WAYS TO SAVE ENERGY

Then and Now

With another energy crisis possibly looming, *HPAC Engineering* dusts off and revises a list of ways to conserve fuel and electricity

In May 1975, *HPAC Engineering* published a two-page "data sheet" listing 133 ways to save energy in existing buildings. Modifications to the building shell, HVAC and lighting systems, and operations-and-maintenance practices were suggested. A lot of emphasis was placed on industrial buildings, as well as general HVAC considerations. Published at the peak of the oil embargo, the list was very well-received.

Once again, energy conservation is a priority for property owners—a trend that is likely to last beyond the current surge in oil, gas, and electricity prices and regional supply uncertainties. Responding to reader inquiries for an updated list, we revised the 1975 data sheet.

Although the list from 1975 has many brute-force energy-conservation measures that are valid today, there have been a lot of refinements to the art of saving energy. To list them all would be impossible. The point of this list is to inspire progress in achieving energy-efficient systems, not to document every way to save a Btu.

The following is the revised list. Some old methods, such as, "Fix broken windows," were dropped, while a new category—best practices—was added. Also, the list was broken down into more subcategories to make it easier to use. For comparison, the 1975 list is contained in the sidebar on pages 51 and 52.

By **MICHAEL G. IVANOVICH**, Editor; **THOMAS HARTMAN, PE**; and **JACK TERRANOVA**, PE

Prior to becoming editor of HPAC Engineering, *Michael G. Ivanovich was a research scientist working on environmental projects in a variety of areas, including energy efficiency. Thomas Hartman, PE, is the principal of The Hartman Co., a Marysville, Wash.-based high-technology engineering and development firm. Jack Terranova, PE, is division manager for Colliers ABR Inc. in New York. Both Hartman and Terranova are members of* HPAC Engineering's *Editorial Advisory Board.*

Engineers must evaluate items on these lists to ensure they are suitable and safe for their buildings.

BEST PRACTICES

1. Participate in voluntary above-code performance programs, such as Building Research Establishment Environmental Assessment Methodology (BREEAM) and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED).
2. Verify that the design conforms to or surpasses the state's energy-conservation code (if applicable) and/or ASHRAE standards.
3. Keep operation-and-maintenance (O&M) documentation up-to-date and be certain that O&M staff are knowledgeable, well-trained, informed, and proactive in their duties.
4. Establish energy-consumption and demand goals and track and discuss them with operations staff at regular intervals.
5. Work as a team to keep in mind the building life cycle throughout the design, construction, and operations phases.
6. Educate occupants on recognizing and reporting IAQ and energy problems and reward them for doing so.
7. Participate in public and peer reviews of design for adherence to new codes and standards.
8. Encourage participation in professional organizations, provide training in sustainable practices, subscribe to quality trade publications, and bookmark useful Websites.

THE BUILDING

Envelope

9. Design for low infiltration by employing a high-quality envelope and isolating elevator shafts

Continued on page 54

133 Ways to Save Energy in Existing Buildings

***The following list originally was published in the May 1975 issue of* HPAC Engineering.**

STRUCTURE

1. Add additional insulation to roofs, ceilings, or walls where practical.
2. When reroofing, use light-colored material to reduce solar gain on air-conditioned structures.
3. Ventilate attic spaces.
4. Put solar film on windows to cut cooling loads.
5. Install solar screens on windows to reduce cooling loads.
6. Install double glazing in place of single glazing.
7. Recaulk window and door frames.
8. Reseal curtain walls.
9. Eliminate excessive crackage between double-entry doors.
10. Install weather stripping around windows and doors.
11. Repair broken windows.
12. Keep garage and warehouse doors closed as much as possible.

LIGHTING AND POWER

13. Install higher-efficiency lighting systems where possible.
14. Reduce overall illumination levels.
15. Implement a lighting-maintenance program to obtain maximum efficiency from existing systems.
16. Use supplemental lighting for specific tasks instead of increasing the overall illumination for a given area.
17. Utilize natural lighting in perimeter office spaces.
18. Utilize multiple switching for selective lighting levels in offices, conference rooms, etc.
19. Reduce lighting in areas not requiring higher levels (stockrooms, corridors, etc.).
20. When redecorating, use light colors on ceilings and walls to achieve good illumination levels with less lighting.
21. Reduce decorative and advertising lighting.
22. Use timers or photocells to control outdoor lighting.
23. Reduce parking-lot lighting to minimum levels required for safety.
24. Use proper-sized motors. Grossly oversized motors operate at a low power factor.
25. Apply power-factor correction where applicable.
26. Install demand-limiting equipment.

CONTROLS

27. Recalibrate all controls.
28. Lock thermostats to prevent resetting by unauthorized personnel.
29. Check room thermostats for proper location.
30. Install individual room control whenever possible.
31. Install temperature-control valves (self-contained) in radiators controlled by hand valves.
32. Install enthalpy controls to optimize use of outdoor air for building cooling.
33. Install building automation system if feasible.

HVAC AND MISCELLANEOUS

34. Study system carefully before making changes—some changes may increase energy usage.
35. Retest, balance, and adjust systems.
36. Turn off air-conditioning machinery during unoccupied hours.
37. Revise cleanup schedule so lights and system can be turned off earlier.
38. Optimize system-startup times.
39. Shut off outdoor air during unoccupied hours.
40. Reduce outdoor-air quantity.
41. Reduce system air volume.
42. Reduce air-duct leakage.
43. Adjust outdoor-air dampers for tight closure.
44. Replace dampers with higher-quality ones whenever possible.
45. When balancing or rebalancing a system, consider outdoor-air leakage when making minimum-outdoor-air settings.
46. Adjust dampers in mixing boxes and multi-zone units so that they shut off tight to reduce leakage.
47. Avoid use of preheat coils if possible.
48. Raise the mixed-air temperature.
49. Reset hot and cold deck temperatures in direction of reduced heating and cooling.
50. Set reheat schedule as low as can be tolerated.
51. Reset chilled-water and heating-water temperature in accordance with loads.
52. Use lowest radiation temperature possible in perimeter spaces.
53. Do not permit perimeter and interior systems to buck one another.
54. Optimize multiple chiller operation.
55. Run heating and cooling system auxiliaries only when they are required.
56. Whenever possible, only operate return-air fans for heating during unoccupied hours.
57. Install auxiliary air risers to reduce fan horsepower.
58. Convert constant-volume fan system to VAV.
59. Reduce heating in unoccupied areas.
60. Reduce heating in overheated spaces. Do not open the window to cool these places!
61. Shut off exhaust fans during unoccupied cycles.
62. Check exhaust systems to ensure they are exhausting only the amount of air required.
63. Reduce exhaust-air quantities from toilet rooms, laboratories, etc. when feasible.
64. Convert toilet-room exhaust fans to operate only when room is occupied.
65. Reduce supply temperature of domestic hot-water systems.
66. Use condenser water to preheat domestic hot water.
67. Use condenser water for air-conditioning reheat.
68. Retrofit solar collectors to the building to heat domestic and process water.

Continued on page 52

Continued from page 51

69. Install heat-recovery device to reclaim heat from building, kitchen, and process exhaust.
70. Replace forced-air heaters with infrared heaters.
71. Replace indirect-fired makeup-air units with direct-fired equipment.
72. Insulate piping and ductwork located in unconditioned spaces.
73. Replace worn insulation on boilers, furnaces, pipes, ducts, etc.
74. Reduce hot- and chilled-water flows.
75. Trim pump impellers to match load.
76. Convert three-way valves to two-way operation and install variable-speed pumping.
77. Clean strainer screens in pumping systems.
78. Check vents in hot-water and steam systems for proper performance.
79. Check expansion-tank size. Undersized tanks can cause excessive water loss.
80. Determine whether the boiler plant can be shut down and small boilers and water heaters can be used during the summer.
81. Do not waste condensate; return it to the boiler.
82. When high-pressure steam is available, consider use of steam turbines for pump and fan drives. Turbines can operate as a PRV valve to meet low-pressure-steam needs.
83. Repair all leaks.
84. Use proper water treatment to reduce fouling of transfer surfaces in boilers, chillers, and heat exchangers.
85. Use no more water-treatment chemicals than necessary.
86. Check cooling-tower bleedoff periodically to ensure that water and chemicals are not wasted.
87. Maintain cooling towers, evaporative coolers, and air-cooled condenser for peak efficiency.
88. Periodically inspect and repair faulty equipment.
89. Implement a filter-maintenance program to ensure peak efficiency.
90. Clean and maintain cooking equipment to maintain peak efficiency.

COMBUSTION EQUIPMENT

91. Check buildings for negative pressure, which can reduce combustion efficiency.
92. Check flues and chimneys for blockages or improper draft conditions.
93. Clean combustion surfaces.
94. Check and adjust fuel-air ratios.
95. Replace atmospheric burners with power burners.
96. Install pressure controls on furnaces (industrial).
97. Install automatic air-gas combustion controls.
98. Do not overfire equipment.
99. Repair furnace linings frequently.
100. Reduce production-equipment preheat times to minimum required.
101. Reduce production-equipment temperatures to holding temperatures when production stops for relatively long periods.
102. Shut off drying and curing ovens when not in use. Do not start them until just prior to shift.
103. Seal all cracks in furnaces, ovens, etc.
104. Preheat combustion air with waste heat.

INDUSTRIAL PLANTS

105. Study plant heating and air-conditioning systems to determine if they are of correct design. Many are not.
106. Reschedule operations whenever possible to second and third shift to get them off the 10-a.m.-to-2-p.m. peak electric-demand period.
107. Plan work so that the whole plant can be shut down on given weekends.
108. Shut off machinery when not in use.
109. Keep covers on tanks and vats closed to reduce evaporation losses.
110. Use push-pull ventilation on open surface tanks; 50 percent or more of the air can be saved.
111. Use immersion heaters whenever possible.
112. Use cold-water detergent in washers whenever possible.
113. Combine operations where possible to reduce the number of washers.
114. Shroud openings of furnaces, ovens, paint booths, and washers so that only the minimum amount of exhaust air will be required.
115. Eliminate stratification of air in the plant during the winter, thereby warming the floor. This can be done easily with fans (high) blowing down ducts terminating close to the floor.
116. Use spot heating or cooling of people when they are located far apart. Each should have control of the air direction and velocity over them.
117. Use evaporative cooling for human cooling whenever practical.
118. Determine whether pressure blowers could replace some compressed-air usage.
119. Do not use compressed air at higher pressures than required.
120. Do not permit compressed air to be used for "people" cooling.
121. Reduce the quantity of exhaust air; use local, not general, exhaust.
122. Use low-volume, high-velocity exhaust systems whenever possible.
123. Analyze all solid waste to determine whether it can be recycled, burned, or composted.
124. Salvage all oil used in the plant. It either can be reused through refining or burned in the boilers.
125. If exhaust air is contaminated, evaluate air-cleaning devices to determine if the air could be cleaned and recycled.
126. Determine feasibility of utilizing energy in production operations before exhausting it.
127. Analyze interplant truck runs. Consolidate loads and eliminate trips.
128. Shut off interplant truck engines when not in use.
129. Shut off fork-lift engines when not in use.
130. Replace worn-out machinery with modern, efficient equipment.
131. Keep heat and smoke-relief vents closed during the winter.
132. Consider using waste water for roof sprays during the summer to reduce heat load on the plant.
133. Use automatic regulators to control the volume of water used.

Continued from page 50

and other ventilated areas. Specify tests to ensure that design criteria are met.

10. Employ the highest practical insulation values for the roof, walls, and glazing. Consider reduced mechanical-system size and improvements in comfort.

11. Use swing/revolving doors at building entrances. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the use of these doors can reduce infiltration by 75 percent compared with standard single and double-leaf doors.

12. Specify Low E, double- or triple-pane argon-filled glass with a factory-applied coating (low shading coefficient). Use interior blinds and/or shades to help further reduce cooling loads during peak hours.

13. Consider planting shade trees and shrubbery to reduce cooling loads.

14. Maintain and improve the envelope's resistance to infiltration through aggressive building-entrance and envelope-maintenance/upgrade programs.

Mechanical/electrical systems—general

15. Perform an energy study or visit a nearby site with the application that you are considering.

16. Periodically re-evaluate loads to ensure that the HVAC system and components are properly sized and operationally balanced.

17. Incorporate distributing scheduling so that comfort and lighting energy is expended only when building areas are occupied.

18. Maintain good control of outside air to eliminate excessive outside-air flow at extreme temperature conditions while maintaining adequate air quality at all times of occupancy. Use enthalpy control for air economizers.

Controls

19. Design controls for straightforward operation and maintenance with self-diagnostics and other integrated fault-detection capabilities.

20. Check the location of sensors and control loops and recalibrate them as required to maintain design conditions for comfort and energy efficiency.

21. Keep the control system operating as designed by correcting problems that require manual overrides and other performance-limiting fixes.

22. Upgrade to higher levels of room- or work-station-based control whenever possible.

23. Maintain control software to ensure that programs do not contain errors. Upgrade as required to add control features such as improved scheduling or more operator-adjustment capacity.

24. Upgrade controls or the control system when feasible. The replacement of pneumatic systems with direct digital control can be particularly effective.

25. Consider adding network features to improve alarm and maintenance response and to react to real-time energy-

pricing signals.

26. Maintain a sound maintenance program that includes periodic checks for broken, stuck, or loose dampers, linkages, control valves, and other mechanical control devices.

27. Consider upgrading work stations to provide more information to operators.

28. Consider installing power submeters. Also, consider installing temporary data loggers or extending the control system to detect load and scheduling anomalies.

AIR SYSTEMS

29. Convert constant-volume fan systems to variable-air-volume (VAV) systems to reduce system air volume and energy use at part-load conditions.

30. Replace mechanical air-volume-control VAV systems with variable-frequency-drive (VFD) air-volume control.

31. Place fixed duct static setpoint control of fans with network-based duct static reset or direct zone control of fan volume to reduce energy at part loads.

32. Improve design, installation, and maintenance standards to reduce damper, air-duct, and plenum penetration. Also, improve the design and maintenance of ducts and duct insulation to promote smooth and efficient air flow.

33. Design and maintain a system that can closely control outside air to the actual requirements at all times.

34. Avoid the use of preheat and reheat coils, as well as lockout operation of such coils, when possible.

35. Design and operate systems to raise the mixed-air temperature and to reset hot and cold deck temperatures at part-load conditions.

36. Size filters properly. Do not "overfilter." Also, choose the proper filter efficiency for the job. Ensure that filters do not leak around the edges. Install/specify alarms to measure the differential pressure across each filter bank with alarms back to the burner-management system. Implement a filter-maintenance program to ensure that changes are made to maximize efficiency and minimize filter costs.

37. For VFDs and soft-start fans, use sprocketed belt drives for higher efficiencies. Inspect all fan belts periodically and replace them as needed.

38. Relocate or redirect outdoor-air intakes as required to minimize the intake of exhaust air.

39. Design and maintain air outlets and returns to make them free from obstructions.

EXHAUST SYSTEMS

40. Shut off exhaust fans during all unoccupied cycles except economy purge cycles.

41. Check exhaust systems to ensure that they are exhausting only the amount of air required. If possible, reduce exhaust-air quantities from toilet rooms, laboratories, etc. to minimum acceptable levels.

42. Control room and process exhaust

fans to operate only when a room is occupied or equipment is running.

43. Install an energy-recovery device to reclaim energy from building and process exhaust-air systems.

44. Develop operations strategies that keep laboratory fume-hood doors closed and exhaust fans off when they are not in use.

STEAM AND HYDRONIC SYSTEMS

45. Reset chilled-water and heating-water temperature in accordance with loads.

46. Optimize cooling-tower operation, and use cooling-tower water for hydronic "free cooling" when possible.

47. Find and stop steam leaks; institute a trap-, vent-, and strainer-maintenance program; and insulate steam, hot-water, and condensate lines.

48. Replace old chillers and boilers with new, energy-efficient equipment.

49. Design or convert to variable-flow hydronic systems with VFDs to reduce hot- and chilled-water flows at part-load conditions. Use network-based reset of differential-pressure-set-point or direct-load control of pump speed for lower energy use.

50. Increase pipe diameters to decrease pump head when feasible.

51. Determine whether the boiler plant can be shut down and replaced with smaller boilers and water heaters during the summer.

52. Ensure that all condensate is returned to the boiler plant.

53. Consider replacing PRVs with steam turbines for pump and fan drives. A turbine can operate as a PRV valve to meet low-pressure-steam needs.

54. Use proper water treatment to reduce the fouling of transfer surfaces in boilers, chillers, cooling towers, and heat exchangers. Ensure that only the necessary amount of water-treatment chemicals is used. To cut down on water usage, use improved chemical treatment.

55. Maintain cooling-tower and boiler bleed and blowdown cycles to ensure that water and chemicals are not wasted. Consider sidestream filtration for cooling towers to reduce water and chemical use.

56. Install water-efficient plumbing to reduce hot-water consumption and pumping.

57. Maintain cooling towers, evaporative coolers, and air-cooled condensers for peak efficiency.

58. Use low-flush (1.6-gpm) toilets, occupancy sensors at flushometers, etc.

59. Add a water-side economizer cycle for free cooling instead of operating the chiller.

MISCELLANEOUS

60. Periodically retest, balance, and adjust air and hydronic systems.

61. Commission building systems after retrofits and renovations.

62. Improve access to filters, coils, and other system components to make maintenance easier and more frequent.

63. Optimize multiple-chiller operation to stage chillers for maximum efficiency and the lowest electrical demand.

64. Design and operate systems for coordinated control to minimize simultaneous heating and cooling in perimeter and interior systems or within air handlers and unitary equipment.

65. Reduce heating and raise cooling setpoints in unoccupied areas.

66. Notice when personal heaters and fans are being used. Find out why and then solve problems with the building HVAC system.

ALTERNATIVE ENERGY

67. Design or retrofit solar collectors to heat domestic and process water.

68. Consider photovoltaic roofing materials and curtain wall panels.

69. Consider infrared heating in place of forced-air heaters for areas subject to much outside-air infiltration.

COMBUSTION EQUIPMENT

70. Design and periodically check combustion equipment for proper air supply and adequate flue conditions.

71. Periodically check and adjust fuel-air ratios on combustion equipment.

72. Consider installing automatic air-gas combustion controls.

73. Do not overfire equipment. Carefully plan and facilitate operation to minimize energy usage while meeting process or comfort-load requirements.

74. Replace indirect-fired makeup-air units with direct-fired equipment when feasible.

75. Preheat combustion air with waste heat.

76. Check boilers, furnaces, ovens, etc. for cracks or damage and repair as required. Keep combustion surfaces clean and well-maintained.

INDUSTRIAL PLANTS

77. Update plant heating and air-conditioning systems as comfort and process requirements change.

78. Consider operations schedules to minimize peak electric-demand periods.

79. Plan work so that the whole plant can be shut down on given weekends.

80. Shut off machinery when not in use, such as during lunchtime.

81. Keep covers on tanks and vats closed to reduce evaporation losses.

82. Use cold-water detergent in washers whenever possible.

83. Combine operations when possible to reduce the number of washers.

84. Shroud openings of furnaces, ovens, paint booths, and washers to minimize the amount of exhaust air required.

85. Eliminate stratification of air in high-bay plants during the winter by heating at the floor level.

86. Use spot heating or cooling for people when they are located far apart.

87. Use evaporative cooling for human cooling when practical.

Continued on page 75

Continued from page 57

88. Determine whether pressure blowers could replace some compressed-air usage. Do not use compressed air at higher pressures than required.

89. Design for reduced exhaust air with the use of local, rather than general, exhaust systems, such as ventilated welding guns, hoods for portable grinding equipment, and local traveling hoods for molten-metal pouring.

90. Consider recycling industrial-waste streams.

91. Consider heat recovery or filtration for recycling industrial exhaust air.

92. Determine the feasibility of utilizing waste heat in production operations before exhausting it.

93. Analyze interplant truck runs. Consolidate loads and eliminate trips.

94. Replace worn-out machinery with modern, efficient equipment.

95. Keep heat- and smoke-relief vents closed during the winter.

LIGHTING AND POWER

96. Design and retrofit high-efficiency lighting systems.

97. Reduce excessive illumination.

98. Consider a group relamping program for bulbs and ballasts.

99. Install daylighting utilizing dimming ballasts and photo sensors.

100. Utilize multiple switching for selective lighting levels in offices, conference rooms, etc. Utilize dimming-ballast technology to have the light level match the task.

101. Reduce lighting in areas that do not require high levels of it, such as stockrooms and corridors.

102. When redecorating, use light colors on ceilings and walls to achieve good illumination levels with less lighting.

103. Reduce decorative and advertising lighting.

104. Use timers or photocells to control outdoor lighting.

105. Implement bi-level lighting triggered by motion sensors to lower light levels when no one is around.

106. Reduce parking-lot lighting to the minimum levels required for safety.

107. Use proper-sized high-efficiency motors operated by VFDs when capacity requirements fluctuate.

108. Apply power-factor correction when possible.

109. Stage the startup of loads to keep demand down, and install demand-limiting equipment.

110. Connect lighting and comfort-conditioning systems to the building automation system to minimize energy use in unoccupied areas.

111. Replace low-efficiency fixtures with high-efficiency fixtures (HID and HPS).

112. Install motion sensors and dimmable fluorescent fixtures in warehouses for maximum energy savings.

Continued from page 57

88. Determine whether pressure blowers could replace some compressed-air usage. Do not use compressed air at higher pressures than required.

89. Design for reduced exhaust air with the use of local, rather than general, exhaust systems, such as ventilated welding guns, hoods for portable grinding equipment, and local traveling hoods for molten-metal pouring.

90. Consider recycling industrial-waste streams.

91. Consider heat recovery or filtration for recycling industrial exhaust air.

92. Determine the feasibility of utilizing waste heat in production operations before exhausting it.

93. Analyze interplant truck runs. Consolidate loads and eliminate trips.

94. Replace worn-out machinery with modern, efficient equipment.

95. Keep heat- and smoke-relief vents closed during the winter.

LIGHTING AND POWER

96. Design and retrofit high-efficiency lighting systems.

97. Reduce excessive illumination.

98. Consider a group relamping program for bulbs and ballasts.

99. Install daylighting utilizing dimming ballasts and photo sensors.

100. Utilize multiple switching for selective lighting levels in offices, conference rooms, etc. Utilize dimming-ballast technology to have the light level match the task.

101. Reduce lighting in areas that do not require high levels of it, such as stockrooms and corridors.

102. When redecorating, use light colors on ceilings and walls to achieve good illumination levels with less lighting.

103. Reduce decorative and advertising lighting.

104. Use timers or photocells to control outdoor lighting.

105. Implement bi-level lighting triggered by motion sensors to lower light levels when no one is around.

106. Reduce parking-lot lighting to the minimum levels required for safety.

107. Use proper-sized high-efficiency motors operated by VFDs when capacity requirements fluctuate.

108. Apply power-factor correction when possible.

109. Stage the startup of loads to keep demand down, and install demand-limiting equipment.

110. Connect lighting and comfort-conditioning systems to the building automation system to minimize energy use in unoccupied areas.

111. Replace low-efficiency fixtures with high-efficiency fixtures (HID and HPS).

112. Install motion sensors and dimmable fluorescent fixtures in warehouses for maximum energy savings.