Digester Gas: Uses and Considerations

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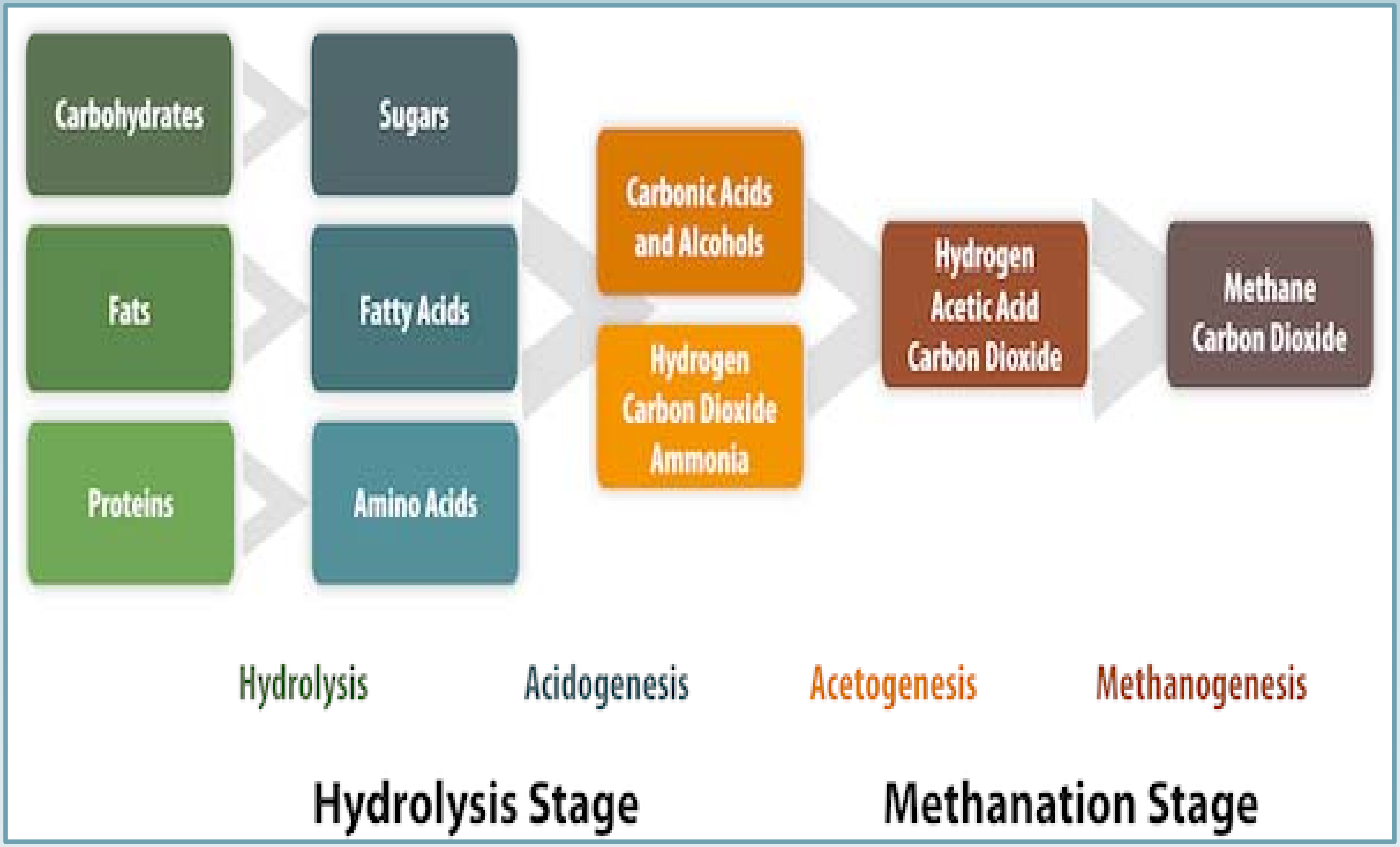
Where are we going?

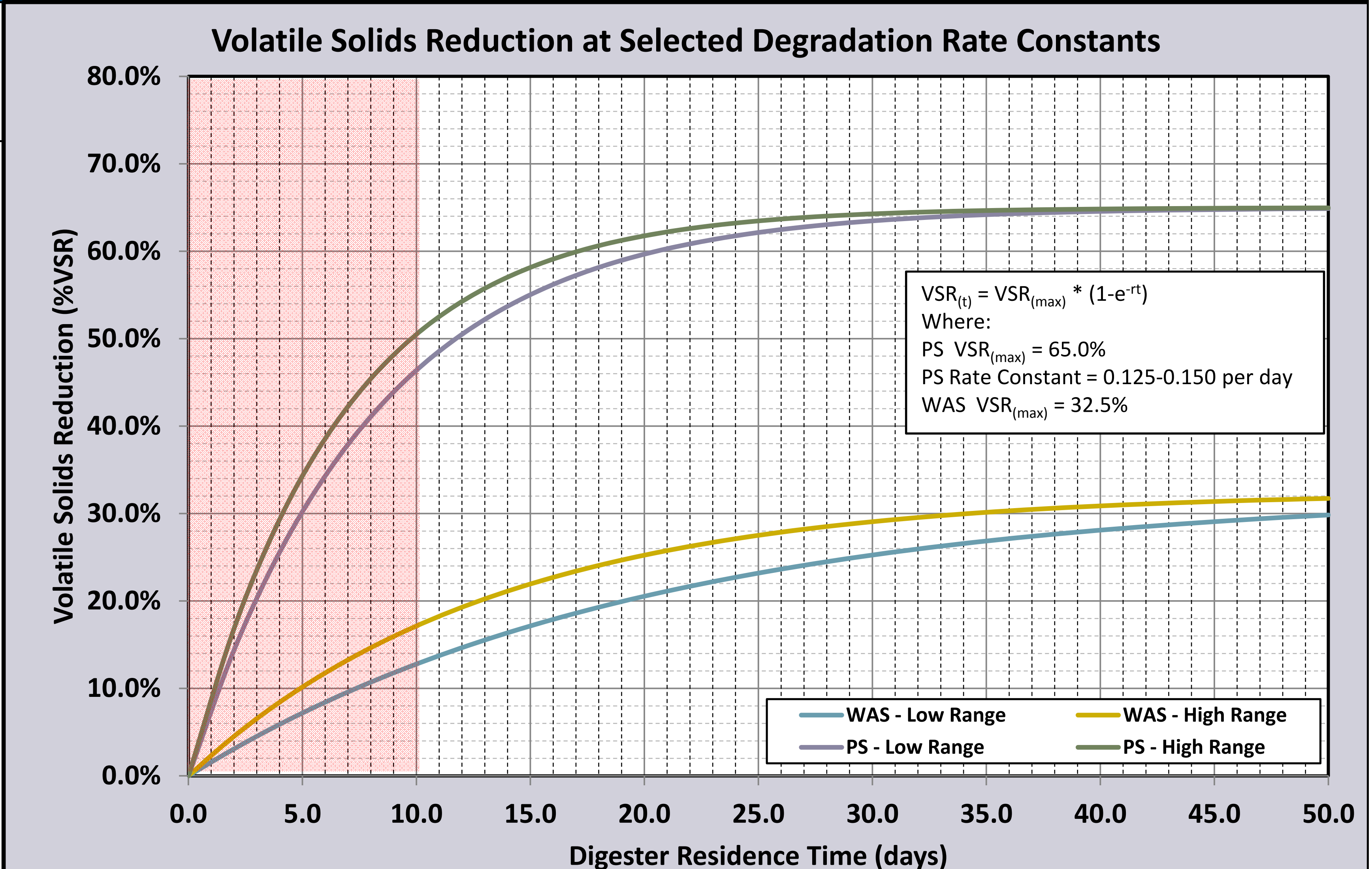
- Where does digester gas come from and how much can we make.
- Just what is in digester gas and why does that matter.
- Some important digester gas safety and handling considerations.
- Just what can we do with the digester gas.

WHERE DOES DIGESTER GAS COME FROM AND HOW MUCH CAN WE MAKE?

Anaerobic digestion converts complex organics into gaseous byproducts.



The specific digester feedstock will significantly impact gas yield.



Practical implications of the digester feedstock on digester gas production.

Plant Type	No Primary Clarifiers	With Primary Clarifiers	
		Primary	Secondary
Feed Solids Rate (lbs/MG Treated)	1,780 0.77 VS/TS	1,250 0.80 VS/TS	970 0.82 VS/TS
Digester MCRT (days)	20	20	20
Volatile Solids Reduction (% VSR)	22.5%	62.5%	22.5%
Volatile Solids Destroyed (lbs VSR/MG Treated)	310	625	180
Gas Production (SCF/MG Treated)	4,700	12,100	

Note: Sludge production estimate based on 250 mg/L influent BOD and TSS concentration, 10-day MCRT activated sludge process, 30% BOD removal and 60% TSS removal in primary clarifiers (where applicable), influent VS/TS fraction 0.80, 20% influent volatile solids un-degradable particulate solids, gas production rate of 15 SCF/lb VSR.

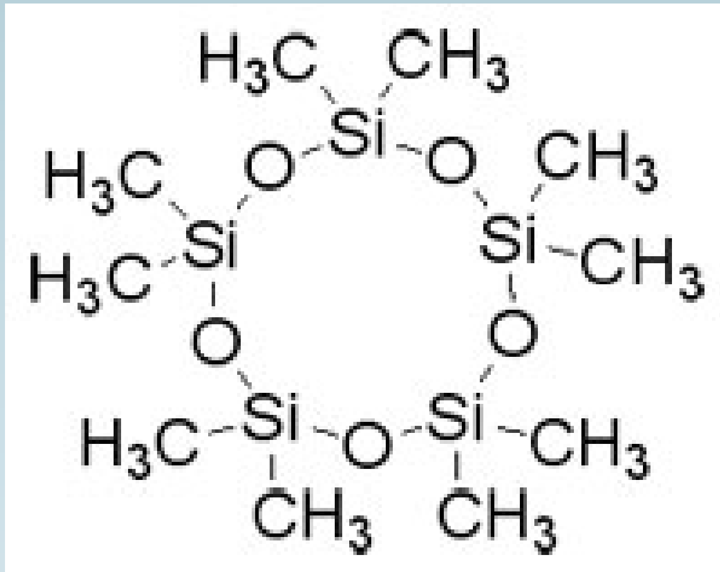
Off-site FOG/HSW can be co-digested to boost digester gas production rates.

JUST WHAT IS IN DIGESTER GAS AND WHY DOES THAT MATTER?

Macro-constituent (CH_4 and CO_2) are generally “predictable” for digester gas.

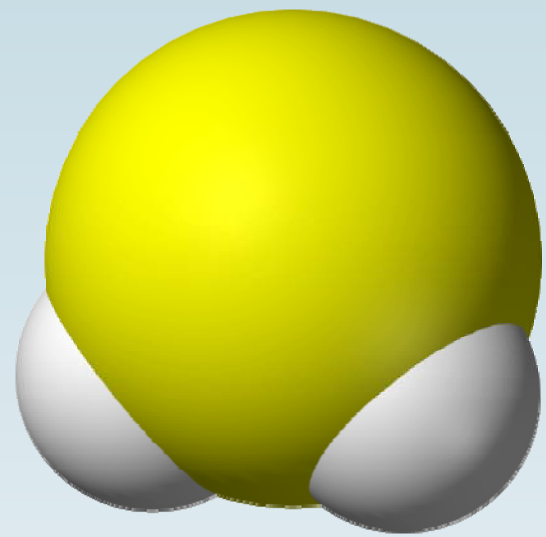
Location	Methane (by volume)	Energy Density (BTU/CFT)
North Durham WWTP (NC)	71.5%	722
Irwin Creek WWTP (NC) (Before Iron Sponge)	60.4%	610
Irwin Creek WWTP (NC) (After Iron Sponge)	61.6%	622
CFPUA Northside WWTP (NC)	66.7%	675
CFPUA Southside WWTP (NC)	61.7%	625
RWSA Moores Creek WWTP (VA)	58.7%	594
WVWA Roanoke WWTP (VA) (After Iron Sponge)	61.2%	621
Henrico County WWTP (VA)	70.6%	710

Its not the big things but the little (micro-constituents) things that cause issues.



Typical Siloxane Molecule
Decamethyl-cyclopentasiloxane

Hydrogen Sulfide
Molecule



Micro-constituent quality requirements vary depending on the downstream use.

	Hot Water Boiler	Internal Combustion Engine	Micro-Turbine
Moisture Removal	Preferred	YES	YES
Compression, psig	> 1.0	1-5	75-100
Hydrogen Sulfide, ppmV	N/A	< 1,000	< 25
Total Siloxanes, ug/L (as Silicon)	N/A	< 10	< 0.4
Total Siloxanes, ug/L (as Siloxane)	N/A	< 25	< 1.0
Total Siloxanes, ppbV	N/A	< 1,800	< 60

Hydrogen sulfide was the predominant sulfur species and concentrations varied

Location	H2S (ppbV)	Other Reduced Sulfur (ppbV)
North Durham WWTP (NC)	690,000	304
Irwin Creek WWTP (NC) (Before Iron Sponge)	52,000	559
Irwin Creek WWTP (NC) (After Iron Sponge)	N/D	44
CFPUA Northside WWTP (NC)	765,000	1,510
CFPUA Southside WWTP (NC)	250,000	2,287
RWSA Moores Creek WWTP (VA)	118,000	N/D
WVWA Roanoke WWTP (VA) (After Iron Sponge)	N/D	160
Henrico County WWTP (VA)	75,000	997

Iron sponge treatment can be very effective for sulfide removal.

Siloxane nomenclature and silicon mass fraction for commonly observed species

Name	Shorthand Descriptor	% Silicon (by mass)
Trimethylsilanol	TMS	31.14%
Hexamethyl-disiloxane	L2	34.59%
Octamethyl-trisiloxane	L3	35.62%
Decamethyl-tetrasiloxane	L4	36.16%
Hexamethyl-cyclotrisiloxane	D3	37.87%
Ocamethyl-cyclotetraisiloxane	D4	37.87%
Decamethyl-cyclopentasiloxane	D5	37.87%
Ocamethyl-cyclothexasiloxane	D6	37.87%

Siloxane following combustion generally leaves silicon deposits behind.

Images provided courtesy GE Jenbacher

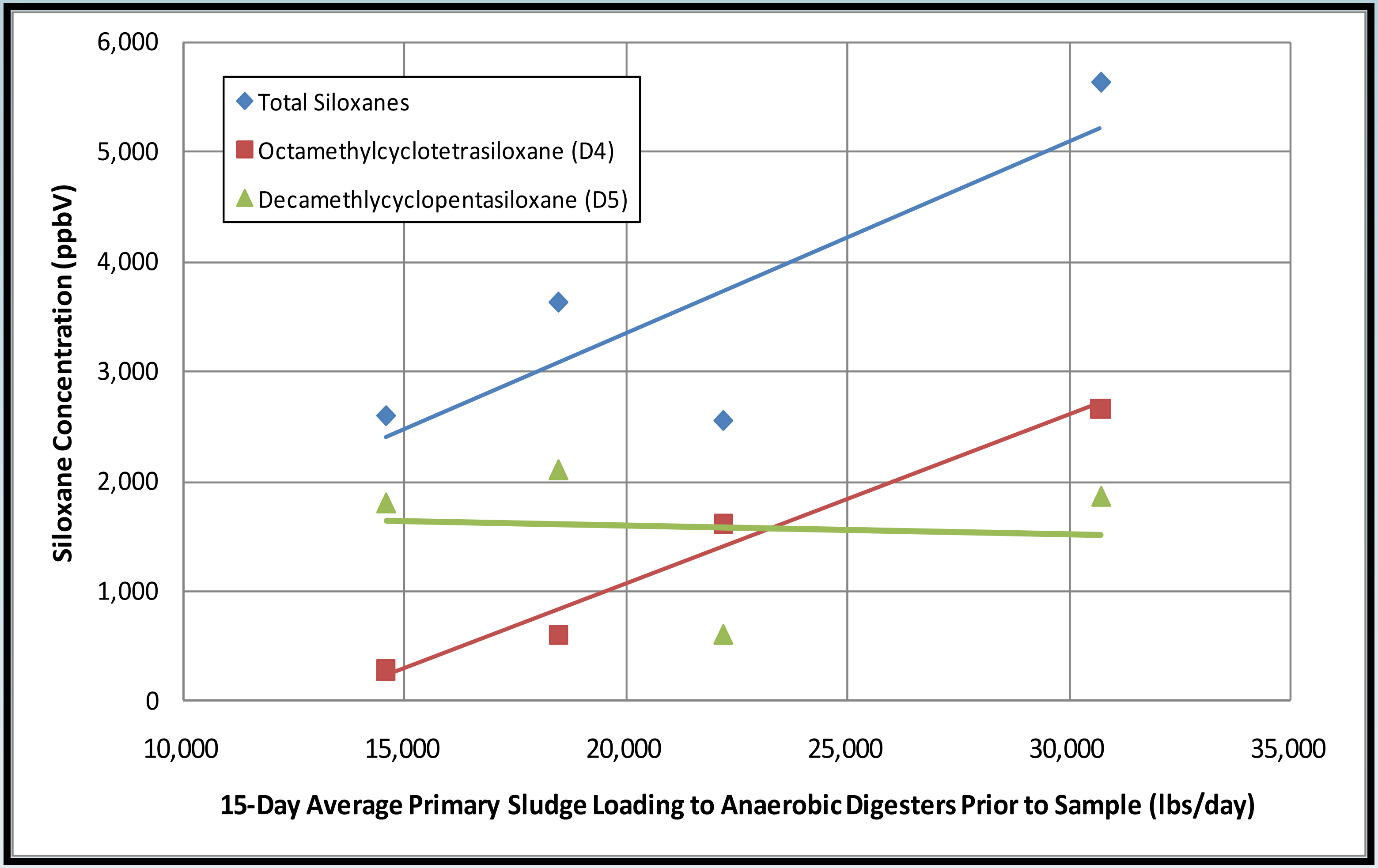
Total siloxane concentration varied widely among facilities sampled.

Location	Total Siloxane (ppbV)	Dominant Species
North Durham WWTP (NC)	3,103	D4
Irwin Creek WWTP (NC) (Before Iron Sponge)	375	D3
Irwin Creek WWTP (NC) (After Iron Sponge)	740	D3
CFPUA Northside WWTP (NC)	1,457	D5
CFPUA Southside WWTP (NC)	2,246	D5
RWSA Moores Creek WWTP (VA)	2,569	D5
WVWA Roanoke WWTP (VA) (After Iron Sponge)	3,477	D5
Henrico County WWTP (VA)	747	D5

At a single plant siloxane content can vary widely over time.

Location	11/15/09	12/14/09	01/11/10	02/09/10
Methane Content, % (vol)	60.9%	60.6%	57.2%	59.4%
Energy Density, BTU/CFT	619	615	581	604
Hydrogen Sulfide, (ppmV)	102	84	114	136
Total Siloxane, (ppbV)	2,595	5,626	3,627	2,551
Dominant Species	D5	D4	D5	D4
D4 Concentration, (ppbV)	280	2,660	610	1,610
D5 Concentration, (ppbV)	1,800	1,860	2,100	610

Sampling data may indicate some affinity of D4 siloxane to primary sludge feed



Activated carbon filtration is commonly used for siloxane treatment.

SOME IMPORTANT DIGESTER GAS HANDLING AND SAFETY CONSIDERATIONS

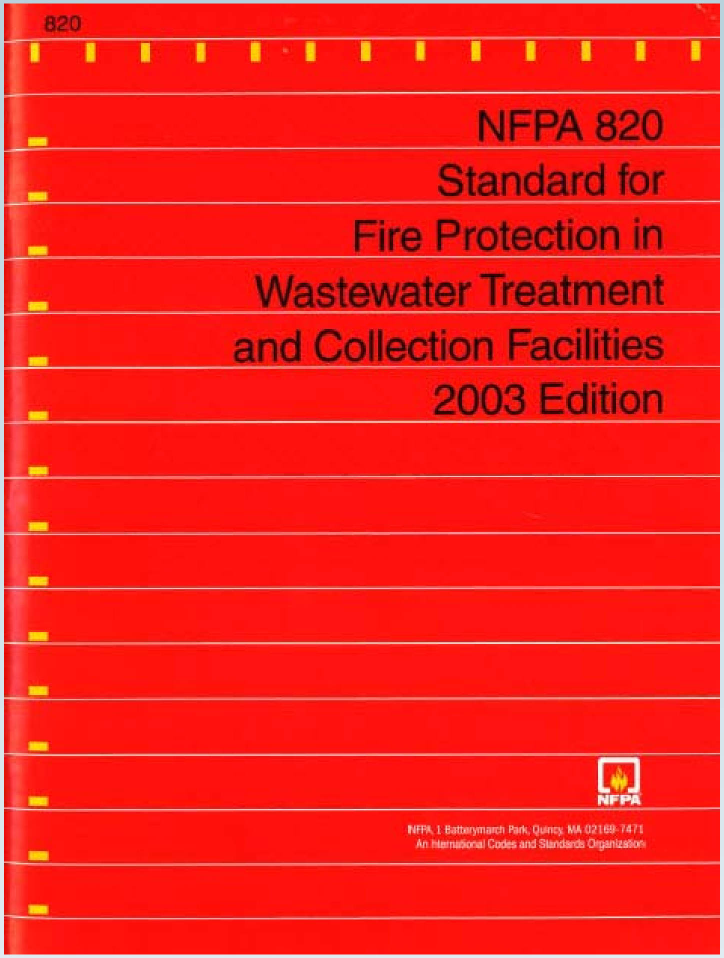
Gas handling and safety equipment is required to properly manage the gas.

Gas storage will also require special considerations for sizing and safety.

Gas cleaning and treatment may also require special considerations.




Special considerations are outlined for digester facilities in NFPA 820.



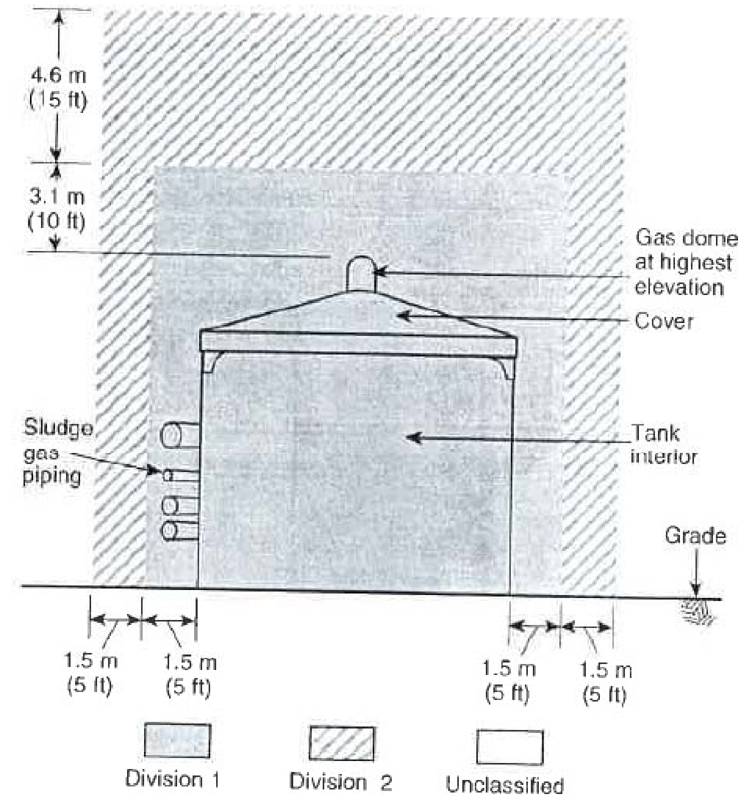


FIGURE A.6.2(a) Anaerobic Digester with Fixed or Floating Cover Above Grade Not Enclosed in a Building; Illustration of Table 6.2(a), Rows 15a and 15b.

Low ventilation rates require area be classified under NEC as a "C1/D1" space.

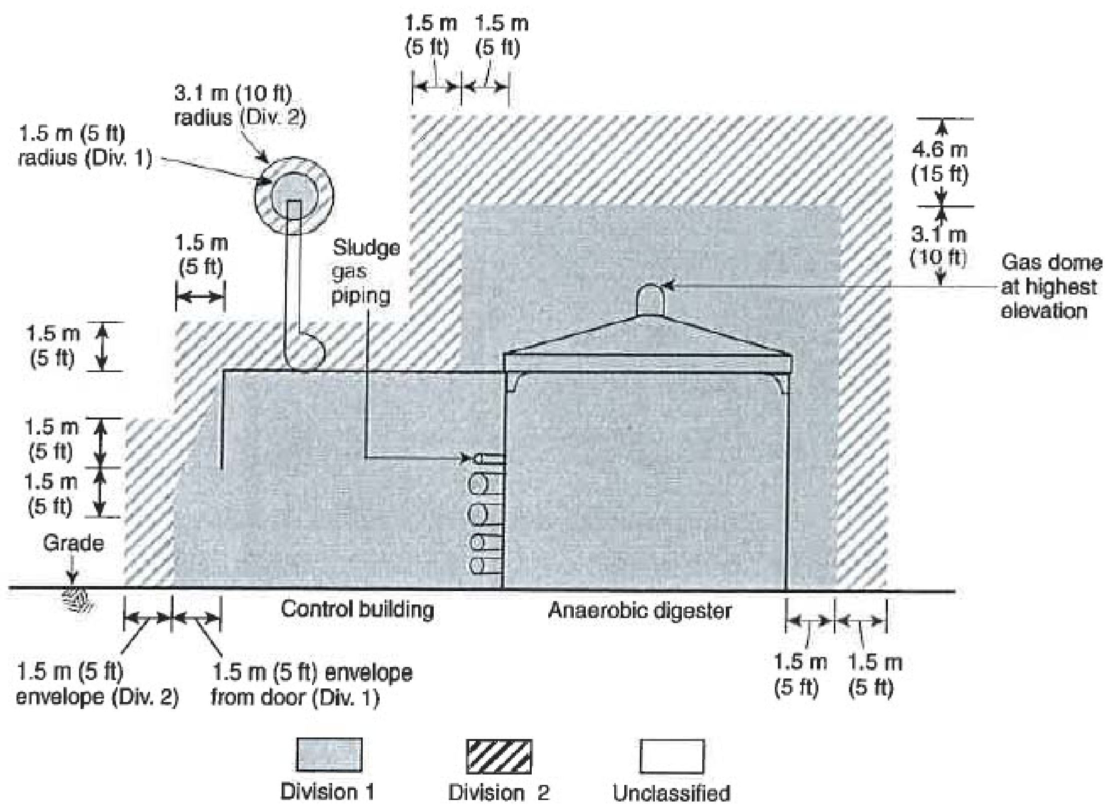


FIGURE A.6.2(b) Anaerobic Digester Control Building Containing Sludge Gas Piping and Using Ventilation Method (A); Illustration of Table 6.2(a), Row 16a.

Gas safety equipment and processing equipment trigger space classification.

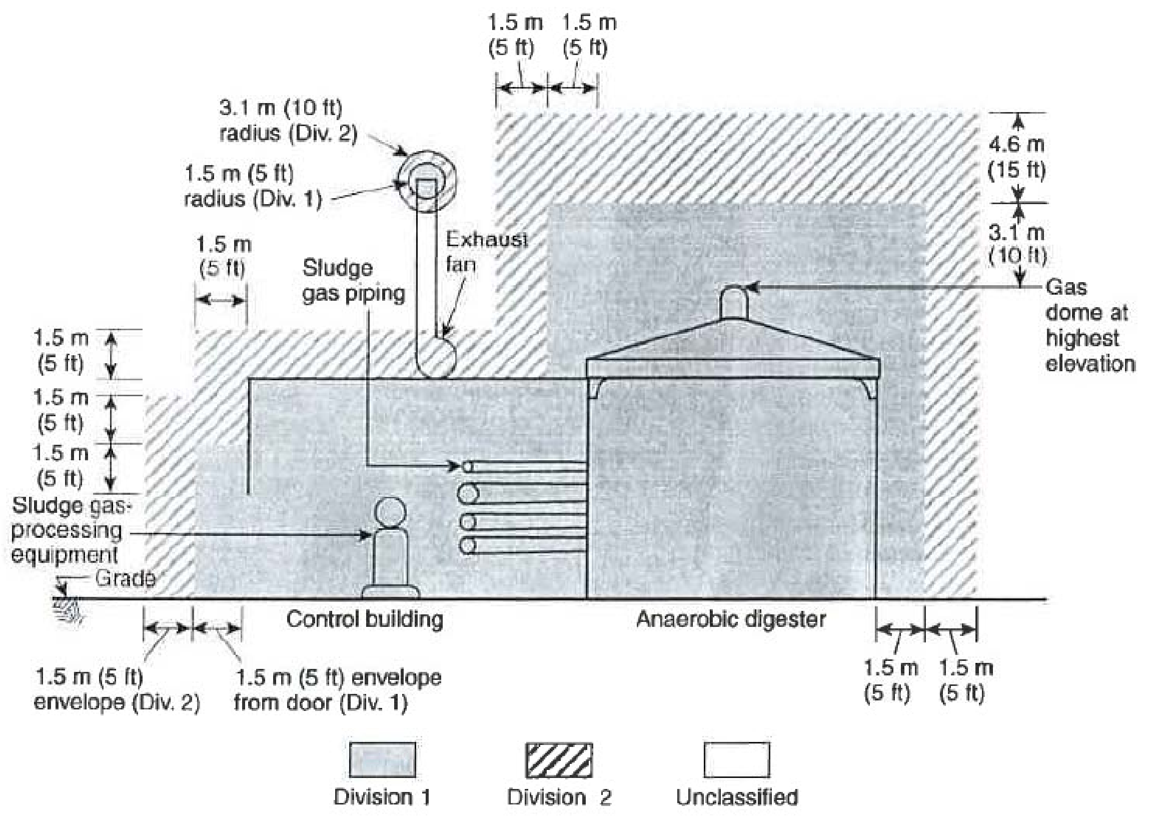


FIGURE A.6.2(e) Anaerobic Digester Control Building Containing Sludge Gas–Processing Equipment not Physically Separated and Using Ventilation Method (A); Illustration of Table 6.2(a), Row 16.

Ventilation and physical separation can provide some relief from classification.

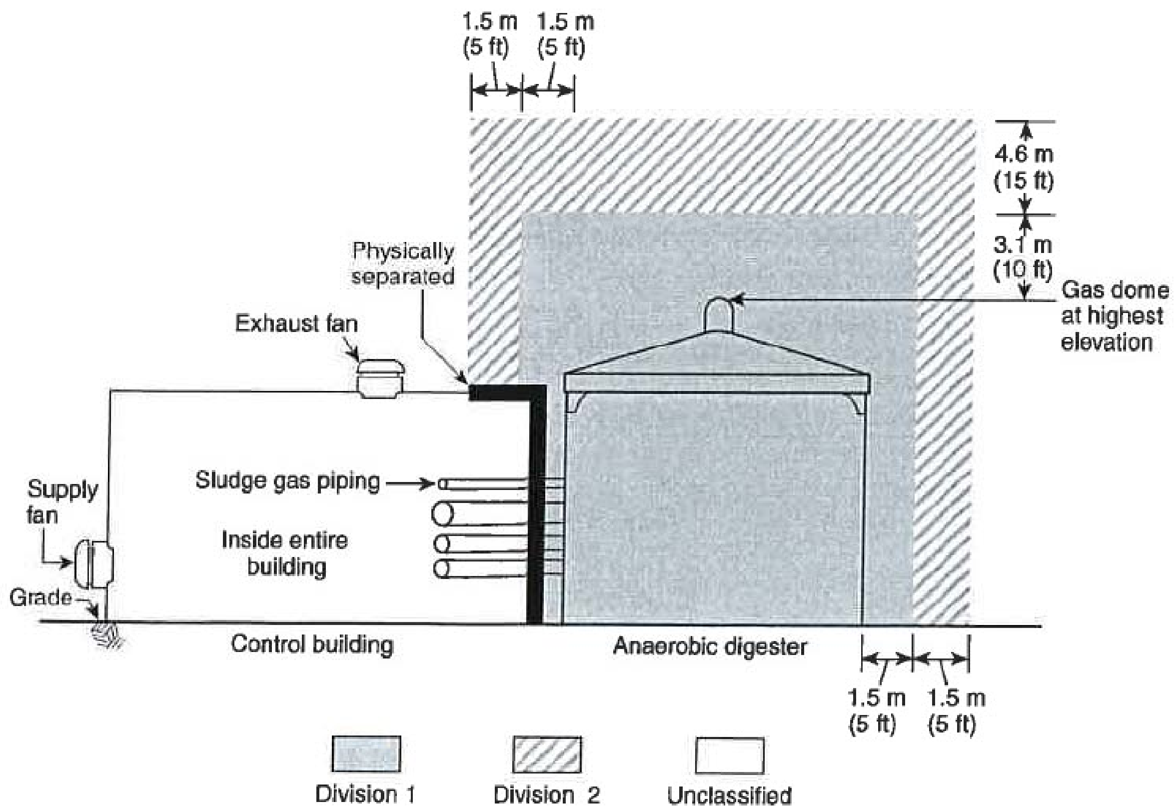


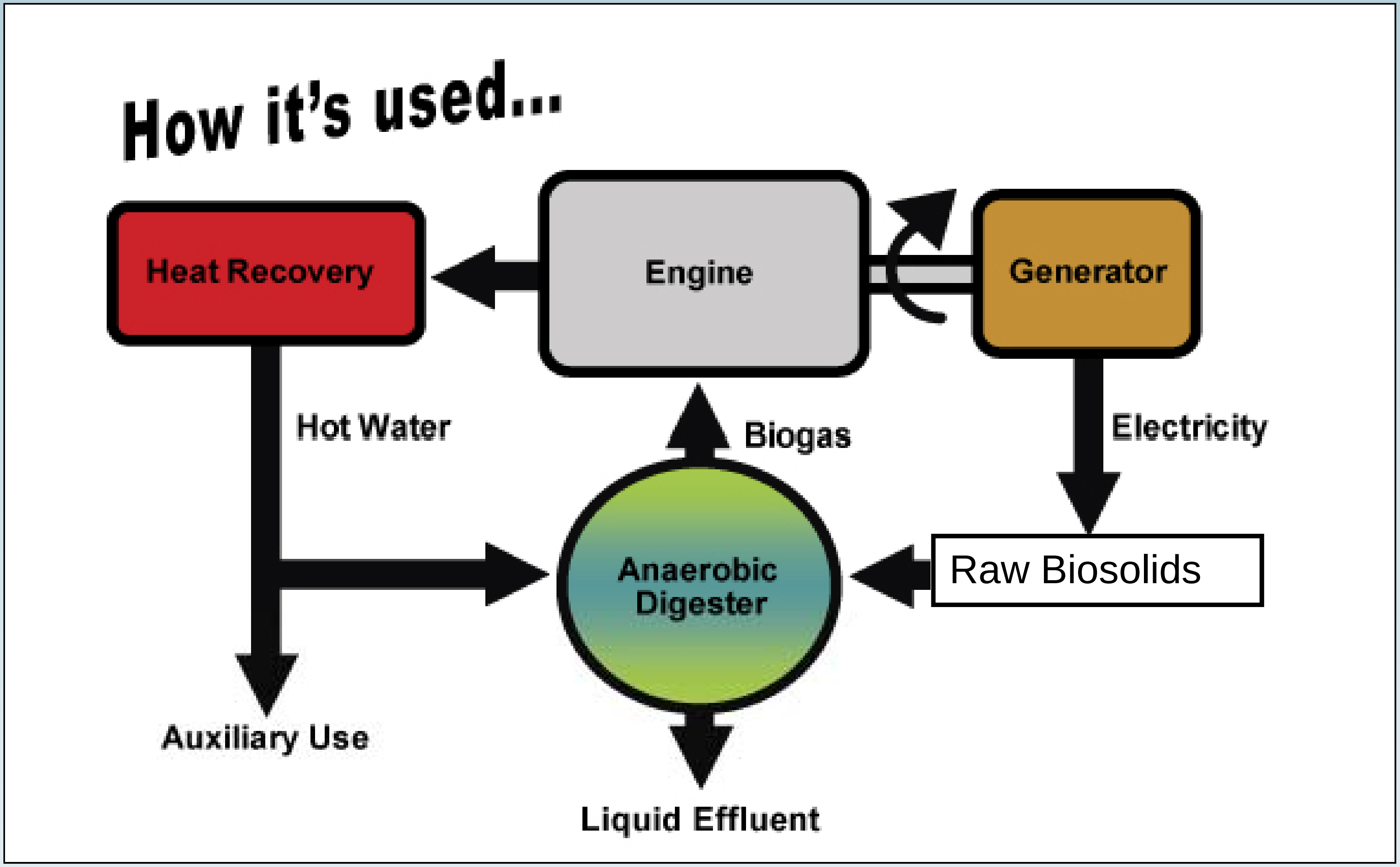
FIGURE A.6.2(c) Anaerobic Digester Control Building Containing Sludge Gas Piping and Using Ventilation Method (C); Illustration of Table 6.2(a), Row 16c.

JUST WHAT CAN I DO WITH DIGESTER GAS?

Unfortunately, you can always waste the digester gas.

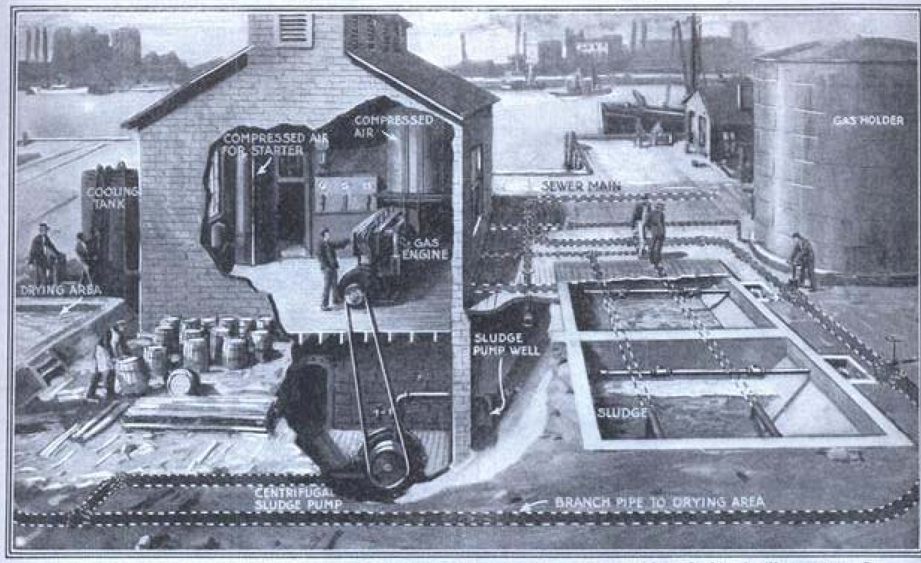
Use it in a hot water boiler for process and/or building heating.

Gas can be beneficially used to make both thermal and mechanical energy.



“Sewage Gas” utilization for on-site power production really isn’t all that “new”.

Gas from Sewage Waste Runs City Power Plant



How the sewage disposal plant at Birmingham, England, supplies its own power is described in the illustration. Gas from the sewage drives an engine of 20 brake horsepower, which operates a centrifugal sludge pump

SEWAGE that costs large cities tremendous sums each year can be turned into a source of power equivalent to thousands of tons of coal! The waste now dumped into rivers or shipped to sea may be used to run factories or to light buildings!

That conversion of sewage into power is possible has been proved conclusively by the city of Birmingham, England. There a suction gas engine of 20 brake horsepower has been successfully driven by the gases given off by sewage sludge.

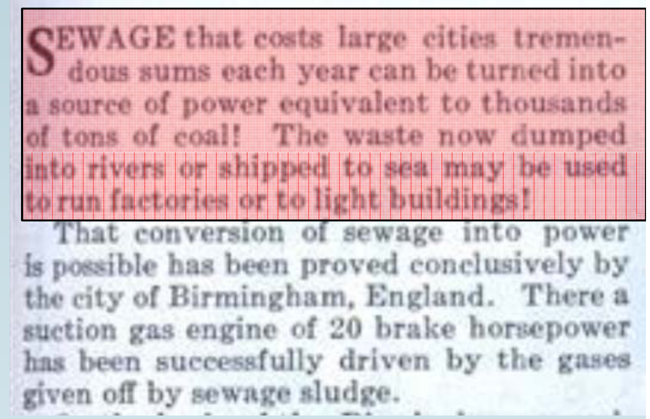
On the basis of the Birmingham experiments, an American city that must now pay for the disposal of 400,000 tons of sewage sludge a year might produce 320,000,000 cubic feet of gas suitable for heat and power, or, in terms of energy, 16,000,000 horsepower hours at 20 cubic feet per brake horsepower.

The apparatus for producing gas from sewage consists of two sludge digestion tanks in which the sewage is allowed to ferment. The gases given off are composed of from 25 to 75 per cent of methane, or marsh gas.

A gas engine of the usual type will run on sewage gas without adjustment of the valves. Sewage gas has a higher calorific value than some illuminating gas, averaging about 650 thermal units to the cubic foot, as against 550.

The Birmingham engine runs about six hours a day and is used to operate a centrifugal sludge pump that moves the wet sludge from the gas-generating tank to the drying grounds. In this process a small proportion of the waste material produces enough power to run the pumps of the sewage disposal plant. If all the material were used, there would probably be enough gas available to light the city.

Popular Science 1922



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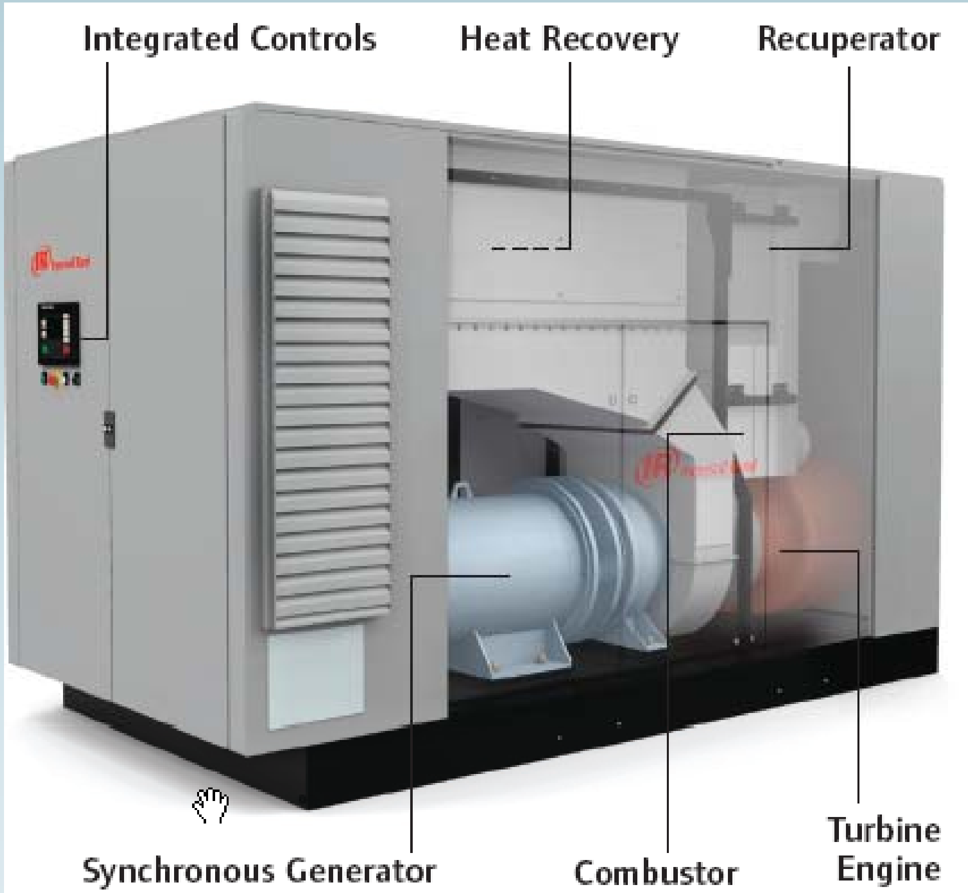
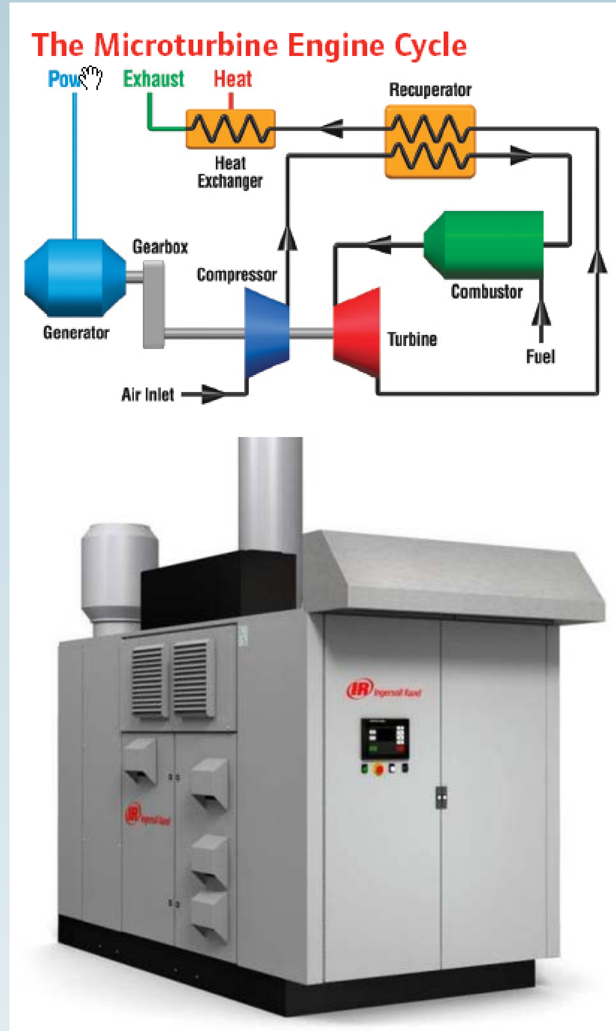
Boy haven’t we come a long way in the last 90 years….

Digester gas for on-site power production still makes good sense in 90 years later.

- Digester gas is a "free" fuel source.
- Typical gas production rates can meet between 20% to 40% of a plant's power demand.
- As a renewable fuel it reduces GHG emissions.

Microturbine systems are available in sizes from 30kW to 300kW output





…ges: Courtesy Ingersoll-Rand

A containerized 350 kW RICE-GEN unit in Charlottesville, VA.

A large 2,150 kW containerized RICE-GEN CHP system near Atlanta, GA.

One (of two) 550 kW installed in an existing building in Roanoke, VA.

1,600 kW output unit retrofitted into an existing building in Atlanta, GA.

Some other options are also out there for biogas utilization, including:

- Stirling Engines
- Fuel Cells
- Pipeline Injection
- Automobile Fuel

The three big take-away items!

- Digester gas can be a valuable resource for on-site energy production.
- Special consideration should be given to safety and handling of digester gas.
- Digester gas treatment may be required before you can beneficially utilize the resource – the small things (hydrogen sulfide and siloxanes) can matter.

Questions