# Renewable Energy at Resource Recovery Facilities

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# Understand Where You're At

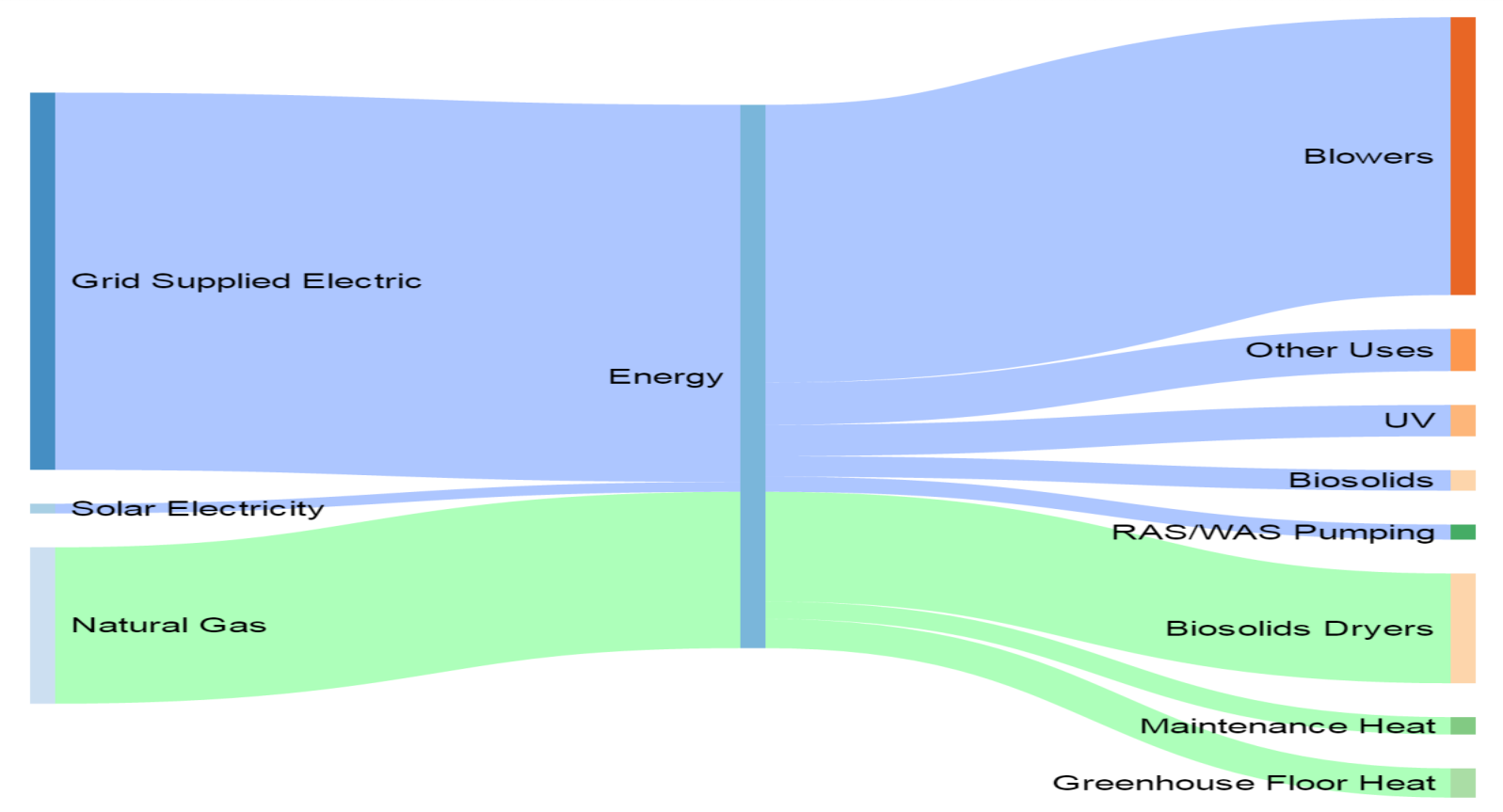
- Determine Significant Energy Sources
  - Electricity (grid supplied, onsite generated)
  - Natural Gas
  - Diesel
- Determine Energy Uses
  - Pumping
  - Aeration
  - Drying
- Determine Baseline Energy Consumption
  - Total energy in from all sources
  - Add in onsite renewables
  - Estimate all consumption

- Determine Basic Design and Operating Criteria
- Take advantage of DOE programs
  - Industrial Assessments
- Develop an Energy Management System
  - ISO 50001
  - Superior Energy Performance (SEP)

# Begin by Making A Plan

- Look at establishing an ISO 50001 Energy Management System (EnMS)
- Look at incorporating DOE's Superior Energy Performance (SEP) program
- Submeter where necessary

# Kent County Energy Balance



# Renewable Energy Options

- Solar
- Hydro
- Geothermal
- Wind
- Biomass

# Solar Options

- Photovoltaic
- Solar Biosolids Drying
- Passive Design

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# Hydro Options

- Head
- Flow
- P (kW) = 10 * n * Q * H

N = Efficiency

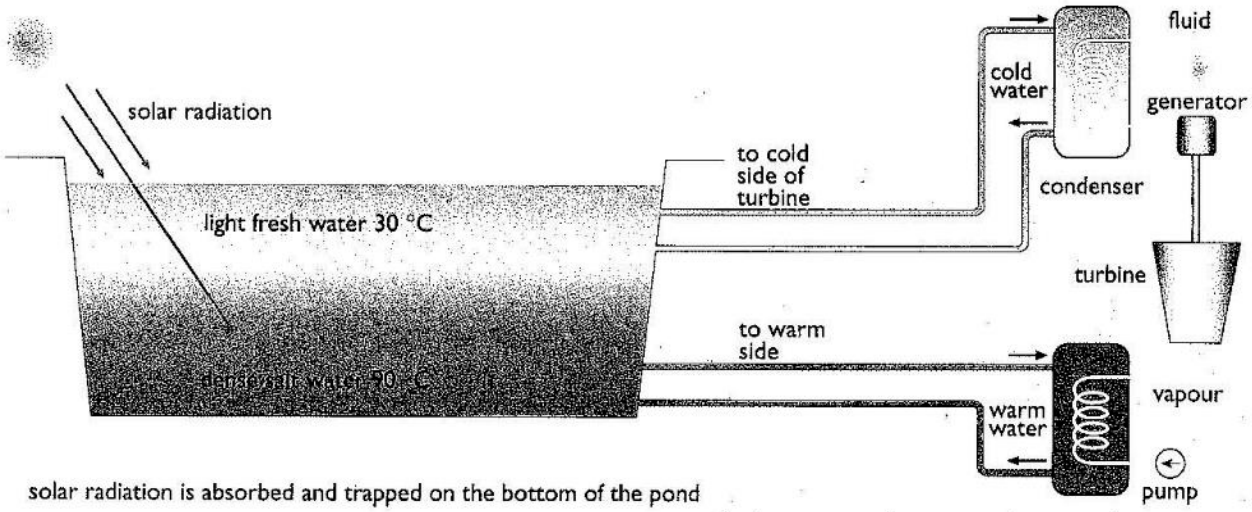
Q = Flow

H - Head

# Geothermal Options

- HVAC

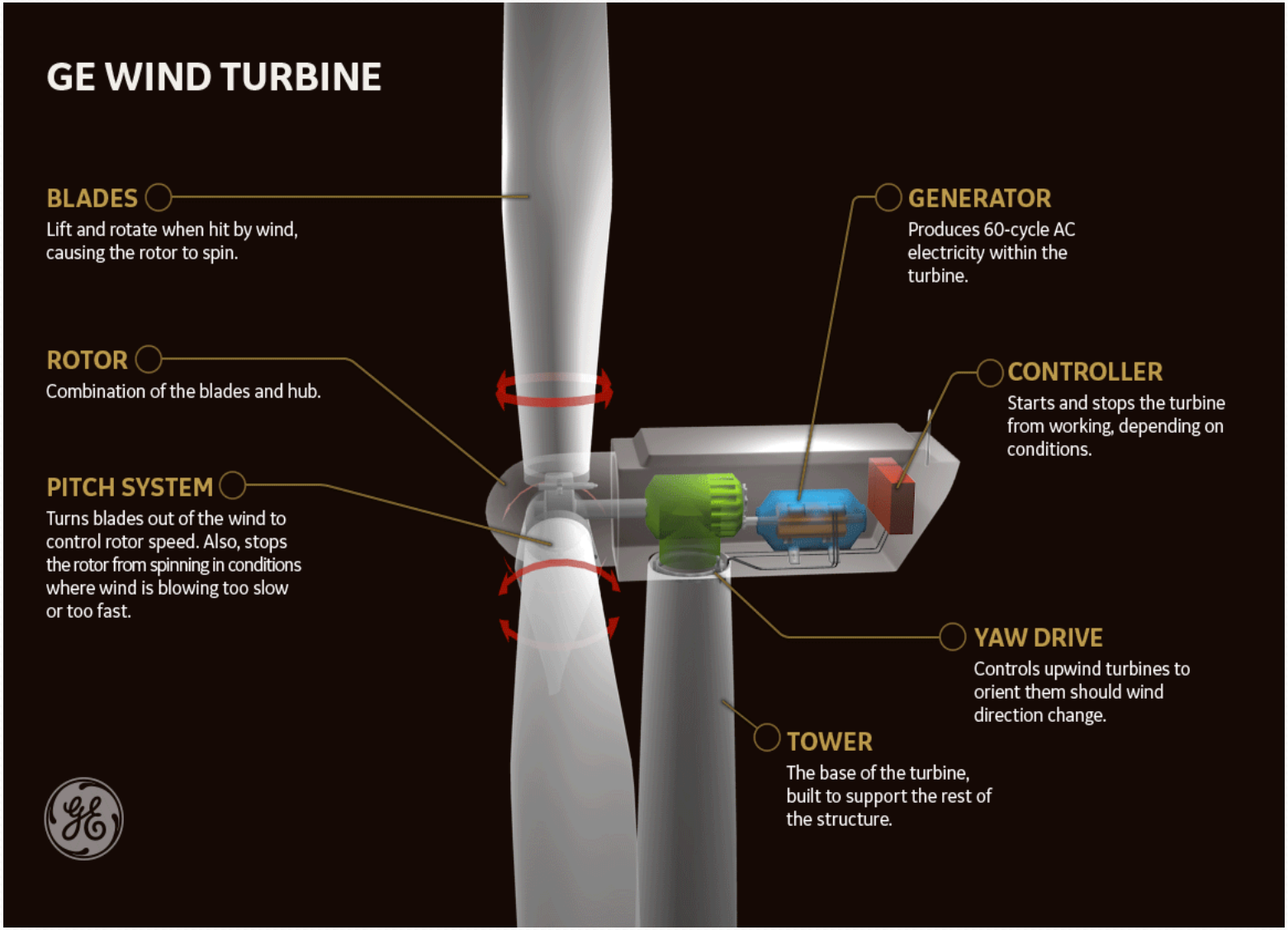
- Thermal energy in water

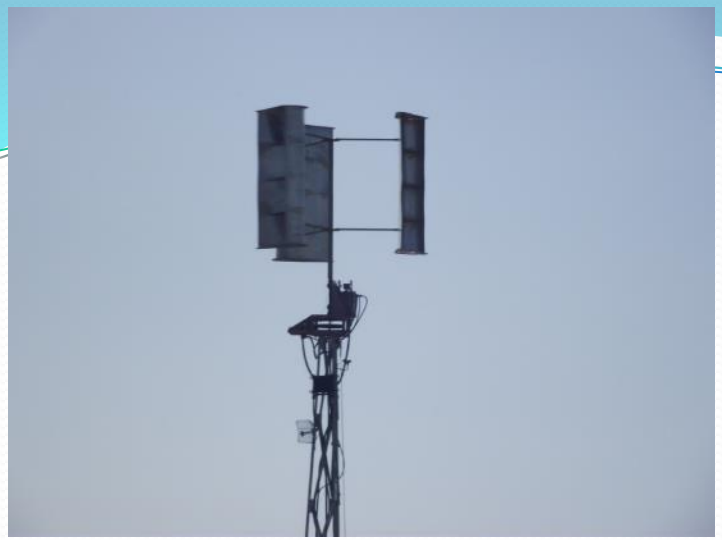


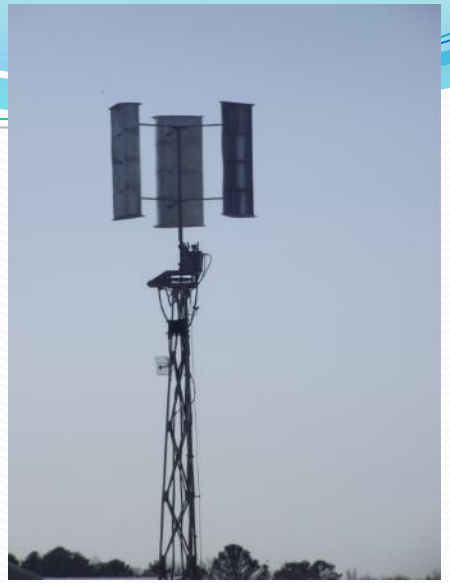
solar radiation is absorbed and trapped on the bottom of the pond

# Wind Options

- Horizontal Turbines
- Vertical Turbines
- Other systems

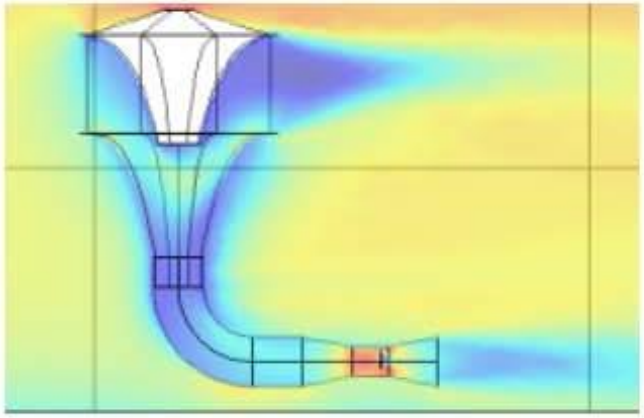

GE WIND TURBINE
BLADES
Lift and rotate when hit by wind, causing the rotor to spin.
ROTOR
Combination of the blades and hub.
PITCH SYSTEM
Turns blades out of the wind to control rotor speed. Also, stops the rotor from spinning in conditions where wind is blowing too slow or too fast.
GENERATOR
Produces 60-cycle AC electricity within the turbine.
CONTROLLER
Starts and stops the turbine from working, depending on conditions.
YAW DRIVE
Controls upwind turbines to orient them should wind direction change.
TOWER
The base of the turbine, built to support the rest of the structure.



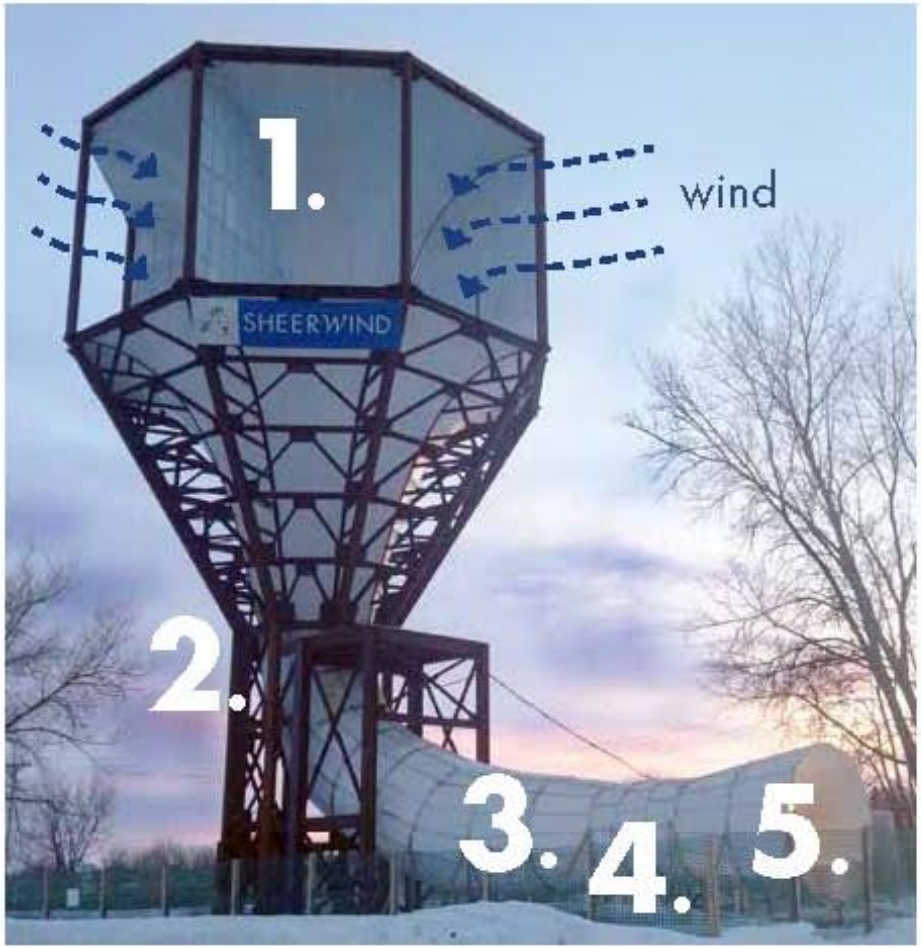


# How INVELOX works

1. 360° intake collects wind
2. Wind is funneled to concentrate
3. Venturi is used to increase wind speed
4. Turbine generators are placed at optimum wind speed and convert wind power to electrical energy
5. Diffuser slows wind before returning to environment



For more information visit SHEERWIND.com



High resistance,
starts producing
at 7.5 mph (12 km/h)
wind speed
Low resistance,
starts producing
at 2 mph (3 km/h)
wind speed
Traditional
Gearbox
Turbine
Up to 200 ft
6 ft across
170 lbs (77 kg)
Honeywell
Gearless
Wind Turbine

# Wind power formula

Power = k* Cp* 1/2 *ρ* A*$V^3$

Where

P = Power output, kilowatts

Cp = Maximum power coefficient, ranging from 0.25 to 0.45,dimension less (theoretical maximum = 0.59)

ρ = Air density, lb/$ft^3$

A = Rotor swept area, $ft^2$ or π $D^2$/4 (D is the rotor diameter in ft, π = 3.1416)

V = Wind speed, mph

k = 0.000133 A constant to yield power in kilowatts.

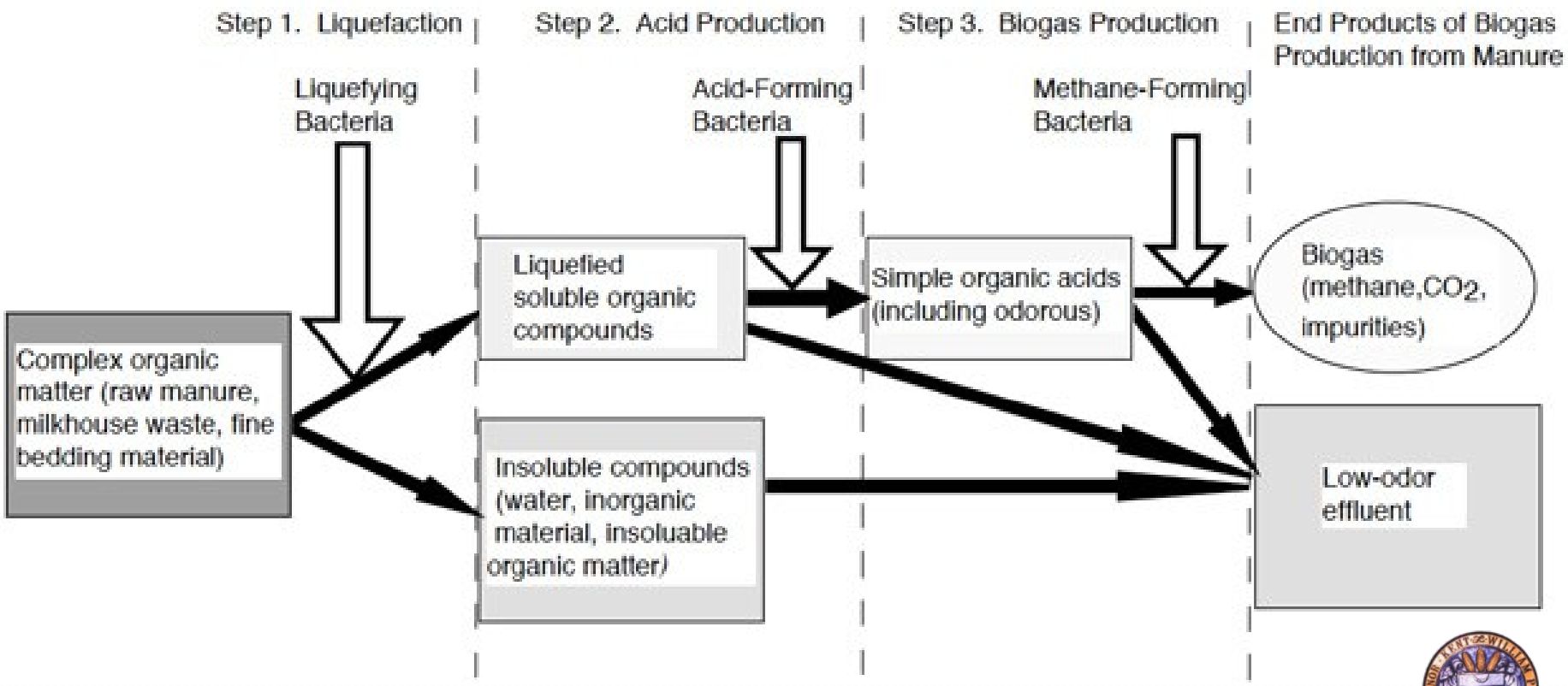
(Multiplying the above kilowatt answer by1.340 converts it to horsepower. [i.e., 1 kW = 1.340 horsepower]).

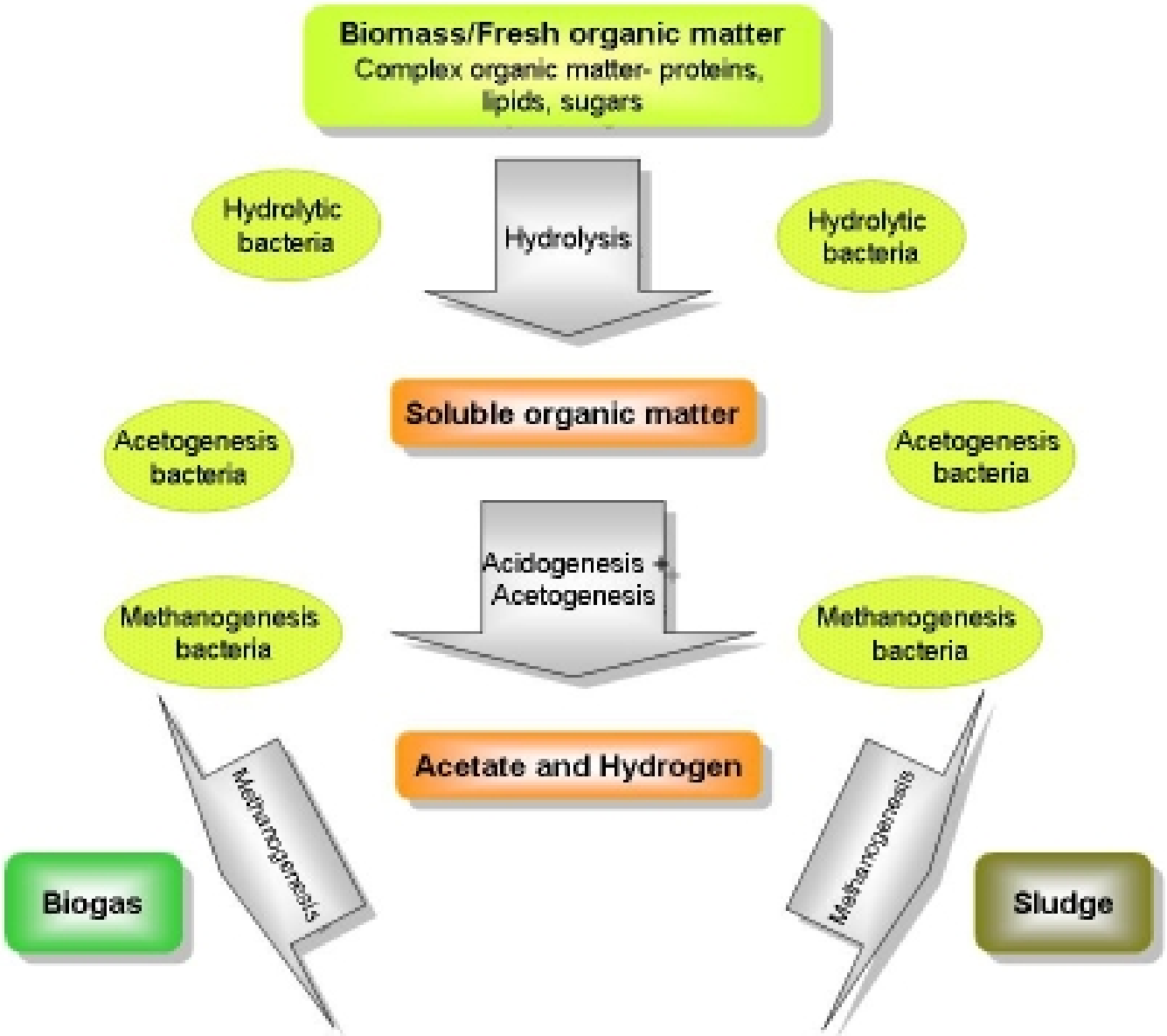
# Biomass Options

- Anaerobic Digestion
- Composting
- Landfill Gas

# Biosolids Digestion

- Anaerobic digestion considerations
  - Control temperatures
  - Generate digester gas
  - Add other fuel materials
    - FOG
    - Food waste
    - Yard waste


Step 1. Liquefaction
Step 2. Acid Production
Step 3. Biogas Production
End Products of Biogas Production from Manure
Liquefying Bacteria
Acid-Forming Bacteria
Methane-Forming Bacteria
Complex organic matter (raw manure, milkhouse waste, fine bedding material)
Liquefied soluble organic compounds
Insoluble compounds (water, inorganic material, insoluable organic matter)
Simple organic acids (including odorous)
Biogas (methane, $CO_2$, impurities)
Low-odor effluent


Biomass/Fresh organic matter
Complex organic matter- proteins, lipids, sugars
Hydrolytic bacteria
Hydrolysis
Hydrolytic bacteria
Soluble organic matter
Acetogenesis bacteria
Acetogenesis bacteria
Acidogenesis + Acetogenesis
Methanogenesis bacteria
Methanogenesis bacteria
Acetate and Hydrogen
Methanogenesis
Methanogenesis
Biogas
Sludge

- About 1 $ft^3$ of digester gas can be produced per person per day
- 1 $ft^3$ of digester gas can provide 2.2 watts of power
- Heating value of digester gas is 600 BTUs per $ft^3$
- For each 4.5 MGD processed at a WWTP, the generated digester gas can produce 100 kW of electricity and 12.5 million BTUs of thermal energy