTRIAL DIGESTERS IN INDIANA

- General Mills, New Albany, IN (1997)
- Grain Processing Corporation, Washington, IN (1999)
- Culver Duck, Middlebury, IN (2012)

Source: Kramer, (2011); www.etruth.com/article/20120817/NEWS01/708179993

WWTP DIGESTERS IN INDIANA

- West Lafayette WWTP, West Lafayette, IN
- Princeton WWTP, Princeton, Gibson County, IN
- Speedway WWTP, Indianapolis, IN
- Stever et al. (1976) sampled sludge from WWTP digesters in 12 cities in Indiana

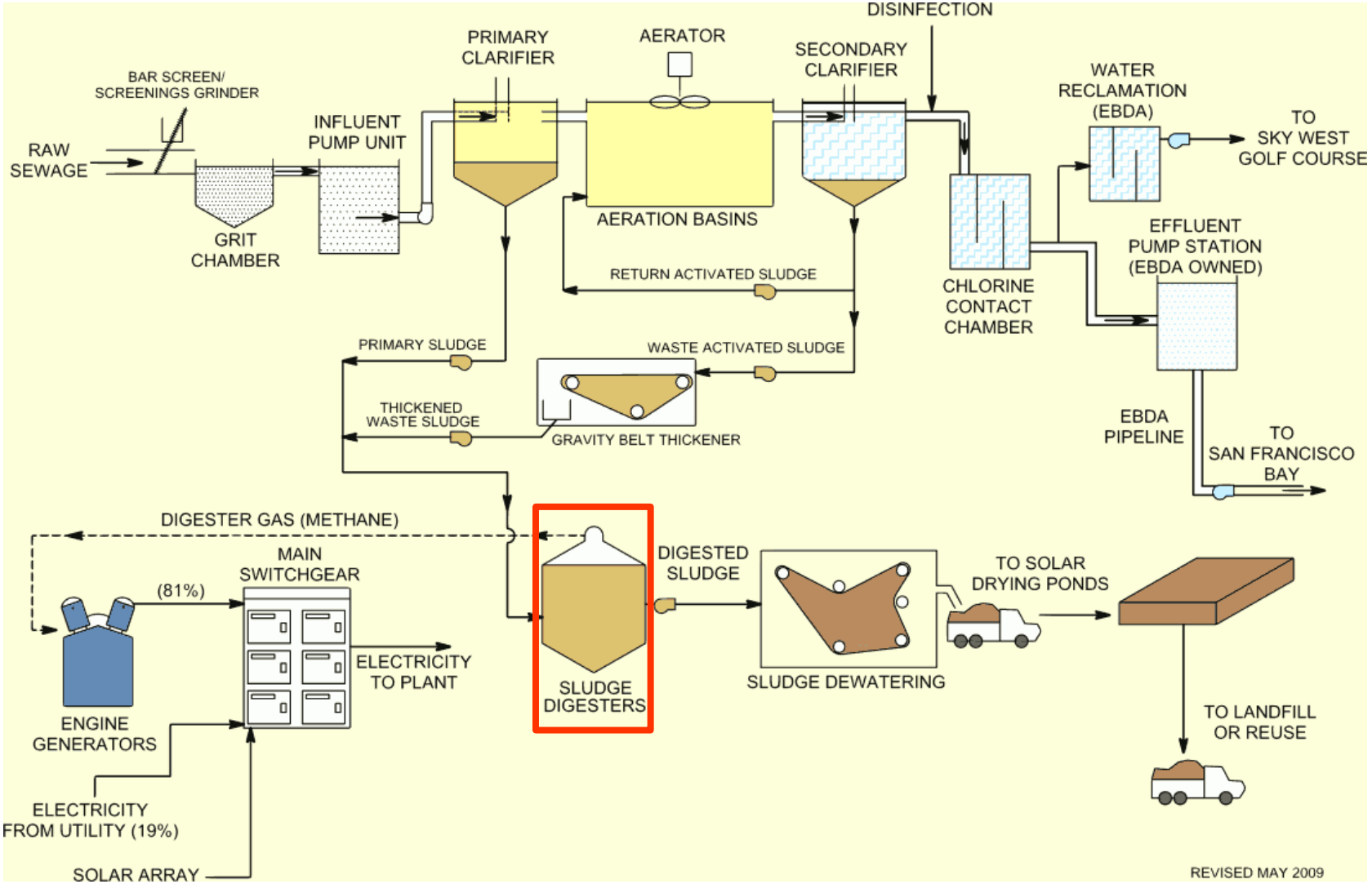
Photos: internet

WEST LAFAYETTE WWTP

- Originally constructed in 1958, expanded in 1970 and upgraded in 1997 in West Lafayette, Indiana;
- Serves 29,000 residents, plus Purdue University and the old regional sewer district, and food wastes;
- Uses micro turbines to generate 70 kW electricity.

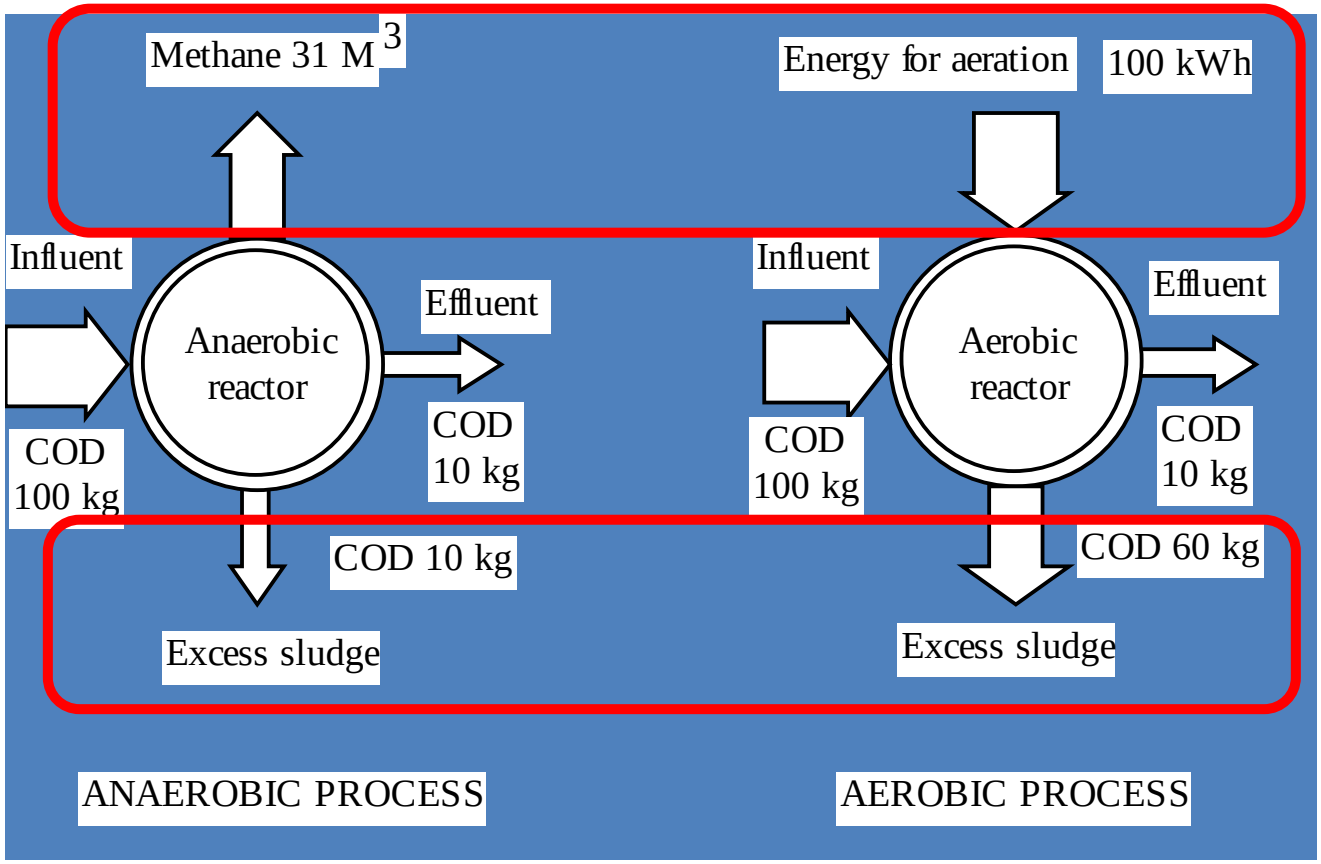
Source: www.westlafayette.in.gov/department/division.php?fDD=11-185; Photos: Ni

In Wastewater Treatment Plant



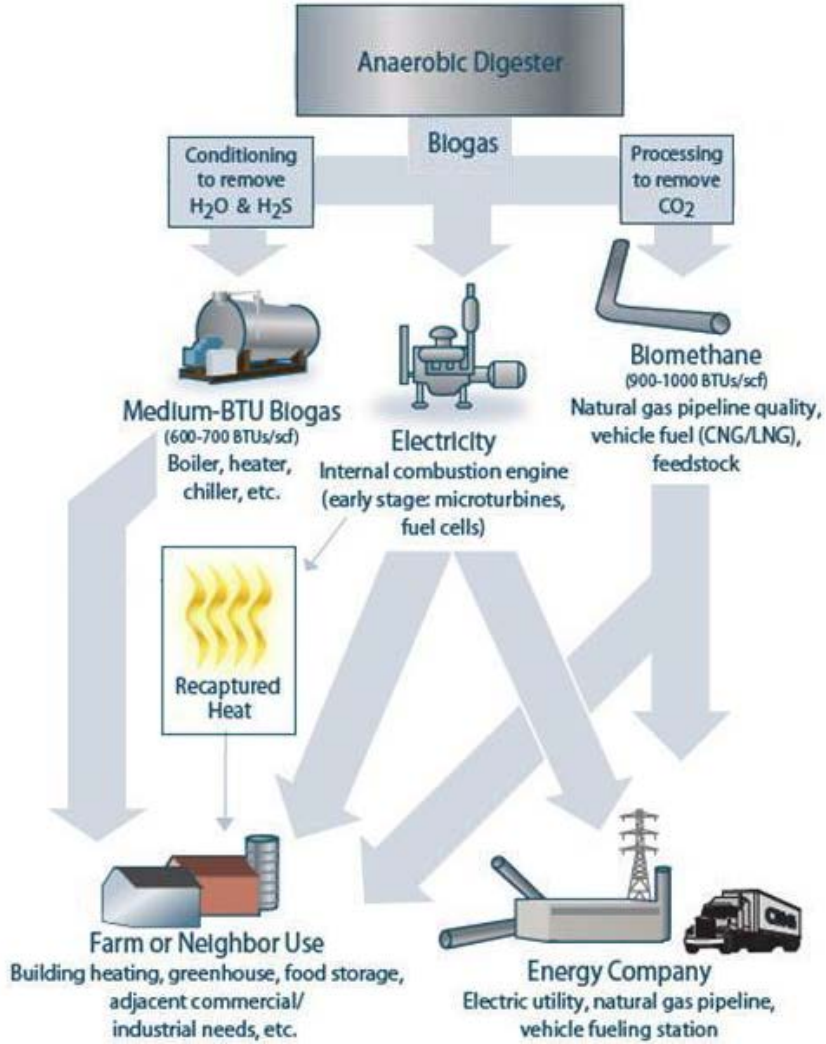
Source: www.oroloma.org/sewer/treatment/diagram/index.html

ENERGY FOR SLUDGE TREATMENT



Source: Ni et al. 1993

BIOGAS PRODUCTION AND USE



- Most visible benefit
- Energy policy and price
- Usage vs. system size
- Biogas processing

Drawing adapted from: EPA AgStar digester_flow_diagram.pdf

BIOGAS USE IN A FARM DIGESTER SYSTEM

1000 m³ biogas holder

8000 m³ digester

1500 m³ x 4 digesters

Boiler

Generator

Restaurant

Photos: HEEE.

VEHICLES USING BIOGAS IN EUROPE

Biogas station and biogas car in Germany
(Photos: Dr. K. Sheng)

A biogas bus in Linköping, Sweden
(www.Wikipedia.com)

BIOGAS FOR VEHICLE FUEL IN USA

Quasar system in Ohio

Indiana's Fair Oaks Farms: trucks powered by biogas to deliver milk

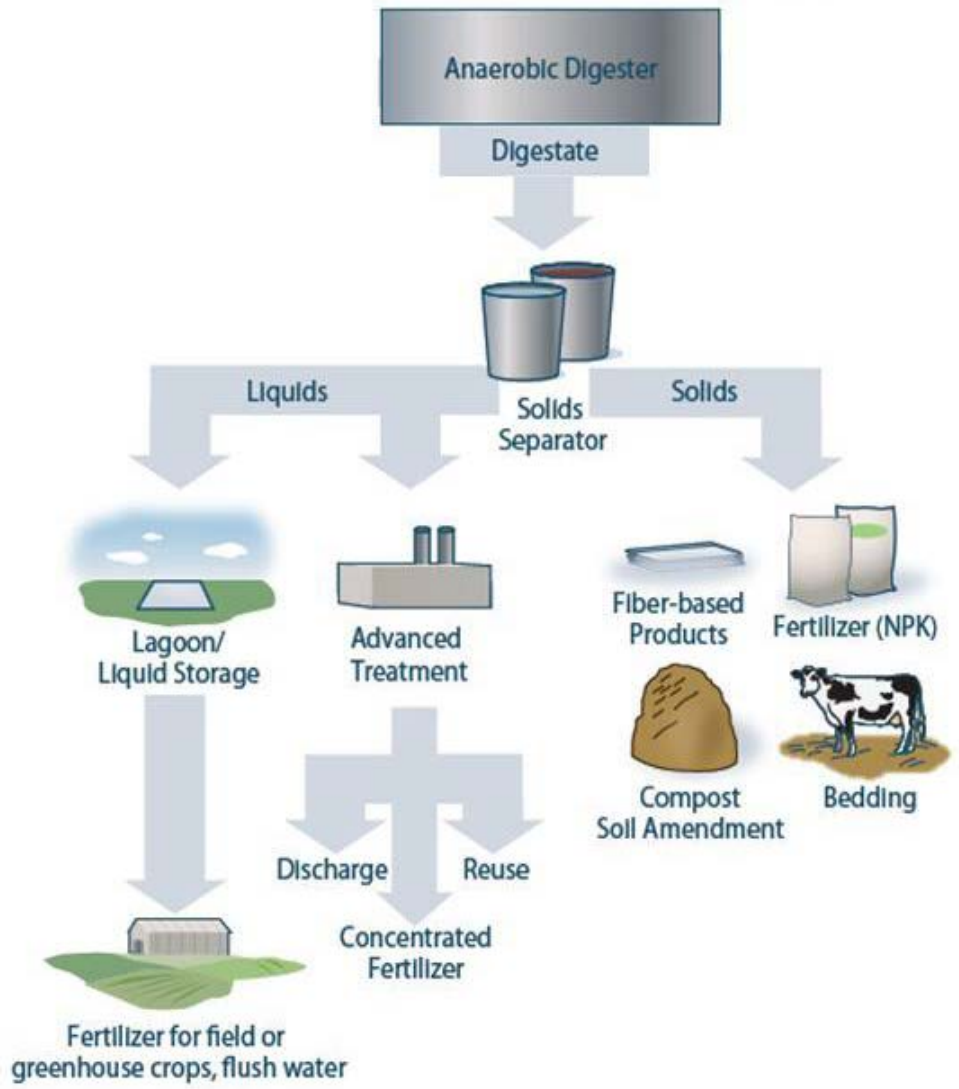
(Photos: Ni)

BIOGAS USE IN GAS GRID

Possible alternative applications of biogas:

- Separate biogas pipe from an existing gas grid
- Injection into the natural gas grid
  - Upgrading to natural gas quality
  - Degrading the gas quality in a section of the natural gas grid
- Biogas in the town gas network in Göteborg (Sweden)
  - Biogas was distributed in the period 1999–2007
  - Limitation: Max. 30% biogas in the town gas
- Biogas injected into gas grid in UK in 2010

ANAEROBIC DIGESTATE (EFFLUENT)



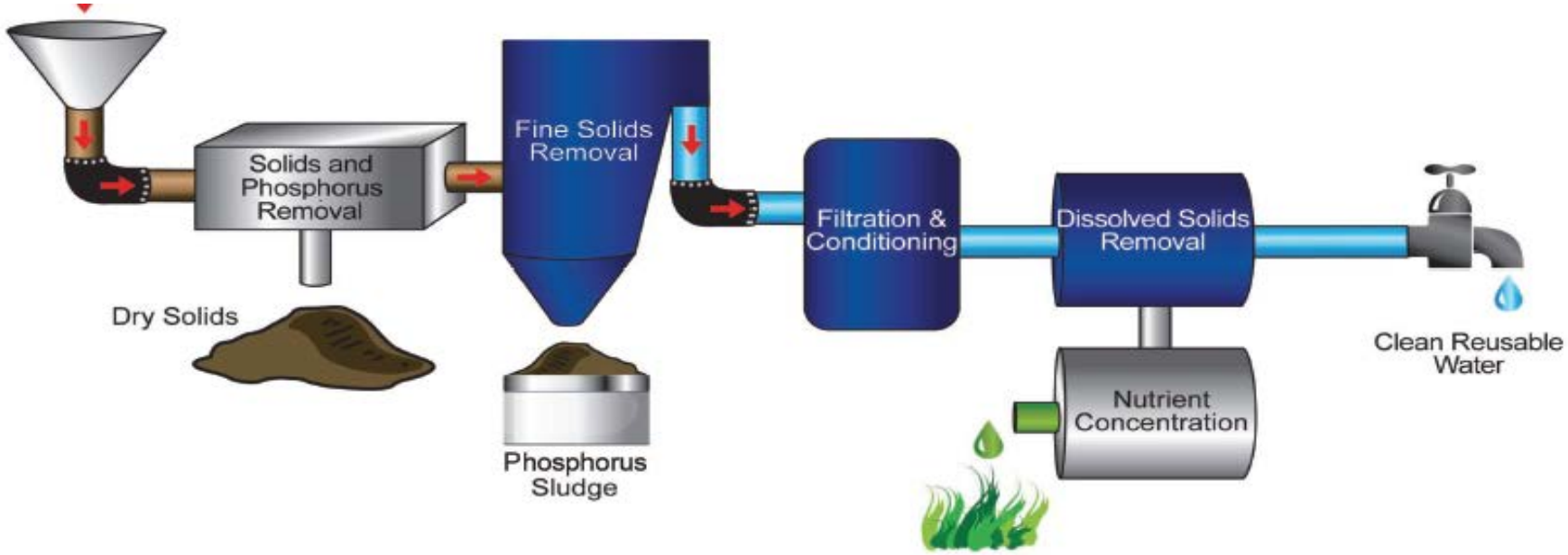
Challenges:

- Digestate processing
- Removal of N and P
- Value-added
- New tech: Anammox

Drawing adapted from: EPA AgStar digester_flow_diagram.pdf

DIGESTATE TREATMENT

- Pollution reduction
- Value-added
- Water recycling



Livestock Water Recycling, Inc. technology from Canada

FUTURE RESEARCH AND IMPLEMENTATION

- Technology development
  - Fermentation process control and optimization
  - Engineering design of digester, pre- and post-treatment equipment, etc.
- Technology application
  - Agricultural, municipal, agro-industrial, food wastes
  - Operation and maintenance
  - Maximize energy and environmental benefits
- Political, economic, social, environmental issues

THANK YOU!