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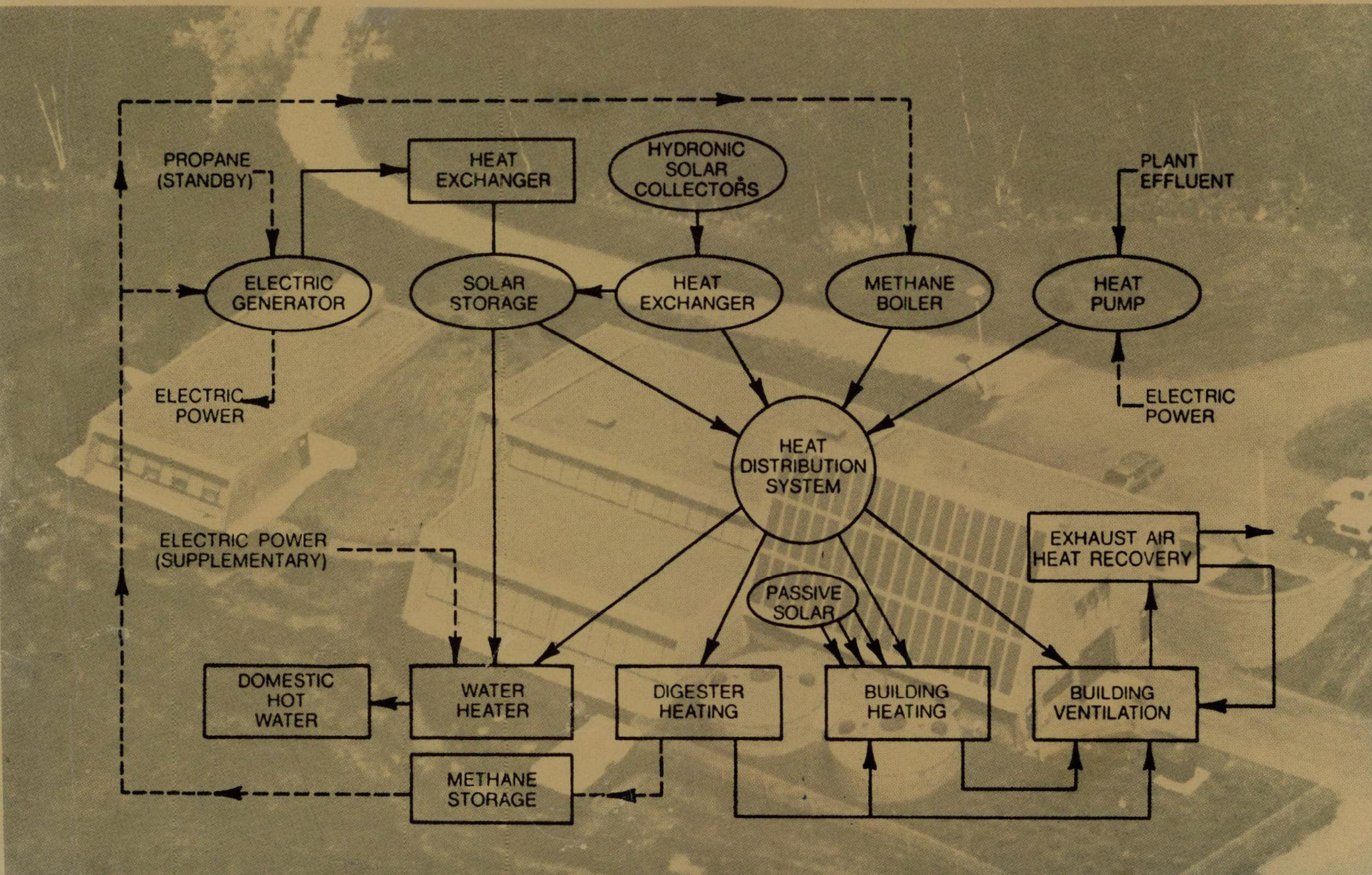
Energy Conservation In Wastewater Treatment

Chapter II

Considerations For Design Concepts and Operational Parameters



ENERGY CONSERVATION IN WASTEWATER TREATMENT

Considerations for
Design Concepts and Operational Parameters

Chapter II

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Cover: The Wilton, ME Wastewater Treatment Plant - *Photo and diagram courtesy of the design engineers Wright, Pierce, Barnes, Wyman Engineers of Topsham, ME.* The design makes use of passive and hydronic solar collectors, along with digester gas, to heat and otherwise fuel the facility.

Energy Conservation in Wastewater Treatment

Consideration for Design Concepts
and Operational Parameters
U.S. EPA Region 1

Introduction

This document is the second in a series prepared in response to a National effort directing our immediate attention to excessive use of energy in the treatment of the Nation's wastewater streams. Subsequent chapters will be written to update the information contained herein and to present new case histories of energy-efficient plant designs and operations as we learn of their existence.

The first chapter identified general energy conservation measures being employed by treatment facilities in Region 1, and recommended new measures that should be considered when planning and designing future wastewater treatment plants.

Three sections are presented in this chapter. The first section focuses on energy-saving design concepts employed by the Wilton, Maine Wastewater Treatment Facility. The Wilton plant combines a total energy-conscious design approach with the latest technology in wastewater treatment. We have presented the Wilton facility as a major case history of energy-conscious design. The manner in which the plant achieves effective treatment with low energy consumption is explored in detail.

The second section looks at energy conservation through the eyes of the plant operator. We have learned of many practical measures operators are taking to conserve energy through daily operation and maintenance procedures. Presented herein are some of the more imaginative ideas we received from plant operators in New England.

The final section presents a summary of energy-saving new technology employed by wastewater treatment plants in New England. With fuel and electricity costs rising, the increasing need for energy conservation has challenged operators and engineers to develop better ways to treat wastewater at lower energy demands. This section presents wastewater treatment projects that have been identified by EPA as innovative technology or important examples of energy-conscious design.

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MAJOR CASE HISTORY

The Wilton Wastewater Treatment Plant

New England has a number of treatment facilities that were designed with energy conservation in mind. The Wilton, Maine plant is presented in this report as a major case history of energy-efficient plant design and operation. The facility was designed to provide effective treatment with low energy demands.

The Wilton plant was designed to provide secondary treatment of wastewater with a minimum amount of commercial energy. The 450,000 GPD plant, located in the west-central mountain region of Maine, serves a community of 4,200 residents.

The treatment processes employed in the facility were chosen for their energy-conserving operation and maintenance. Preliminary treatment consists of trash screening, grit removal, comminution and bar screening, flow measuring and sampling. Primary treatment is accomplished by rotostrainers. Secondary treatment consists of rotating biological contactors and final clarification. The effluent is disinfected and discharged into the Wilson River.

Sludge screenings from the primary rotostrainers are combined with sludge from the final clarifiers and pumped to anaerobic digesters for stabilization. Sludge is then dewatered and hauled to fields for land application.

The Wilton plant combines an energy-conscious design approach with the latest technology in wastewater processing. Direct solar energy, backed by methane gas produced from the anaerobic digesters, may supply as much as three-fourths of the heat required to run the plant, thereby reducing the dependency on commercial energy. Recycling of waste heat energy further contributes to the overall efficiency of the plant. Energy-efficient rotating biological contactors provide secondary treatment. The 450,000 GPD facility takes maximum advantage of site location, natural terrain, and novel building construction to minimize energy needs.

SITE LOCATION

The site location for the Wilton plant was carefully chosen to take full advantage of sunlight and natural terrain. Maximum utilization of sunlight was achieved by orienting the main building to face directly south. Gravity flow is used throughout most of the plant to minimize the need for energy-consuming pumps. Treatment processes are grouped for maximum gravity flow and heat utilization. Snow covering and earth placement provide natural insulation.

Landscaping allows winter sunlight to reflect off the snow onto the solar panels for better efficiency. Low-profile trees have been planted to provide a windbreak. An area, near the plant, has been set aside for storage of sludge for future use as a soil conditioner to supplement high-energy fertilizer.

BUILDING DESIGN

Energy conservation is evident in the design of the treatment plant buildings. The main building was designed to trap snow on its roof and against its walls for insulation. All building materials were especially chosen for their low maintenance and high durability characteristics. Light colored stone chips provide a reflective coating on the roof to reduce heat gain in the summer and radiation loss in the winter. Maximum control of heat loss is achieved by partitioning the interior of the building into separate areas according to temperature requirements. All windows and doors have been fully insulated.

The main building's interior was also designed to provide for a pleasant working atmosphere with a minimum amount of space to be heated and a maximum amount of natural illumination. Interior room partitions are constructed of translucent fiberglass to allow maximum utilization of available light. Interior walls not intended to transmit light are painted light colors to provide maximum reflection.

PLANT PROCESSES

Headworks

The plant processes were especially chosen for their energy-efficient operation. Screw pumps lift the wastewater to a height sufficient to allow gravity flow throughout the remainder of the plant. Screw pumps were selected because they use less power than centrifugal pumps, require no appreciable wet well, are easily accessible for maintenance, and can handle variable flows without changing speed.

Primary Processes

Primary solids removal is achieved by self-cleaning primary rotostrainers rather than by conventional primary settling tanks. The strainers consist of cylindrical stainless-steel wedgewire screens rotated by a half-horsepower motor. The motor that drives the strainers consumes less power than conventional sludge pump-motors. The screens are continuously cleaned by a wiper blade. The screenings are deposited by gravity into a sludge hopper directly below the rotostrainers. Particles not removed by the blade are removed by backwash action.

Secondary Processes

The Wilton plant uses rotating biological contactors (RBC's) for secondary treatment. Final clarifiers provide the physical separation process. The secondary system will achieve 85 - 95% removal of BOD and total suspended solids.

The RBC system employs a fixed-film biological mass supported on thin, closely-spaced plastic discs. There are four units of RBC's used in Wilton. In each unit, the discs are mounted on a shaft in two separate groups. The shafts rotate to allow the microorganisms exposure to oxygen as well as contacting the waste water. The motors that rotate the shafts use less energy than the motor-driven mechanical aerators or the blowers that are usually employed in biological treatment systems. The average detention time in the RBC process is only 30 minutes, and because of the high biomass concentration that is maintained, high organic loading may be treated effectively.

Flexibility is an important advantage of the RBC system. The RBC's are arranged so that two, three, or four units may be used at any time depending on plant operating conditions. The efficiency of the RBC process is temperature dependent. Four units are usually required during the winter months. However, during the summer, the operator may be able to achieve effective treatment with two or three units. This flexible arrangement also allows for maintenance of the units during normal downtime.

Final Clarifiers

Two peripheral-feed final clarifiers process the effluent from the RBC units. Skirts are positioned in the tanks to distribute flow equally around the periphery and direct the flow to the bottom of the tanks. This in turn helps prevent short-circuiting. The overflow launder located in the center is adjustable to ensure proper flow.

Unlike the activated sludge process, no recycling of sludge is required in the RBC system. RBC's, therefore, operate at a lower energy demand than the more conventional activated sludge systems. However, the sludge must be removed from the clarifiers on a regular basis. Generally speaking, RBC sludge is characterized by large floc particles that exhibit good settleability. The particles dewater more easily than sludge produced in an activated sludge process. These qualities favor potential energy savings.

Disinfection

The effluent from the final clarifiers passes through a flow-metering system, and is then dosed with a solution of sodium hypochlorite produced on-site. The sodium hypochlorite is generated electrochemically at a rate of 250 lbs. per day, by converting sodium chloride to sodium hypochlorite. The cost is comparable to commercial chlorine gas. The generation of sodium hypochlorite at the plant greatly reduces the safety problems and supply uncertainties inherent with gaseous chlorine.

SOLAR ENERGY

The application of passive and active solar heating is one of the most significant energy conservation measures used within the facility. Fourteen thousand square feet of active solar panels are located on the south roof of the main building. The pitch of the roof was set at 60 degrees to achieve maximum winter radiation from the sun. The solar panels can function primarily as heat collectors for the anaerobic digesters. An antifreeze solution, pumped through the panels, is heated to a temperature of between 120 and 140 degrees Fahrenheit. Through heat exchangers, this heats water which then may heat the digesters. The heat may also be passed on to the building's heating system. A methane-fired boiler, and as a last resort, a heat pump extracting energy from the plant effluent, provide backup for prolonged cold and cloudy weather.

Passive solar energy, transmitted through translucent fiber-glass panels, is the only source of heat for some of the buildings. An exception is the RBC building where very little sunlight is allowed because the growth of algae is counter productive for RBC operation.

HEATING SYSTEM

A small treatment facility such as the Wilton plant would ordinarily need all the methane gas produced in winter to heat the anaerobic digesters. The Wilton plant, however, uses solar energy to heat the digesters, thereby freeing the methane gas to be stored for use in heating the building and running an electric generator. Methane is more economical to store than solar heated water and is much more flexible to use. The methane heating system itself is tailored to interface with numerous heat recovery systems located throughout the plant. Excess heat is recovered from the effluent water, exhaust air, and from the generator coolant, for re-use within the building. Heat recovered from exhaust air in the ventilation system is used to preheat cold air drawn into the plant. The effluent, normally discharged at a temperature of 50° F., acts as a heat source for a heat pump. The pump extracts heat from the effluent and captures as much as 12 degrees of heat energy from 450,000 gallons of effluent flow.

Operating Costs

Operating costs for the Wilton plant are presented below. These are estimates based on the 1977 calendar year. This information was extracted from Water & Wastes Engineering, March 1976, p. 20.

A conventional system with no heat recovery and no additional controls would require approximately 900 x 10^6 BTU/year of #2 fuel oil.

$$\frac{900 \times 10^6}{140{,}000} \times .7 = 9184 \text{ gallons/year}$$

At 48 cents/gallon (1977)
9184 x .48 = $ 4408/year saved by not using #2 oil.

The Wilton plant was designed to use approximately 586 x 10^6 BTU/year

Building requires: 586 x 10^6 BTU/year
Heat supplied by solar: 356 x 10^6 BTU/year
Heat supplied by methane: 200 x 10^6 BTU/year
Net commercial energy required: 31 x 10^6 BTU/year
Heat pump coefficient performance = 2.8 electric use.

$$\frac{31 \times 10^6}{2.8 \times 3.4} = 3256 \text{ KWHR/year (1977)} = \$ 114\text{/year}$$

3256 KWHR x $.035/KWHR =	700/year
Total Cost	$814/year

Additional electricity savings from pumps and fans, and excess methane used to generate electricity: 25000 KWHR/year x $.035 = $875/year savings.

Total Savings of System = 4408 - 814 + 875 = 4469/year (1977)

Savings per square foot floor area = $4469/13494 = $.33/sq. ft./year.

<u>Note</u>: Present 1981 fuel oil prices result in far greater savings than those listed above, and this trend will surely continue. However, since today's costs are not readily available, there will be no attempt to update the savings presented. It is safe to say that with the inflated and rising power costs that we now have with us, any means to conserve energy through design will pay off.

The Wilton plant clearly demonstrates a conscious effort to provide effective wastewater treatment with minimum energy demand. Although the Wilton plant features extraordinary design concepts, it is not alone in the application of new technology now taking place. Many features of the Hillsborough Treatment Plant in New Hampshire parallel those of the Wilton plant. Further information on the Wilton or Hillsborough plant may be obtained from the reference listings at the end of the this report.

The next chapter of this Energy Conservation Series will continue the focus on wastewater facility designs that demonstrate outstanding efforts to conserve energy.

MINOR CASE HISTORIES

Many plant operators in our region have used their ingenuity and experience to save energy. To tap this source of information, operators throughout New England were approached through their associations and asked to share their experiences and case histories with us. It was encouraging to find the degree of interest in energy conservation that exists among the operators.

Interest in energy conservation is becoming paramount in the minds of designers and operators alike. Rapid increases in power and heating costs have led to plant designs and operations that may well be oriented more toward saving energy than to reliable wastewater treatment. Designers may elect to reduce mechanical processes in favor of more labor-intensive units. This could have adverse effects if the labor intensive operations are neglected by plant personnel. Similarly, plant operators may want to conserve energy by reducing power or heating costs at the expense of treatment quality. Actions taken by operators to reduce aeration, lower temperature, decrease pumping, or otherwise modify the plant's operation, must be carefully weighed to assure that efficient process performance is not being impaired. Energy conservation is not an acceptable excuse for effluent violations.

The following examples were chosen from operator responses to show the spectrum of activities being practiced to conserve energy. These activities range from simple common-sense changes to complete modification of process operations. All have an energy savings impact. The impact, if any, on plant efficiency will clearly show on discharge monitoring reports.

- Somersworth Wastewater Treatment Facility, Somersworth, New Hampshire

  Superintendent: Mark Gauthier

Plant Description: The 2.4 MGD plant accomplishes secondary treatment by complete mix extended aeration. The sludge processing consists of floatation thickeners and vacuum filters.

Operators at the Somersworth facility have been making a conscious effort to save energy, chemicals, and manpower. They bypass their floatation thickeners during the winter months and use secondary clarifiers as gravity thickeners. This process saves both energy and chemicals, and provides adequate concentration of the sludge prior to coil filtration. Sludge thickening is accomplished by installing timers on the return pumps, set to run for 10 minutes out of each hour. The concentrated sludge is then pumped directly into holding tanks. This modification in the wasting schedule cut the operating time of the sludge pumps by 60 percent, and reduced much of the need for operator surveillance. A polymer-feed line was installed on the coil filter to improve sludge conditioning, and thereby reduce the amount of chemicals used in dewatering. Considering manpower, electricity, and chemicals, there is a saving of $2,600 per month when gravity thickening is employed.

Two wood stoves were installed to reduce oil consumption. One of the stoves was tied into the plant's air handling system to warm the main building. Ceiling fans were installed to circulate heat down to work areas rather than allowing heat to escape through the roof. A homemade stove was installed at the other end of the building and a fan placed behind it to circulate the heat. With both stoves operating, the plant was able to cut oil consumption by 60%. All operators cut wood from city-owned property adjacent to the plant, eliminating the need to purchase wood.

The operators are taking measures to save on electricity. The public-utility company changed the plant's electric meter to a magnetic tape system that provides them a print-out of electricity used at half-hour intervals during the entire month. This enables them to determine when their highest demands occur and make appropriate adjustments. Starting pumps at different intervals and running equipment during off-peak demand periods has greatly reduced power costs.

- Several plants have invited utility companies to conduct energy audits. The recommendations from such audits usually result in substantial energy savings.

- Optimization of heat in the digesters often produces excellent results with minimal commercial fuel use.

- James Deile has saved $106,000 this past year by burning waste crankcase oil in their fluidized-bed incinerator (Torrington WWTP, Harwinton, CT).

- Substantial savings in the cost of electric power can be achieved by monitoring dissolved oxygen levels closely to match aeration to changing needs. CAUTION: Do not sacrifice process quality to save power!

- Common-sense energy-conservation measures will reduce fuel and electricity costs. These include weather stripping windows and doors, keeping thermostats down, rewiring lights to illuminate selected areas of large rooms, and turning off lights that are not needed.

- <u>Woonsocket Wastewater Treatment Facility, Woonsocket, Rhode Island</u>

  Chemist: Adel Banoub
  Plant Description: The 16-MGD plant achieves secondary treatment by conventional activated sludge processing. Sludge is thickened by gravity thickeners and dewatered by vacuum filtration.

  A considerable number of kilowatt-hours have been saved by closer monitoring and control of dissolved oxygen concentrations in the aeration tanks. Results of a kilowatt-hour survey conducted throughout the plant revealed that one blower could be used instead of two for much of the time, and still maintain effective treatment. The savings in power in the last year are summarized in the following table:

Month	Power Consumed, KWH		KWH Saved
	1979	1980	
April	634,200	491,400	142,000
May	593,600	446,600	147,000
June	618,800	446,600	228,200
July	632,800	450,800	182,000

- Larry Spencer has been able to save an average of 300 gallons of fuel oil per day by changing his incinerator sludge-burning schedule. He was burning sludge on a daily basis, but now he burns sludge 24 hours a day for three to four days and then puts the incinerator on standby for three days. (Merrimack WWTP, Merrimack, NH).

- William Royce saves an average of 4,000 gallons of No. 2 fuel oil annually by changing his incinerator sludge burning-schedule. He has also installed an 80-gallon electric water heater to save on fuel oil. Water is heated by the electric heater in the summer and by an oil-fueled boiler in the winter. This saves the plant 3,000 to 3,500 gallons of No. 2 fuel oil annually. (Newport WWTP, Newport, NH).

- Charles Buttrick fills adjoining tanks in winter months to reduce heat loss through tank walls. He also puts plywood covers on the gratings over sludge holding tanks to keep heat in during the winter. (Greenville WWTP, Greenville, NH).

- Joel Goode bypasses most of the instrumentation and automatic controls on his heating and ventilation system. By running the system in the manual mode, the operator has saved 200 to 700 gallons of oil weekly. (Berlin WWTP, Berlin, NH).

- Staggered running of pumps and motors may reduce peak demands of electricity.

New Technology

The Clean Water Act of 1977 clearly established the intent of Congress to encourage the use of innovative and alternative technology (I/A). The I/A program is a part of the Federal Construction Grant program, and all municipalities in the U.S. that can apply for a normal 75% Federal Construction Grant to construct improved wastewater treatment works may also be eligible for an I/A (85%) grant. The objectives of the I/A program are to:

*Reclaim, re-use water
*Recycle wastewater constituents
*Eliminate surface discharge
*Conserve or recover energy
*Lower total costs

The active I/A Technology Program has been established as further inducement for the consideration of innovative technologies. This program is a joint effort of the EPA Construction Grants and Reserach and Development Program.

The overall thrust of this program is to: (1) identify recently emerging I/A technologies ready for implementation, (2) identify and recommend project sites throughout the country that may potentially benefit from emerging technology (3) assist local communities and their consulting engineers with assessment and analysis of emerging technologies that may be applicable to their specific wastewater treatment control or management problems, (4) to provide consulting engineers with detailed planning and engineering assistance on a project-by-project basis.

The following are innovative or alternative projects in Region 1 either approved or under consideration that provide for some degree of energy reduction. (The Wilton plant was designed prior to the enactment of the I/A program and is therefore not included in the listing):

° Hillsborogh, New Hampshire

Total energy concept: Solar heated anaerobic digesters; active and passive solar building heat; energy conservation building technology; effluent heat pump; rotating biological contactors.

- Kennebunk and Dexter, Maine

  Ultraviolet Radiation Disinfection System: Eliminates energy-intensive pumps and evaporators normally required in gaseous chlorine systems. No residual disinfection exists, thus eliminating the possible need for dechlorination or reaeration. Dangers associated with the production of hazardous chlorinated hydrocarbons are also eliminated.

- Cranston, Rhode Island

  Improved Aeration System: Provides high oxygen transfer efficiency at low power levels. The aeration system utilizes draft-tube, submerged turbine aerators in deep (25 to 30 foot tanks). Air is introduced approximately mid-depth, immediately below the axial-flow turbine, thus reducing blower discharge pressure. The flow is carried down to the bottom of the tank where pressure increases oxygen absorption before undissolved gases rise to the surface.

- Isleboro, Maine; Vassaboro, Maine; Sabattus, Maine; Weare, New Hampshire; Ossipee, New Hampshire:

  Subsurface Septic Tanks and Leaching System: On-site treatment eliminates the need for energy-demanding pumps, aeration equipment, and other processes required by a wastewater treatment plant.

There have been other projects approved by EPA Region 1 that, although do not qualify under the I/A program, do incorporate energy-saving devices or processes. The following is a list of some of these projects. This list will be expanded in subsequent reports:

- Framingham, Massachusetts (Saxonville Pump Station)

  Heat Utilization: The pump station is independent of commercial electricity. The pumps are driven by D-8 caterpillar tractor engines fueled by natural gas. Generators driven by the pump engines provide electricity for lights and equipment. The engines heat the building and provide snow-melt heating of the walks and driveway.

° Ellsworth, Maine

Energy Saving Concept: Methane gas from anaerobic digesters is used to heat the digesters and the building. Passive solar heating of buildings. Rotostrainers provide primary treatment, and RBC's provide secondary.

Conclusion

We have looked at several existing plants that take advantage of effective energy-conservation measures in their design and operation. The Wilton plant demonstrates the kinds of energy-saving measures that can be incorporated into the design of a treatment plant. The Somersworth and Woonsocket plants are impressive examples of conscious efforts by operators to minimize energy demand from existing equipment or processes. It is hoped that this document will encourage operators and design engineers to give more attention to energy conservation.

Our next report will present new case histories of energy-conserving treatment plants. We will also discuss in more detail how some of the latest energy conservation devices or processes work.

It is requested that the consulting engineers, the State and Federal reviewers, and the operators of facilities, all make an effort to provide us with suggestions, case histories, or other data that can be used to promote the energy conservation cause in the treatment of wastewater. Your contribution should be sent to:

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