



The Solutions Network

Rochester, New York

Use of WWTP Digester Gas to Generate Power

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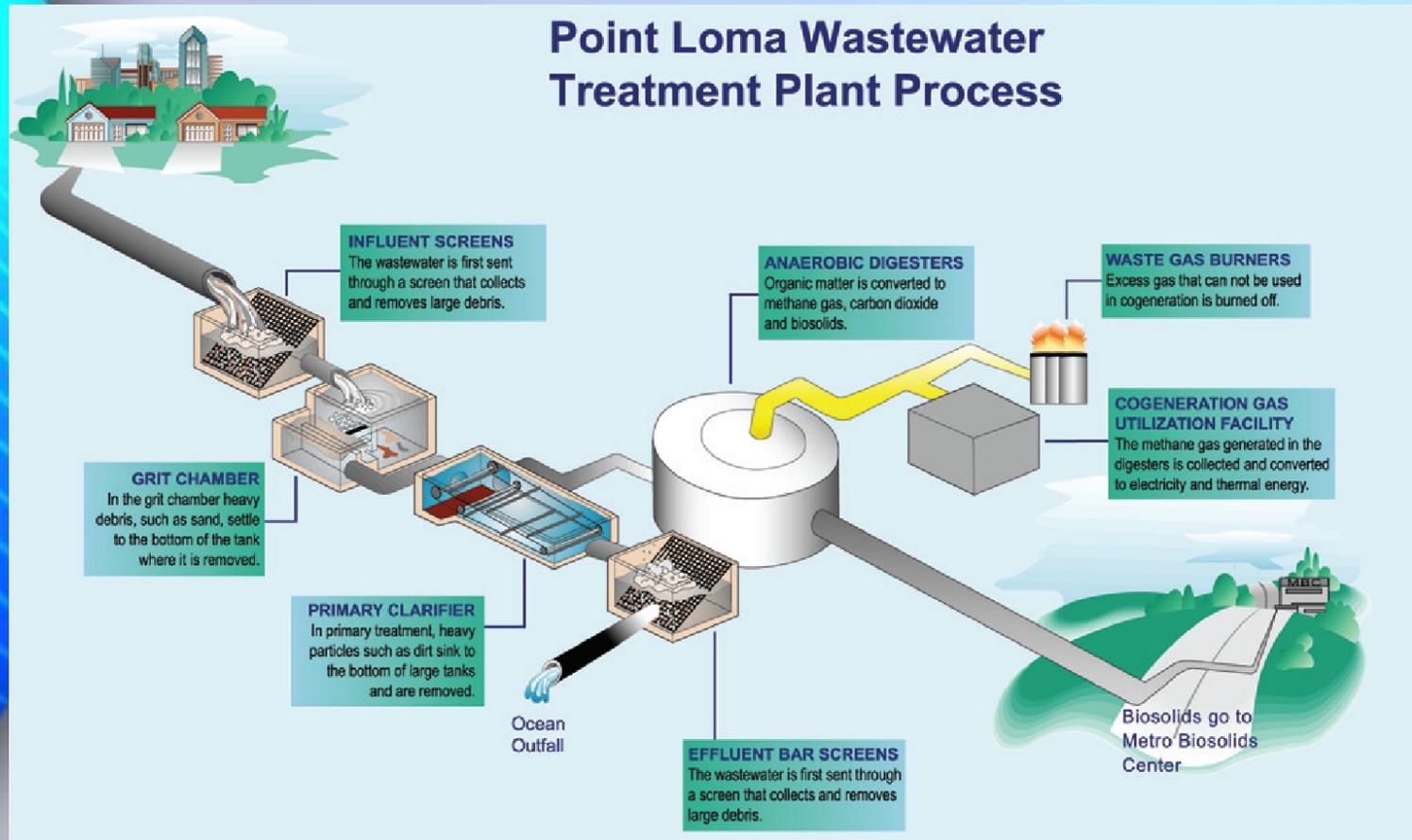
Overview

- ❖ What is WWTP Digester Gas?
- ❖ Applications
- ❖ Process Issues
- ❖ WWTP Gas to Power

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Wastewater Treatment Plant





Wastewater Treatment Process

- ❖ Preliminary Treatment
- ❖ Primary Treatment
- ❖ Secondary Treatment
- ❖ Tertiary Treatment
- ❖ Sludge Thickening
- ❖ Sludge Dewatering
- ❖ Digestion and Stabilization

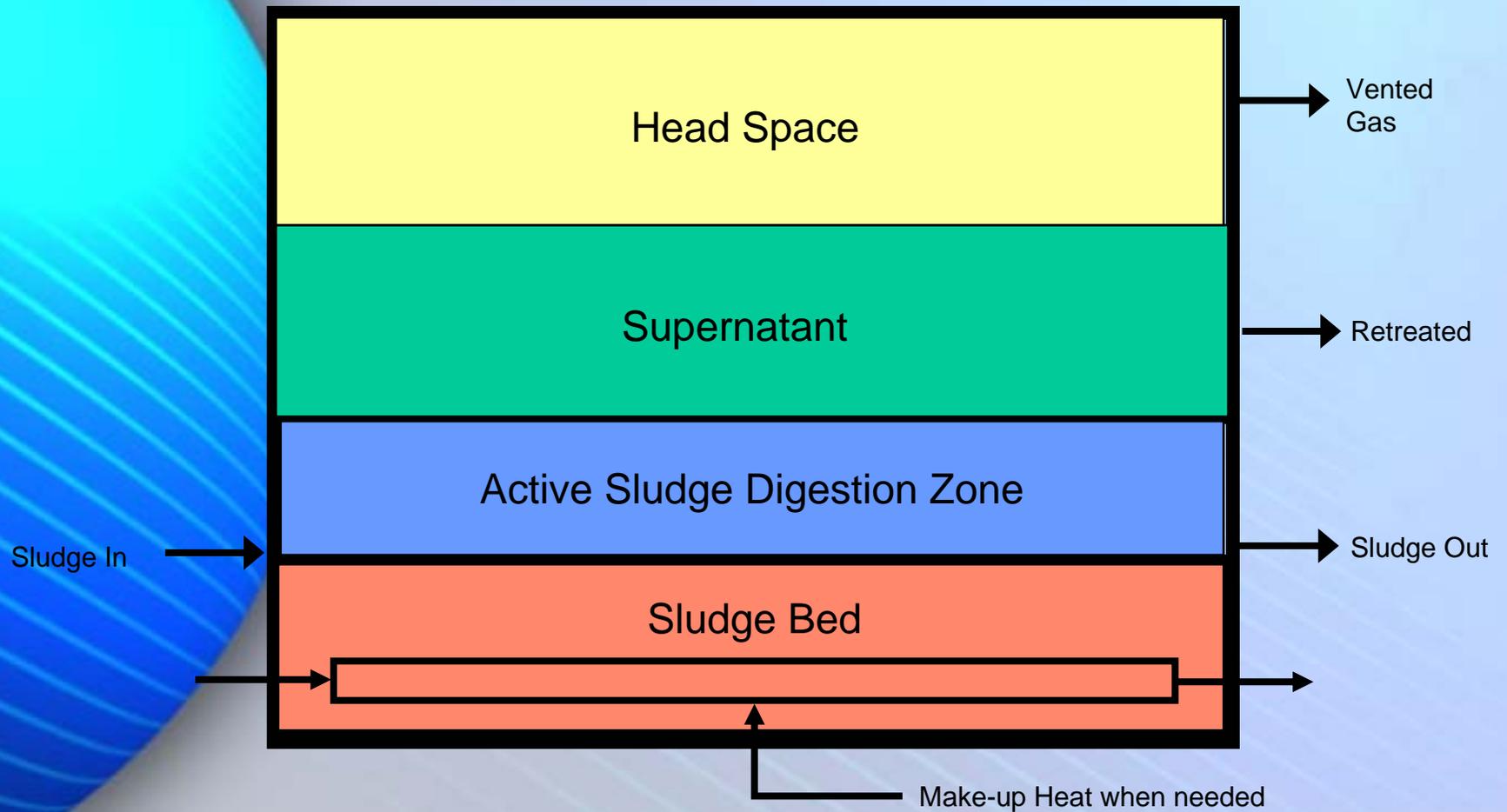


Anaerobic Digestion

- ❖ Sludge & resident anaerobic bacteria pumped into large covered tank, anaerobic conditions
- ❖ Temperature 90 - 95 °F, pH circum-neutral
- ❖ Supernatant and scum periodically returned to beginning of the treatment process
- ❖ Sludge allowed to sit for 1 – 3 months



Anaerobic Digester



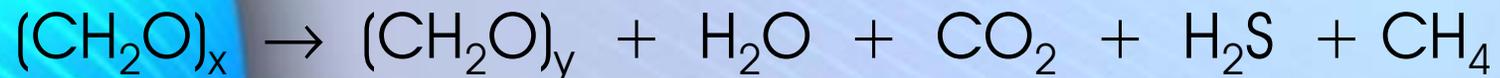
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Anaerobic Digestion

- ❖ Bacteria (methanogens, SRB) metabolize complex hydrocarbons in the sludge



- ❖ Gas collects in head space, periodically drawn off (Typical production = 1 scf / capita / day)
- ❖ Even small concentration of H_2S problematic
 - Odor
 - Corrosive properties



Anaerobic Digestion

Optimum Temperature	95 - 98 °F
Optimum pH	6.7 - 7.8
Gas production	7-10 ft ³ /lb volatile solids
Gas composition	64% CH ₄ , 35% CO ₂ , trace H ₂ S
Gas heating value	600 Btu/ft ³
Retention time	30 – 90 days
Typical tank diameter	20 – 115 ft



Digester Gas to Power

- ❖ Substitute for natural gas
- ❖ Internal combustion (IC) engines
- ❖ Small gas turbines & Microturbines
- ❖ Sterling engines
- ❖ Fuel cells

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Reciprocating Engines

- ❖ Most common choice for DG applications
- ❖ Wide capacity range (1 kw – 6 MW)
- ❖ Wide range of fuels (liquid and gaseous)
- ❖ Feed rates from under 5,000 scf/day
- ❖ Can utilize low BTU gas – some models as low as 300 Btu/scf



Reciprocating Engines

- ❖ Proven and reliable technology
- ❖ Tolerate H₂S in the 200 ppm range
- ❖ Generally more emissions problems than other types of equipment but cleanup is understood
- ❖ Heat from exhaust can be used to heat digester
- ❖ Lowest capital cost at 300 – 500 \$/kW



Microturbines

- ❖ Better for smaller operations – “plug and play” for pipeline quality gas
- ❖ Small “modular” units available: 30 – 100 kW
- ❖ Inlet pressures from 0.2 to 55 psi
- ❖ Inlet temperatures from – 20 to 50 °C
- ❖ Feed rates from 10,000 – 40,000 scf/day
- ❖ Some models tolerate high levels (7%) H₂S



Microturbines

- ❖ Heat from exhaust can be used to heat digester
- ❖ Low NO_x (< 9 ppm – most models)
- ❖ Most run on air bearings having only one moving part (the central shaft with turbine) → less maintenance than reciprocating engines
- ❖ Cost is 1,000 -1,500 \$/kW
- ❖ For large plants good strategy to use recips for bulk of power and use microturbines for peaking power

Fuel Cells

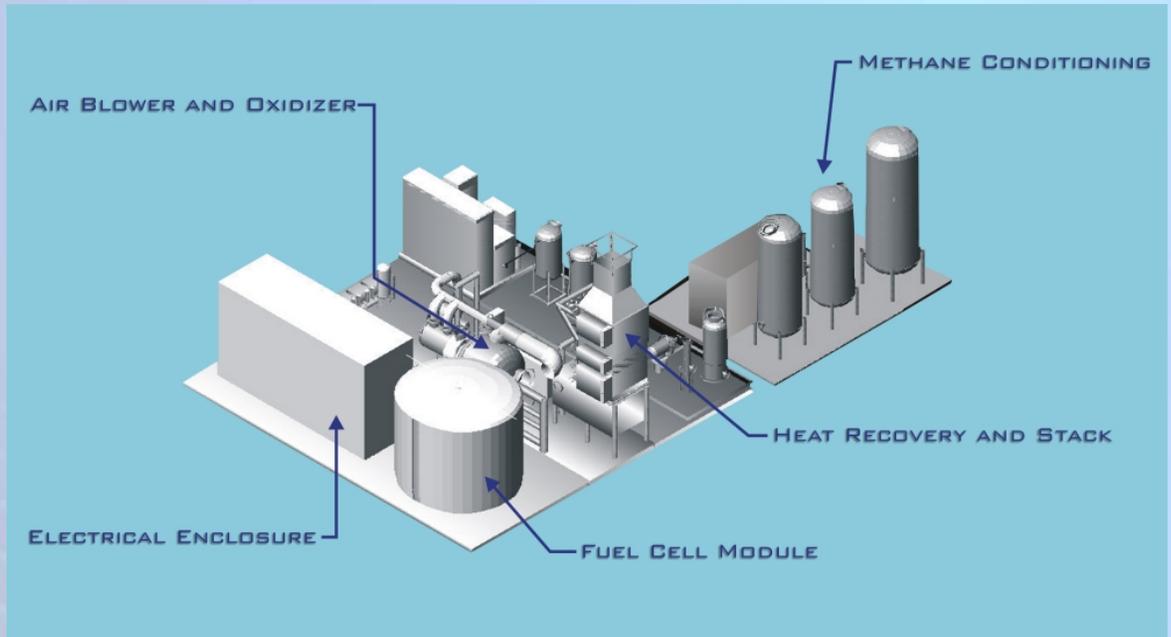
- ❖ Low Emissions

- H₂O
- Heat

- ❖ Heat used for digesters

- ❖ Low O&M costs – no moving parts

- ❖ High capital cost > 2,000 \$/kW





Success Story 1

- ❖ Point Loma, San Diego Metropolitan WWT Dept.



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Point Loma

- ❖ Treats up to 240 MGD
- ❖ Two reciprocating engine generators – 4.5 MWe
- ❖ Exhaust heat – heats digesters
- ❖ Dual fuel recip. engine generator – 1.2 MWe
- ❖ In 2000:
 - saved \$3 million energy costs
 - sold \$1.4 million to grid



Success Story 2

- ❖ South Treatment Plant – King County (Seattle) Washington



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South Treatment Plant

- ❖ Uses a Binax scrubber to remove CO₂, H₂S and Siloxanes
- ❖ Scrubber produces pipeline quality gas, sold to Puget Sound Energy
- ❖ Can use two 3.5 MWe Solar turbine/generators (under construction)
- ❖ Lessons learned: removing the CO₂ from digester gas is expensive
 - Better to utilize lower Btu gas
 - Occasionally has been cheaper to flare than to run the scrubber



South Treatment Plant

❖ Alternative Usage of Unscrubbed Gas

- Can use in 1 MWe molten carbonate FuelCell Energy fuel cell
- Fuel with CO₂ is preferred
- H₂S removed with SulfaTreat



Success Story 3

- ❖ West Point Treatment Plant
King County
(Seattle)
Washington



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West Point Treatment Plant

- ❖ 133 MGD, 1.4 mmscfd digester gas
- ❖ Two 1.3 MWe recip. engine generators
- ❖ Exhaust heats LP boilers producing steam for digesters
- ❖ Engines have modified carburetors to use lower Btu gas



Digester Gas to Power

❖ Other Issues to Consider:

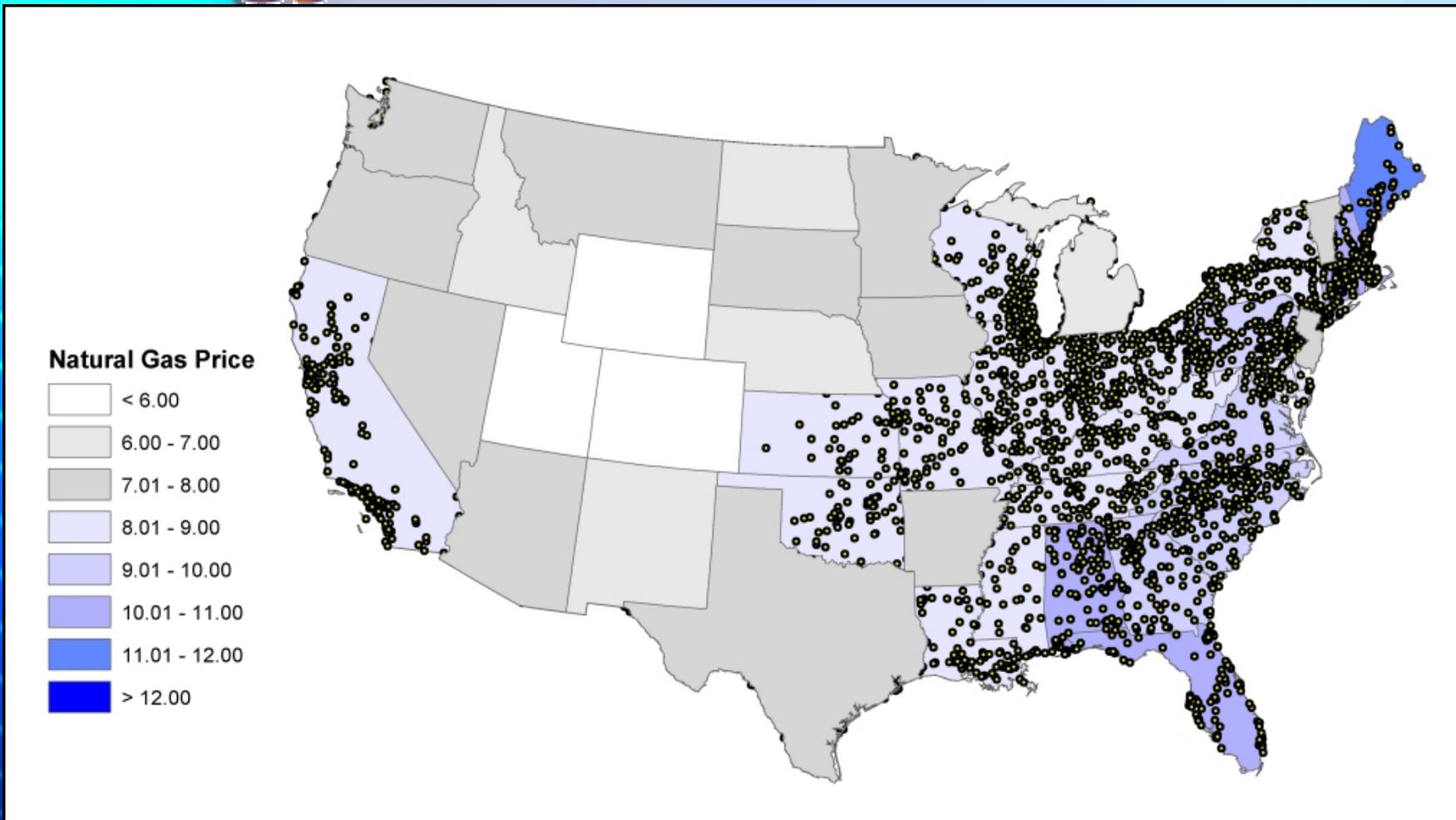
- Availability
- Economics
- Energy Security
- Regulations & Environment
- Contracts

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Natural Gas Prices

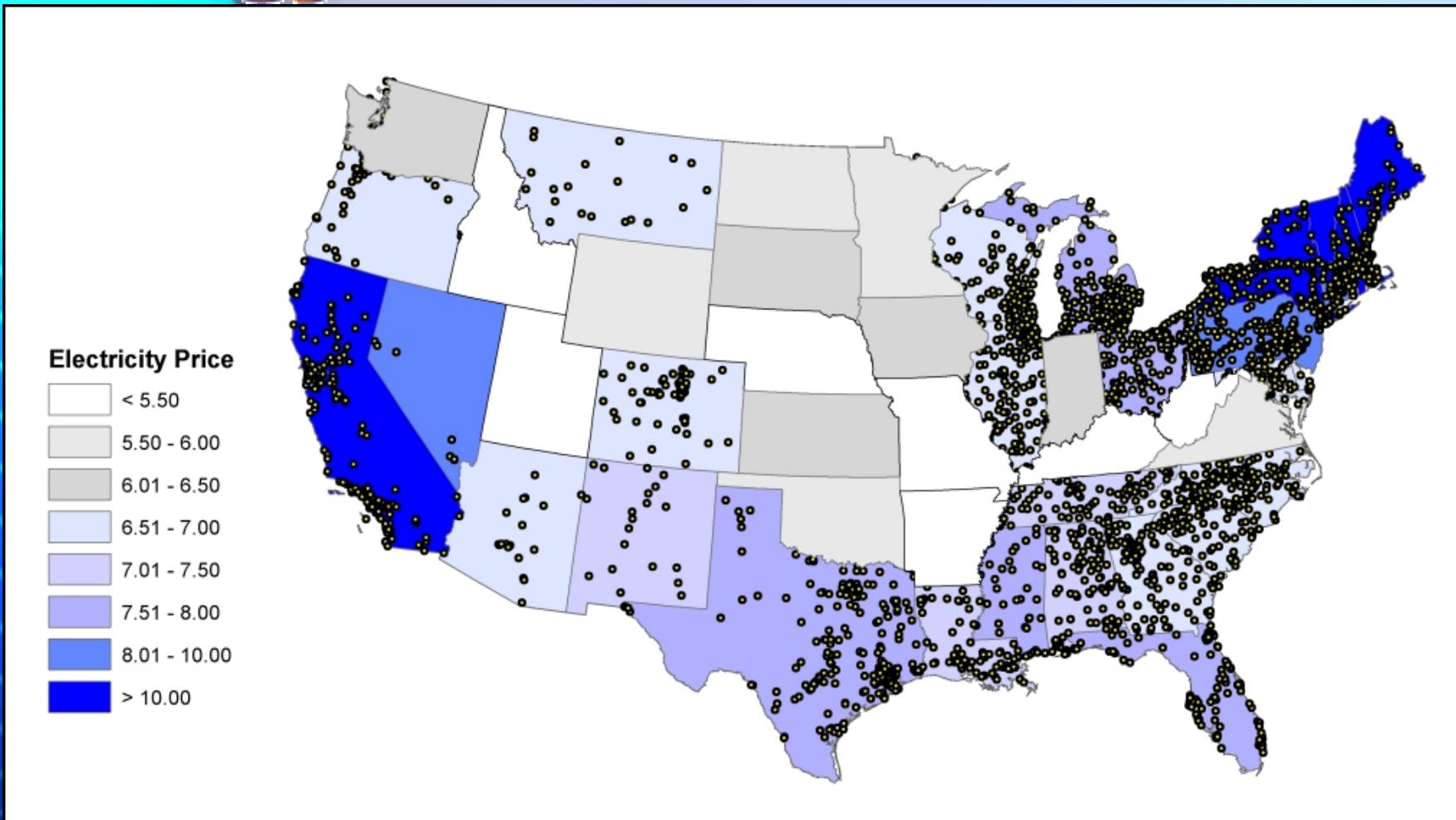


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Electricity Prices



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Economic Evaluation

- ❖ Digester gas cost includes base price plus:
 - Cost of H₂S and H₂O removal
 - Cost of transportation
 - pipeline construction
 - land right of ways, etc.
 - Cost of gas conditioning (i.e. compressing, etc.)
 - Special adaptation to combustors or engines



Economic Evaluation

- ❖ Can be a long-term, low cost renewable fuel source for generating electricity and heat
- ❖ Requires in-depth economic comparison to competing fuel and/or energy sources
- ❖ Issue is further complicated when digester gas availability fluctuates during the year
- ❖ Mitigating factor: digester gas can be burned in combination with natural gas, landfill gas, and other organic waste materials



Economic Evaluation

❖ Issues to Take into Account

- Use of certain renewable and alternative fuel sources to generate electricity qualifies for green tax credits
- The tax credits can be used to improve the financial viability of a project either directly or through their sale



Economic Evaluation

❖ Issues to Take into Account

- Explore state incentives for use of green and/or renewable fuel sources to generate power
- Explore utility company incentives for use of green and/or renewable fuel sources to generate power



Economic Evaluation

❖ Issues to Take into Account

- Include avoided costs when performing financial evaluation
- Consider value to customer of protection from grid outages and volatility of competing fuel costs
- Consider any potential O&M Savings



Successful Approaches

- ❖ Use digester gas in combination with other locally available renewable resources
- ❖ Generate as much electricity (or heat) as you can, use what you can at the facility, sell the rest
- ❖ When using digester gas and other renewables to generate electricity, capture and use process heat, i.e. CHP



Digester Gas to Power

❖ Resources are Available:

- DOE's Office of Energy Efficiency and Renewable Energy
- Federal Energy Management Program
- FEMP's Biomass and Alternative Methane Fuels (BAMF) Super ESPC group
- EPA Office of Wastewater Management (OWM) for general information, laws and regulations, permitting and location data for WWTPs
 - <http://www.epa.gov/owm>
- Water Environment Federation (WEF), the national WWTP trade association
 - <http://www.wef.org>



Digester Gas to Power

❖ BAMF

- Streamlined contracting vehicle for federal facilities to utilize digester gas (and other fuels)
- Financing alternative to Congressional appropriations
- Trained and experienced technical core team
- More information available from:
 - NETL booth
 - FEMP booth
 - Workshop "BAMF Baseball"

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Conclusion

- ❖ Use of digester gas in generating electricity and/or steam can be an attractive approach especially when used in combination with conventional or other renewable fuels
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