PART 2

ENERGY CONSERVATION MEASURES

This part of the protocol concentrates on the typical energy conservation measures in different types of facilities.

1 Energy Conservation Measures

This protocol applies to government/public-owned and/or -operated nonindustrial and industrial facilities. The energy assessment described in the protocol addresses major energy sources and areas of end use, including

- Building envelope
- HVAC and automation systems and their operation
- Central energy plants with heat and chilled water distribution systems
- Water supply systems
- Compressed air systems
- Lighting systems
- Internal loads (motors, drives, etc.)
- Production processes
- Control strategies

1.1 Special Features of Industrial Sites

Industrial energy assessment shall focus on site-specific, critical cost issues, which if solved, will make the greatest possible economic contribution to a facility's bottom line. Major potential costs issues include capacity utilization (bottlenecks), material utilization (off spec, scrap, rework), labor (productivity, planning, and scheduling), energy (steam, electricity, compressed air), waste (air, water, solid, hazardous), equipment (outdated or state of the art), and so forth.

From a strict cost perspective, process capacity, materials, and labor utilization can be far more significant than energy and environmental concerns. All of these issues, however, must be considered together to affect the facility mission in the most efficient and cost-effective way.

Therefore, there may be two ways to approach the problem:

1. If the general costs are too high (or if the building needs renovation anyway) one should start a cost assessment and an energy assessment (as part of the cost assessment). This renews the processes and also (with little extra money) can achieve an energy optimization.

2. If the energy costs are too high, there may be two alternatives:
   a. One may reduce energy costs without changing the processes, the building, or the equipment. This corresponds to adapting the consumption to the energy demand and requires long-term measurements and analyses (Level II assessment) to become sustainable.
   b. Alternatively, one may identify possibilities to reduce demand. These include redesign of processes, retrofitting of the building envelope, or replacing HVAC components with more energy-efficient ones.

1.2 Special Features of Nonindustrial Sites

The most typical nonindustrial target facilities are

- Office buildings
- Business and commercial buildings (shopping malls, hotels, shops)
- Schools and university buildings, laboratories, kindergartens
- Hospitals, homes for the elderly, health care centers
- Dormitories and barracks
- Sport facilities
- Computer/data centers and virtual training facilities

In most nonindustrial buildings, the HVAC systems are fairly simple and the energy use consists mainly of space heating, air handling units, air conditioning, and domestic hot water heating. Electricity use is mainly limited to lighting, socket loads, and HVAC systems. In hospitals, laboratories, computer centers, swimming halls, and ice arenas, the energy-using systems are more complex, and there are more cross-acting energy flows to take into account.

In cold climate conditions, space heating (to compensate for heat losses through the building envelope); and ventilation are the main energy consumers. In a hot and humid climate, air conditioning with dehumidification may be the main consumer.

1.3 Typical Areas in Which to Look for Improvement

Analysis of energy flows and balances is a useful tool to identify energy waste and inefficiencies, which are potential areas of energy conservation. A convenient way to present energy flows is a Sankey diagram. Figures 21 and 22 show examples of the energy flow into a site and building electrical energy and heat flowcharts.

It can be easily seen from these figures that the analysis of energy flows and balances is quite complex; therefore, it needs tools and models consistent with the selected tool and the adjustment of these models to the actual case.

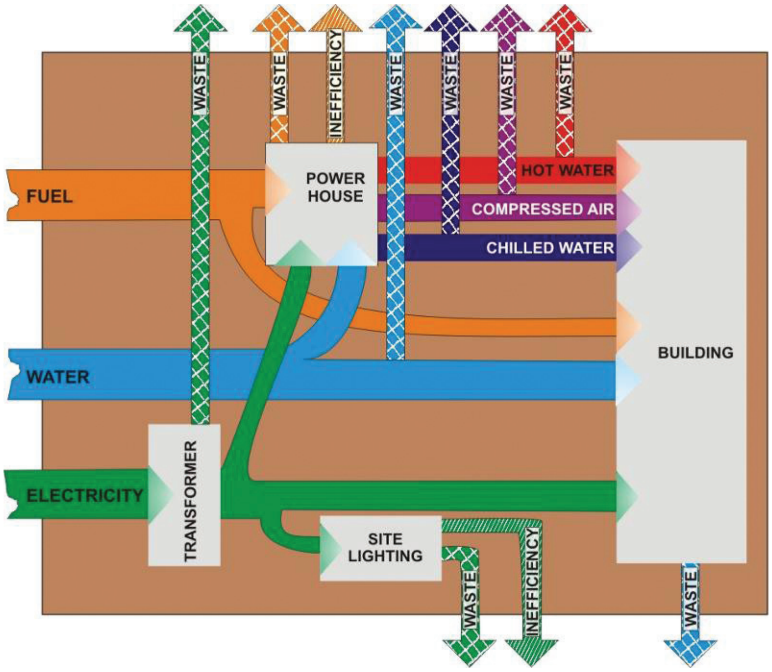

Figure 21. Site energy flows.

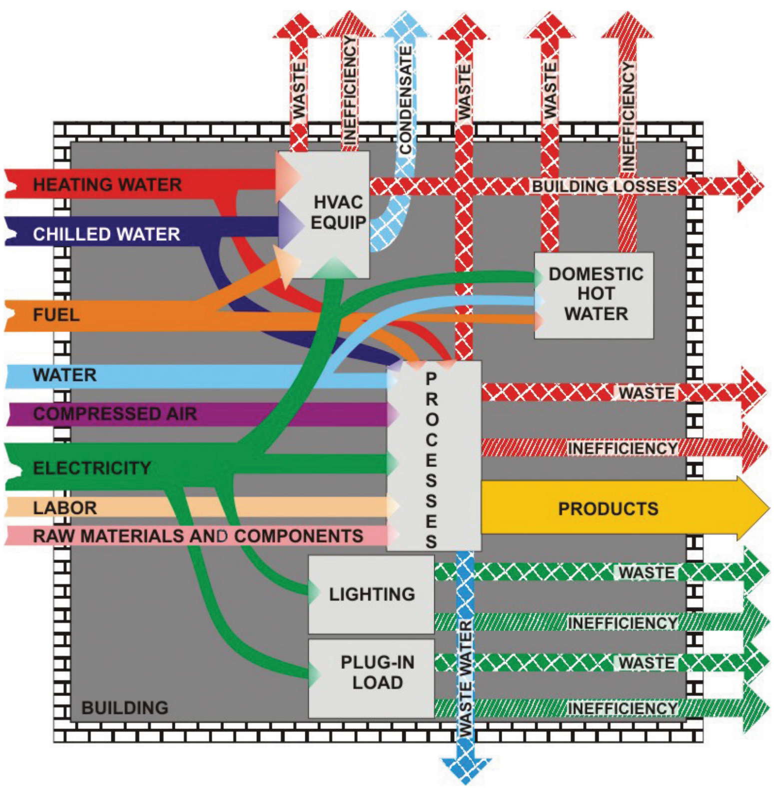

Figure 22. Building energy flows.

If detailed energy consumption data is not available, it is possible to identify and analyze potential wastes and inefficiencies (represented by arrows in Figures 21 and 22) and select corresponding sets of ECM. Experienced auditors might recommend how to rank and quantify application of these ECM.

These diagrams provide an overall view of sources of waste and inefficiency. Heat is given off by equipment in the power house. Heat is lost in the distribution systems that deliver tempered fluids to systems that require them. Waste is defined as use of excess energy due to a system or piece of equipment not performing up to its capabilities. This can be caused by poor maintenance, improper operation, and/or a need to replace a worn out element. Inefficient equipment can also lead to excessive energy use. The efficiency of the boilers results in excess energy in the flue gases and blowdown water. Efficiency improvements can be accomplished by investments that add additional or new components to a system. These investments must be cost-effective, thus it may not be wise to pay more for highly efficient equipment that is seldom used.

The energy flow into individual systems can also be illustrated by a Sankey diagram. Two of these diagrams can be found on the preceding page of this section (Figures 21 and 22). Systems presented in this manner are building envelope, HVAC, lighting, painting processes, and other processes.

1.3.1 Building Considerations

Buildings house the processes that the organization needs to carry out its goals, the people in the organization, and all the organization's assets. The building must protect the people and processes from the outdoor environment and have a well-insulated and reasonably airtight building structure. Windows placed in the building allow sunlight to enter, which aids the heating system but detracts from the cooling system performance. These windows also allow natural light to enter, which reduces the need for electrically powered lighting.

Common building envelope problems (Table 1) are

- Poorly insulated roof, walls, large doors, or single-pane windows
- Drafts through cracks in building envelope
- Excessive solar gains through the roof and glazing
- Large unprotected apertures (e.g., doors) left open for traffic coming in and out of the building
- Unprotected entrance doors connected to the air-conditioned spaces, kept open with human traffic entering the building before and after shifts

These problems result in energy waste for heating, cooling and humidity control. They may also contribute to potential health hazards and discomfort in winter due to drafts and low temperature. Other concerns are indoor air quality issues, reduced productivity as the result of low or high working space temperature, and possible damage to the building caused by water intrusion in building structures that may create mold and mildew problems. For a listing of possible wastes and inefficiencies refer to Table 1.

TABLE 1. CAUSES OF ENERGY WASTE IN BUILDING ENVELOPES

	Problem description	Reference/appendix
Walls	Poor wall insulation (waste)	D1.1.1
	Walls have multiple penetrations in the air barrier	D1.1.2
	Thermal bridges in the wall	D1.1.3
	Damaged or poor quality wall insulation	D1.1.4
	Open courtyard	D1.1.5
Roof	Poorly insulated sloped roof	D1.2.1
	Poor flat roof insulation	D1.2.2.
	Metal roof painted with a low-reflectivity paint	D1.2.3
	Ceiling and internal walls surfaces painted in dark colors	D1.2.4
	Poor attic floor insulation and sealing	D1.2.5
	Standing seam metal roofs have openings to the interior or attic space	D1.2.6
Floors	Poor slab over unheated basement insulation	D1.3.1
	Poor slab-on-grade insulation	D1.3.2
	Floor penetrations	D1.3.3
	Single-pane windows with frames having no thermal breaks	D1.4.1
Windows	Failure of window seals	D1.4.2
	Gaps/leaks in and around window frames	D1.4.3
	Significant wall area of industrial building is filled with single-pane windows	D1.4.4
	Large single-pane windows in residential and office buildings	D1.4.5
Doors	Doors lacking door seals (waste)	D1.5.1
	In cold and humid climates, having doors or air-conditioned spaces that open to the outside (this applies to major entrances and exits of a building)	D1.5.2
	Large doors in industrial and administrative buildings not protected by vestibules	D1.5.3
	Significant infiltration through truck docks	D7.9.3
Air leakage	Air leakage through the building envelope	E
	Operable windows that do not close properly	E
	Building openings or stacks that have no use	E
	Broken windows, skylights and doors	E
Moisture penetration	Poor moisture barriers that allow building components to become wet	
Other	The space height significantly exceeds needed for the current use	

1.3.2 HVAC System Considerations

The building ventilation system provides fresh air for the occupants and to satisfy any process needs. Air is removed from the building to exhaust unwanted odors, process contaminants, heat, and gases. The supply air is heated or cooled to provide a comfortable building environment. Often slightly more supply air is brought into the building than is exhausted to provide a small positive pressure. This positive pressure reduces the amount of outside air that infiltrates into the building through cracks in the building envelope. The result is a proper building air balance (Figure 23). Table 2 lists several things to consider in evaluating a ventilation system for waste and inefficiencies.

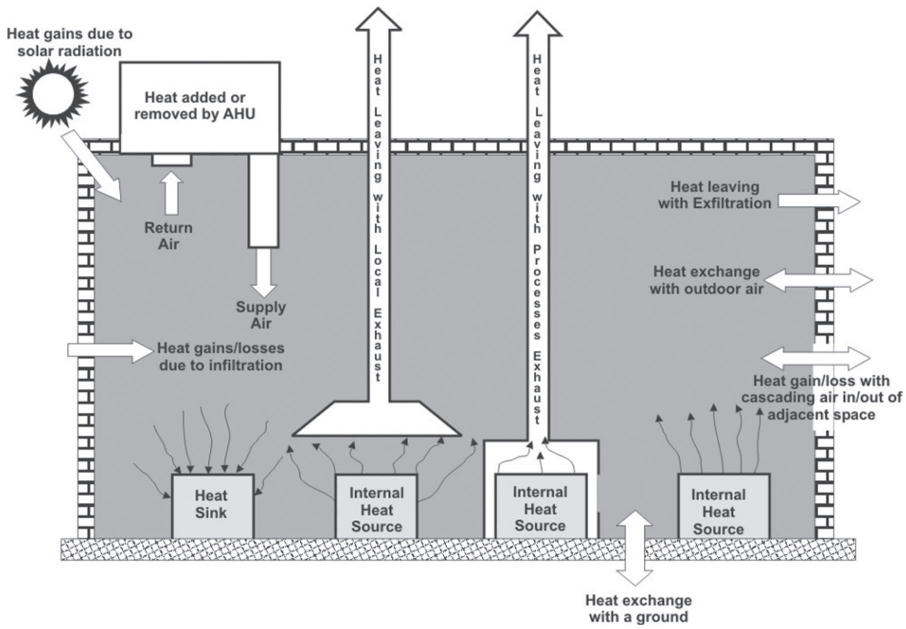

Figure 23. Building HVAC.

Heating, cooling, and humidity control systems maintain the indoor environment at safe and comfortable levels. These systems interact with the building's envelope to achieve the desired conditions (Figure 23). An evaluation will reveal any of a number of causes of waste and inefficiencies in the HVAC systems. The building ventilation system provides fresh air for the occupants and to satisfy process needs. Air is removed from the building to exhaust unwanted odors, process contaminants, heat, and gases. The supply air is heated or cooled to provide a comfortable building environment. Often slightly more supply air is brought into the building than is exhausted to provide a small positive pressure. This positive pressure redu es the amount of outside air that infiltrates into the building through cracks in the building envelope. The result is a proper building air balance. Possible causes or problems with the HVAC system are listed in Table 2.

TABLE 2. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN HVAC SYSTEMS.

	Problem description	Waste/inefficiency	Reference/appendix
Ventilation	Use of excessive dampers to achieve air balance	Waste	D2.1.1
	Loose fan belts in ventilation systems	Inefficiency	D2.1.2
	Ventilation equipment operating when not needed	Waste	D2.1.3
	Use of conditioned air for hood make-up air	Waste	D2.1.4
	Air movement greater than 0.51 m/sec (100 fpm) near exhaust hoods	Waste	D2.1.5
	Hot air warmer than 93.3 °C (200 °F) being exhausted outside in ventilation systems	Waste	D2.1.6.
	Process ventilation systems that operate continuously with the process turned off.	Waste	D2.1.7
	Central exhaust ventilation system connected to multiple hoods operate at a constant airflow with a diverse manufacturing process: contaminant emission occurs at less than 75% working places simultaneously	Waste	D2.1.8
	Use of motors more than 2.271 kW (3 hp) that are less than 85% efficient in ventilation systems	Inefficiency	D2.1.9
	Use of dilution ventilation in processes that could use a hood to capture the contaminants	Inefficiency	D2.1.10
	Use of canopy hoods to control process emissions	Inefficiency	D2.1.11
	Using single side exhaust hood on plating tanks 4 ft wide or wider	Inefficiency	D7.2.4
	Poor exhaust hood design for catering facilities results in heat, grease, and smoke/vapor spillage or in increased exhaust and makeup airflow rates.	Inefficiency	D7.10.9
	Turning (lathe), drilling, milling and grinding machines do not have local exhausts or process enclosures	Inefficiency	D7.3.1
	Using continuous operating welding exhaust	Waste	D7.2.1
	Using stationary welding hoods	Inefficiency	D7.4.2
	Running foundry exhaust systems when not required	Waste	D7.7.1
	Poor exhaust hood design results in heat, grease, and smoke/vapor spillage or in increased exhaust and make-up airflow rates.	Inefficiency	D7.10.9
	Single island canopy hood over kitchen equipment	Inefficiency	D7.10.10
	Supply air jet disturbs airflow around the kitchen hood results in heat, grease, and smoke/vapor spillage	Inefficiency	D7.10.11
	Inefficient positioning of appliances at the wall results in heat, grease, and smoke/vapor spillage or increase exhaust and make-up airflow rates	Inefficiency	D7.10.12
	Separate ventilation systems for a dining room and a kitchen.	inefficiency	D 7.10.15

TABLE 2. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN HVAC SYSTEMS. (*Continued*)

	Problem description	Waste/inefficiency	Reference/appendix
Heating and cooling systems	Use of forced air heating in large, high bay areas	Inefficiency	D2.2.1
	Heating or cooling unused spaces	Waste	D2.2.2
	Heating building with only unit heaters	Inefficiency	D2.2.3
	Clean hot air/gases warmer than 93 °C (200 °F) being exhausted outside	Waste	D2.2.4
	Failure to reset temperature of unoccupied spaces	Waste	D2.2.5
	Temperature stratification with heating	Inefficiency	D2.2.6
	Temperature setting below dew point	Waste	D2.2.7
	Inefficient dehumidification systems	Inefficiency	D2.2.8
	Poor selection of cooling/dehumidification coils	Inefficiency	D2.2.9
	HVAC systems supply air with no reheat	Waste	D2.2.10
	Poorly insulated fan-coil units are located in not conditioned space.	Waste	D2.2.11
	Unnecessary low room air temperature resulting in discomfort, energy waste, and condensation on cold surfaces = mold in these spaces	Waste	D7.11.1
	Simulation equipment is conditioned using DX units connected to training modules. DX condensers reject heat in the air-conditioned space	Waste	D7.11.2
	Simulator manned modules rejects heat into the air-conditioned bay, increasing the cooling load on the air-conditioning system	Waste	D7.11.4
	Computer server rejects heat into the air-conditioned space, increasing the cooling load on the air-conditioning system	Waste	D7.11.5
HVAC distribution systems	No duct and piping insulation	Waste	D2.3.1
	Inoperable dampers	Waste	D2.3.2
	Loose fan belts	Inefficiency	D2.3.3
	Duct air leaks	Waste	D2.3.4
	Excessive airflow	Inefficiency	D2.3.5
	No use of water condensed through air-conditioning process	Waste	D2.3.6
	Use of excessive dampers to achieve air balance	Inefficiency	D2.3.7
	Dirty filters or coils	Inefficiency	D2.3.8
	Water leaks from piping system	Waste	D2.3.9
	Steam leaks from piping systems	Waste	D2.3.10
	Steam traps not maintained	Waste	D2.3.11
	Chilled water pipes do not have sufficient insulation	Inefficiency	D2.3.12

TABLE 2. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN HVAC SYSTEMS. (*Continued*)

	Problem description	Waste/inefficiency	Reference/appendix
Refrigeration	No insulation on cold pipes less than 16 °C (60 °F)	Waste	D2.4.1
	Low refrigerant charge	Inefficiency	D2.4.2
	Frosting of evaporator coils	Inefficiency	D2.4.3
	Increased refrigeration energy use due to open and unprotected freezer doors	Waste	D7.10.3
	Use of oversized equipment	Inefficiency	
	Use of air cooled condensers	Inefficiency	
Building automation and control systems	Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D2.5.1
	Simultaneous heating and cooling	Waste	D2.5.2
	Heating or cooling unused spaces	Waste	D2.5.3
	Not using free cooling	Waste	D2.5.4
	Not using temperature reset off-shift	Waste	D2.5.5
	Overheating or undercooling spaces	Waste	D2.5.6
	Equipment operating when not needed	Waste	D2.5.7

1.3.3 Central Energy Plant and Distribution Systems

Each component of the site energy and water systems needs to be evaluated for energy and water waste and efficiency. It is likely that a building site or installation will have a power house, or central energy plant, where equipment that provides utility-type services to the buildings and processes is located.

In the power house, there may be boilers to generate steam or hot water for the heating needs of the site's buildings and processes. Fuel is consumed in the boilers, and a percentage of the heating energy found in the fuel is transferred to the steam or hot water. Pumps are required to move water through the equipment, and fans are needed to supply air for combustion of the fuel.

There may also be chillers in the powerhouse to cool the chilled water needed by the buildings and processes. Pumps are required in this system to circulate water to the buildings and to the cooling towers. Cooling towers are needed to release the heat removed by the chillers from the chilled water to the atmosphere.

The powerhouse may also have air compressors that generate compressed air for process needs or controls. Heat created by compressing the air is removed by cooling towers using water circulated through coolers on the compressor.

The central plant systems sometimes need booster pumps to transport these fluids to their destination. Chilled and hot water distribution may also require the use of booster pumps on a large site where changes in elevation are dramatic. Both central and local systems may have distribution issues for ductwork and piping systems. Tables 3–5 list potential causes of water and energy waste and inefficiency for central systems and their distribution.

TABLE 3. CAUSES OF WATER WASTE

	Problem description	Waste/inefficiency	Reference/appendix
Water system	Water leaks	Waste	D3.1
	Heat trace equipment operating above 4.4 °C (40 °F) outside temperature	Waste	D3.2
	Water supply to buildings no longer in use	Waste	D3.3
	Use of high pressure pumps to service a remote location instead of use of booster pump	Inefficiency	D3.4
	Discharging condensate water rather than using it for other purposes	Waste	D3.5
Boiler system	Failure to return condensate	Waste	D4.1.2
	Leaks at gaskets, fittings, and valves	Waste	D4.1,3
	Leaking steam traps	Waste	D4.1.4
	Overventing the deaerator	Waste	D4.1.5
Furnace operations	Heated cooling water is wasted	Waste	D7.8.18
Catering process	High flow prerinse spray nozzles use large volumes of water to rinse soiled wares	Waste	D7.10.1

TABLE 4. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN CENTRAL ENERGY PLANT AND DISTRIBUTION SYSTEMS

	Problem description	Waste/inefficiency	Reference/appendix
Boiler systems	More than 5% boiler water blowdown	Waste	D4.1.1
	Failure to return condensate	Waste	D4.1.2
	Leaks at gaskets, fittings, and valves	Waste	D4.1.3

TABLE 4. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN CENTRAL ENERGY PLANT AND DISTRIBUTION SYSTEMS (*Continued*)

	Problem description	Waste/inefficiency	Reference/appendix
Boiler systems (*continued*)	Leaking steam traps	Waste	D4.1.4
	Overventing the deaerator	Inefficiency	D4.1.5
	Poor water treatment	Inefficiency	D4.1.6
	Excessive heat losses due to poor pipes insulation	Waste	D4.1.7
	Dirty burners	Inefficiency	D4.1.8
	Improper operating dampers	Inefficiency	D4.1.9
	Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D4.1.10
	Boiler tubes not cleaned in two years	Inefficiency	D4.1.11
	Damaged or missing refractory	Inefficiency	D4.1.12
	Combustible gases in the flue exhaust	Inefficiency	D4.1.13
	Excessive venting of steam	Waste	D4.1.14
	Steam pressure greater than required by processes	Inefficiency	D4.1.15
	Steam line serving unused areas	Waste	D4.1.16
	More than 20% excess oxygen in flue gases	Inefficiency	D4.1.17
	Flue gases warmer than 66 °C (150 °F) leaving hot water or steam temperature	Waste	D4.1.18
	Blowdown water warmer than 60 °C (140 °F)	Waste	D4.1.19
	Use of dampers to control air flow	Inefficiency	D4.1.20
	Surface temperature of boiler, pipes, or other hot surfaces greater than 52 °C (125 °F)	Waste	D4.1.21
	Use of continuously lit pilots	Waste	D4.1.22
	Boiler cycling on and off at low loads	Inefficiency	D4.1.23
	Vent gases released outdoors warmer than 93 °C (200 °F)	Waste	D4.1.24
	Use of small inefficient steam turbines (less than 65%)	Inefficiency	D4.1.25
	Use of cooling tower or river water to condense steam turbine exhaust steam	Waste	D4.1.26
	Use of pressure-reducing valve to provide pressure reductions	Inefficiency	D4.1.27
	Use of a boiler having an efficiency less than 70%	Inefficiency	D4.1.28
	Use of steam to atomize oil	Inefficiency	D4.1.29
	Use of inefficient burners	Inefficiency	D4.1.30
	Fuel oil too cold for good atomization	Inefficiency	D4.1.31
	No automatic stack damper	Waste	D4.1.32
	Boiler location remote from area served	Inefficiency	D4.1.33

(*Continued*)

TABLE 4. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN CENTRAL ENERGY PLANT AND DISTRIBUTION SYSTEMS (*Continued*)

	Problem description	Waste/inefficiency	Reference/appendix
Chiller systems	Water flow through shutdown equipment	Waste	D4.2.1
	Dirty heat exchangers	Inefficiency	D4.2.2
	Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D4.2.3
	Imbalanced water flow in system	Inefficiency	D4.2.4
	Use of constant chilled water temperature	Inefficiency	D4.2.5
	Use of constant cooling tower water temperature	Inefficiency	D4.2.6
	Use of air-cooled chiller equipment	Inefficiency	D4.2.7
	Use of oversized equipment	Inefficiency	D4.2.8
	Excessive energy use at part load conditions	Inefficiency	D4.2.9
	Water-cooled chillers inefficiency	Inefficiency	D4.2.10
	Cooling plants are primary/secondary systems and are equipped with constant speed primary chilled water pumps	Inefficiency	D4.2.11
	Chiller system uses a constant speed condenser water pumps	Inefficiency	D4.2.12
	Inefficient chiller plant control strategies	Inefficiency	D4.2.13
	Inefficient dehumidification/reheat	Inefficiency	D4.2.14
	No chiller waste heat reclaim	Waste	D4.2.15
	Insufficient cooling load provided by existing chiller system	inefficiency	D4.2.16
	Cooling tower dirty distribution nozzles	Waste	D4.2.17
	Cooling tower leaks and excessive blowdown	Inefficiency	D4.2.18
	Splash bars and drift eliminators in poor condition	Inefficiency	D4.2.20
	Blowdown from supply header or cooling tower basin	Inefficiency	D4.2.21
	Control of fans and pumps not based on cooling tower water temperature	Inefficiency	D4.2.22
	Cooling tower fan blades not adjusted for load or season	Inefficiency	D4.2.23
	No duct at fan discharge for velocity recovery	Inefficiency	D4.2.24

TABLE 5. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN COMPRESSED AIR SYSTEMS

	Waste/inefficiency	Reference/appendix
Running standby dryer	Waste	D4.3.1
Leaks at gaskets, fittings, and valves	Waste	D4.3.2
Dirty heat exchangers	Waste	D4.3.3
Dirty air filters	Waste	D4.3.4
Heated air warmer than 66 °C (150 °F) exhausted outdoors	Waste	D4.3.5
Fouled air/oil separators	Waste	D4.3.6
Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D4.3.7
System pressure greater than required by users	Waste	D4.3.8
Excessive energy use at part load conditions	Inefficiency	D4.3.9
Compressed air used for cooling, agitating liquids, moving product, or drying	Inefficiency	D4.3.10
Providing compressed air to unused areas	Waste	D4.3.11
Use of oversized equipment	Inefficiency	D4.3.12
Use of warm building air for compressors air intake	Inefficiency	D4.3.13
Use of refrigerated air dryers	Inefficiency	D4.3.14
Use of modulation-controlled air compressors at part load	Inefficiency	D4.3.15
Lack of compressor system control system	Inefficiency	D4.3.16

1.3.4 Lighting System Considerations

Building and site lighting can be accomplished by several types of lighting luminaires, each with their own cost and efficiency. Both general/high level and task lighting as shown in Figure 24 may be used in a building. Table 6 lists problems associated with these systems that result in waste or inefficiency.

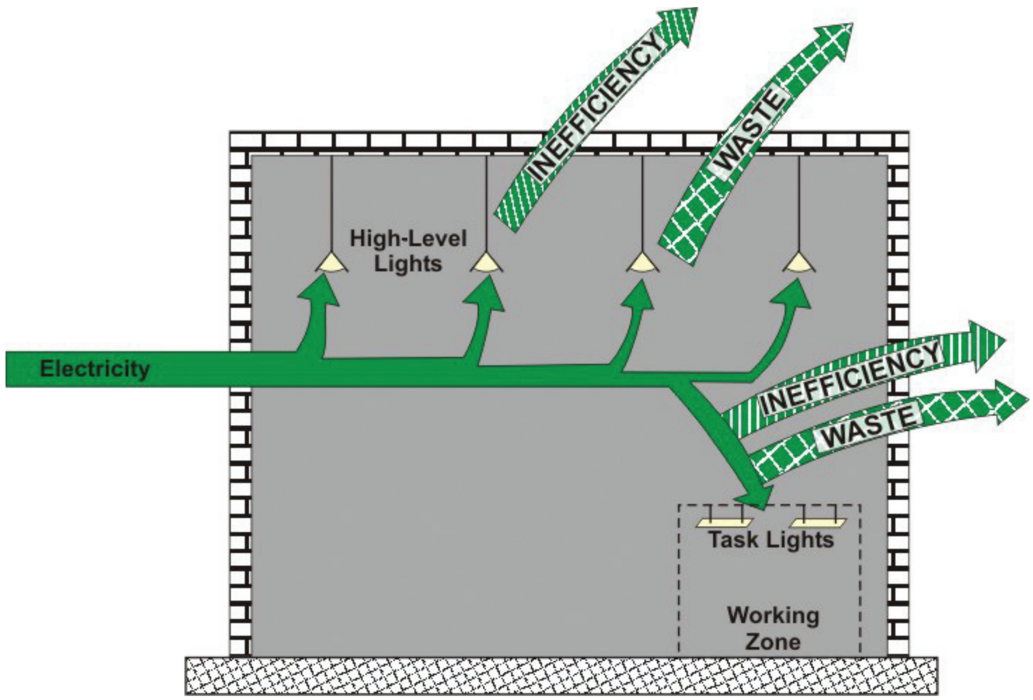

Figure 24. Building lighting.

TABLE 6. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN LIGHTING SYSTEMS.

	Waste/inefficiency	Reference/appendix
Having more light in space than is necessary to perform the task	Waste	D1
Leaving electric lighting on in daylit spaces during daylight hours.	Waste	D5.2
Having the entire floor of a building lit when only a few people are working	Waste	D.3
Leaving lights on in unoccupied spaces	Waste	D.4
Leaving outdoor lighting on during the daylight hours	Waste	D.5
Using outdoor lighting that lights up the sky instead of lighting the streets and walkways	Inefficiency	D.6
Incandescent "A" lamps	Inefficiency	D.7
Older T-8 fluorescent lamps and electronic ballasts	Inefficiency	D.8
Using older technologies such as T12 fluorescent lamps with magnetic ballasts	Inefficiency	D.9
Using incandescent lighting for general lighting instead of compact fluorescent lighting	Inefficiency	D.10
Using warm-colored fluorescent lamps	Inefficiency	D.11
Using high levels of ambient lighting for illuminating tasks rather than using task lighting with lowered ambient lighting	Inefficiency	D.12
Using mercury vapor lamps and ballasts	Inefficiency	D.13
Using exit signs that are not LED exit signs	Inefficiency	D.14

TABLE 6. CAUSES OF ENERGY WASTE AND INEFFICIENCY IN LIGHTING SYSTEMS (*Continued*)

	Waste/inefficiency	Reference/appendix
High-pressure sodium lighting in indoor environments	Inefficiency	D.15
Using poor performance lighting fixtures that trap more light than they distribute to the task area	Inefficiency	D.16
Lack of task lighting and lighting levels greater than 30 footcandles	Waste	D.2.3
Using incandescent lighting in exhaust hoods, walk-in coolers and even dining rooms instead of compact fluorescent lighting	Inefficiency	D.10.2

1.3.5 Electrical Systems

Electricity is used in all buildings and most processes. Electricity is distributed at high voltages for ease of handling and efficiency. Transformers near points of use reduce the voltage to that required by the process equipment. The efficiency of this operation is in the range of 5–10%, with the loss ending up as heat. Table 7 describes energy waste and inefficiency in electrical systems.

TABLE 7. ENERGY WASTE AND INEFFICIENCY IN ELECTRICAL SYSTEMS

	Problem description	Waste/inefficiency	Reference/appendix
Motors	Running when not required	Waste	D6.1.1
	Motors of more than 3 hp that are less than 85% efficient	Inefficiency	D6.1.2
	Rewinding motors more than twice	Inefficiency	D6.1.3
	Use of motor two sizes greater than required	Inefficiency	D6.1.4
	Use of standard efficiency motors	Inefficiency	D6.1.5
	Loads with large variations serviced by constant-speed motors	Inefficiency	D6.1.6
	Idling equipment	Waste	D6.1.7
	Inefficient walk-in cooler and freezer evaporator fan motors in catering facility	Inefficiency	D7.10.4
Pumps	Condensate receiver pumps need repair	Waste	D6.2.1
	Constant speed primary chilled water pumps of above 5 hp	Inefficiency	D6.2.2
	Constant speed condenser water pumps	Inefficiency	D6.2.1
Transformers	Oversized transformers	Inefficiency	
	Transformers oversized	Inefficiency	
	Transformers energized on abandoned buildings	Waste	
	Transformer taps not set at proper settings	Inefficiency	
Metering	Duplication or excessive metering of use	Inefficiency	

1.3.6 Industrial Processes

In industrial facilities, the process operations are major energy users. Electricity is required to power electric motors. Fuels are needed in foundry, forging, heat treat, and drying operations. Heat is used in washing, cleaning, and drying. Heat and cooling are required for painting, machining, and assembly. Performance of manufacturing facilities needs to consider raw materials, previously fabricated parts, labor, and added energy requirements when evaluating efficiency and the creation of waste. Often, nonenergy components of the process are much more costly than the energy used. Process activities can also affect the operation of the buildings HVAC systems. The impact needs to be considered when looking for waste and inefficiencies. Figure 25 shows the energy and resource flows for a typical process, and Table 8 lists some industrial process waste and efficiency issues.

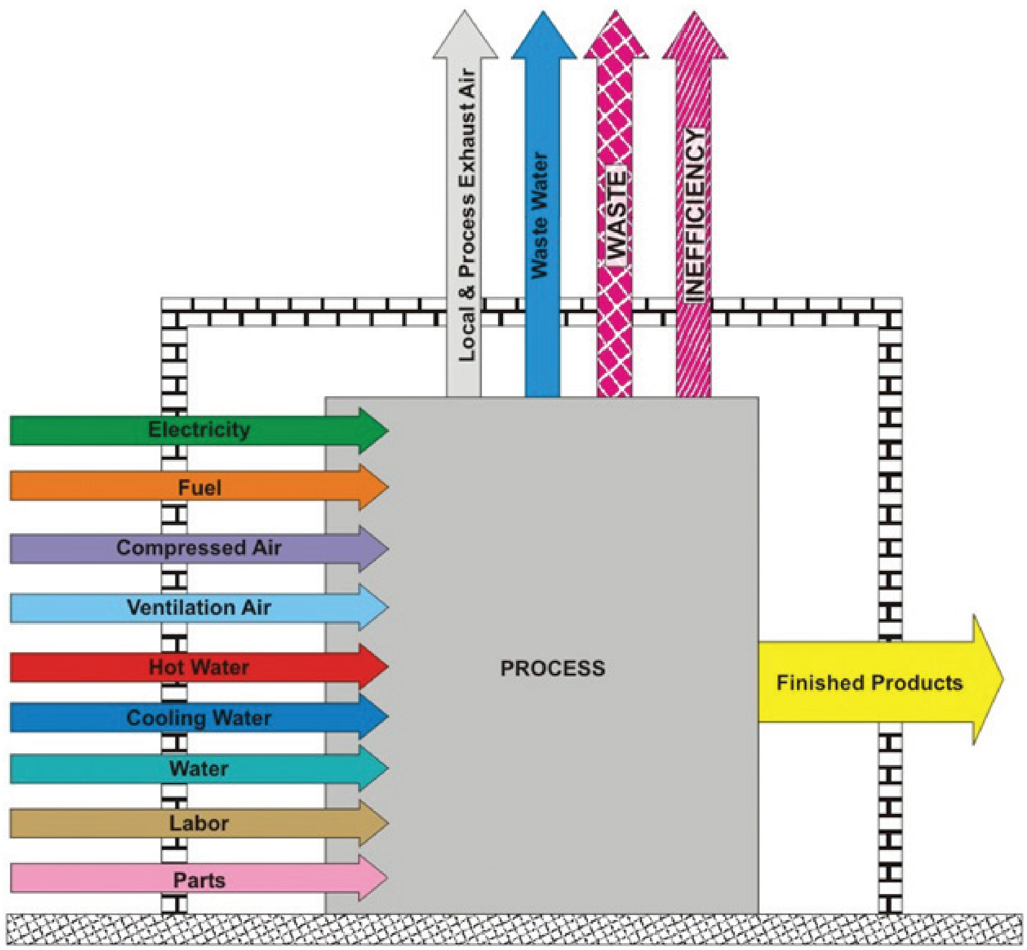

Figure 25. Industrial process energy flow.

TABLE 8. ENERGY WASTE AND INEFFICIENCY IN PROCESSES.

	Problem description	Waste/ inefficiency	Reference/ appendix
Painting	Operating paint booth ventilation system when not painting	Waste	D7.1.1
	Painting when item to be painted is at improper temperature	Inefficiency	D7.1.2
	Operating paint booths under positive pressure, resulting in paint fumes in adjacent spaces	Inefficiency	D7.1.3
	Failure to recirculate more than 70% of oven-heated air	Inefficiency	D7.1.4
	Use of high-pressure spray guns	Inefficiency	D7.1.5
	Operations that are not enclosed, requiring excessive ventilation and movement of paint fumes into adjacent spaces	Waste	D7.1.6
Plating	Air movement greater than 0.51 m/sec (100 fpm) near exhaust hoods	Inefficiency	D7.2.1
	Operating exhaust systems when no plating operations are occurring and at other times when not required	Waste	D7.2.2
	Hot plating tanks having a surface temperature greater than 125 °F	Waste	D7.2.3
	Using single-side exhaust hood on tanks 4 ft wide or wider	Inefficiency	D7.2.4
	Exhausting clean exhaust greater than 93 °C (200 °F)	Waste	D7.2.5
	Uncovered heated tanks over 60 °C (140 °F)	Waste	D7.2.6
Machining	Turning (lathe), drilling, milling, and grinding machines do not have local exhausts or process enclosures	Inefficiency	D7.3.1
	Compressed air leaks	Waste	D7.3.2
	Lack of task lighting and lighting levels greater than 323 lux (30 footcandles)	Waste	D7.3.3
Welding	Using continuous operating welding exhaust	Waste	D7.4.1
	Using stationary welding hoods	Inefficiency	D7.4.2
	Excessive welding fume generation	Inefficiency	D7.4.3
Vacuum systems	Operating at lower pressure than required	Inefficiency	D7.5.1
	Excessive air bleed-in through leaks	Waste	D7.5.2
Assembly	Lack of task lighting and lighting levels greater than 323 lux (30 footcandles)	Inefficiency	D7.6.1
Foundry	Running exhaust systems when not required	Waste	D7.7.1
	Outside furnace temperature exceeding 52 °C (125 °F)	Waste	D7.7.2
	Use of oversized equipment to produce small numbers of parts (waste)	Waste	D7.7.3

(*Continued*)

TABLE 8. ENERGY WASTE AND INEFFICIENCY IN PROCESSES (*Continued*)

	Problem description	Waste/ inefficiency	Reference/ appendix
Furnace operations	Dirty burners	Inefficiency	D7.8.1
	Improper operating dampers	Inefficiency	D7.8.2
	Inoperable, uncalibrated, or poorly adjusted controls	inefficiency	D7.8.3
	Combustible gases in the flue exhaust	Waste	D7.8.4
	Damaged or missing refractory	Waste	D7.8.5
	Openings used for charging too large for operation	Inefficiency	D7.8.6
	Leaks around furnace doors	Waste	D7.8.7
	Temperature not reduced in standby mode	Waste	D7.8.8
	Use of wet and cold materials to be heated in furnaces	Waste	D7.8.9
	Using fast melting rates during low metal demand periods	Inefficiency	D7.8.10
	Clean exhaust air warmer than 93 °C (200 °F) being exhausted outside	Waste	D7.8.11
	More than 20% excess oxygen in flue gases	Inefficiency	D7.8.12
	Furnace or oven cycling on and off at low loads	Inefficiency	D7.8.13
	Furnaces with continuously lit pilot.	Waste	D7.8.14
	No automatic stack damper	Inefficiency	D7.8.15
	Use of inefficient burners (inefficiency)	Inefficiency	D7.8.16
	Fuel oil too cold for good atomization (inefficiency)	Inefficiency	D7.8.17
	Heated cooling water is wasted	Waste	D7.8.18
	Use of underfired heaters (inefficiency)	Inefficiency	D7.8.19
Storage	Maintaining space temperatures over 20 °C (68 °F) in the winter	Waste	D7.9.1
	Slow large doors used for bringing in and out goods	Waste	D7.9.2
	Significant infiltration through truck docks	Waste	D7.9.3
	Lighting levels greater than 161 lux (15 footcandles)	Waste	D7.9.4
	Power use for lighting during the daytime	Waste	D7.9.5

TABLE 8. ENERGY WASTE AND INEFFICIENCY IN PROCESSES (*Continued*)

	Problem description	Waste/ inefficiency	Reference/ appendix
Catering	High-flow prerinse spray nozzles use large volumes of water to rinse soiled wares	Waste	D7.10.1
	Using incandescent lighting in exhaust hoods, walk-in coolers, and even dining rooms instead of compact fluorescent lighting	Inefficiency	D7.10.2
	Increased refrigeration energy use due to open and unprotected freezer doors	Waste	D7.10.3
	Inefficient walk-in cooler and freezer evaporator fan motors	Inefficiency	D7.10.4
	Unnecessary use of refrigerator and freezer antisweat door heater	Waste	D7.10.5
	Inefficient deep fat fryer	Inefficiency	D7.10.6
	Inefficient steamer	Inefficiency	D7.10.7
	Inefficient ovens	Inefficiency	D7.10.8
	Poor exhaust hood design results in heat, grease, and smoke/vapor spillage or in increased exhaust and make-up airflow rates	Inefficiency	D7.10.9
	Single island canopy hood over kitchen equipment	Inefficiency	D7.10.10
	Supply air jet disturbs airflow around the kitchen hood, resulting in heat, grease and smoke/vapor spillage	Inefficiency	D7.10.11
	Inefficient positioning of appliances at the wall results in heat, grease, and smoke/vapor spillage or increase exhaust and make-up airflow rates	Inefficiency	D7.10.12
	Unnecessarily high hot water temperature setpoint	Waste	D7.10.13
	Heat escapes from the hot water storage tank through the water heater flue	Waste	D7.10.14
	Introduction of cool water into water heater from recirculation line results in heating energy waste when facility is not operating	Waste	D7.10.15
Virtual training facilities	Unnecessary low room air temperature, resulting in discomfort, energy waste, and condensation on cold surfaces = mold in these spaces	Waste	D7.11.1
	Simulation equipment is conditioned using DX units connected to training modules; DX condensers reject heat in the air-conditioned space	Waste	D7.11.2
	Power conditioners are installed in and reject heat into the air-conditioned space, increasing cooling load	Waste	D7.11.3
	Simulator-manned modules reject heat into the air-conditioned bay, increasing cooling load on air-conditioning system	Waste	D7.11.4
	Computer server rejects heat into the air-conditioned space, increasing cooling load on air-conditioning system	Waste	D7.11.5

1.3.7 Building Automation System

The objective of an energy management, building and process automation system is to achieve an optimal level of control, for occupant comfort, indoor air quality, as well as environmental parameters required by processes. These control systems are integrating components to fans, pumps, heating and cooling equipment, dampers, valves, thermostats, sensors, process equipments, lighting systems, and so forth. Deficiencies in operation of these systems result in discomfort, reduced productivity, health hazards, reduced throughput, excessive energy use, and damage to the building fabric. Table 9 provides some examples of inefficient control strategies summarized by system category.

TABLE 9. ENERGY-INEFFICIENT CONTROLS STRATEGIES.

	Problem description	Waste/ inefficiency	Reference/ appendix
Ventilation system	Process ventilation systems that operate continuously with the process turned off	Waste	D2.1.7.
	Central exhaust ventilation system connected to multiple hoods operate at a constant airflow with a diverse manufacturing process: contaminant emission occurs at less than 75% working places simultaneously	Waste	D2.1.8
Heating and cooling systems	Failure to reset temperature of unoccupied spaces	Waste	D2.2.5
Boiler system	Boiler cycling on and off at low loads	Inefficiency	D4.1.23
Chiller system	Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D4.2.3
	Inefficient chiller plant control strategies	Inefficiency	D4.2.13
	Control of fans and pumps not based on cooling tower water temperature	Inefficiency	D4.2.22
Compressed air system	Inoperable, uncalibrated, or poorly adjusted controls	Inefficiency	D4.3.7.
	Lack of compressor system control system	Inefficiency	D4.3.16.
Lighting systems	Leaving electric lighting on in daylight spaces during daylight hours.	Waste	D5.2
	Having the entire floor of a building lit when only a few people are working	Waste	D5.3
	Leaving lights on in unoccupied spaces	Waste	D5.4
	Leaving outdoor lighting on during the daylight hours	Waste	D5.5

TABLE 9. ENERGY-INEFFICIENT CONTROLS STRATEGIES (*Continued*).

	Problem description	Waste/ inefficiency	Reference/ appendix
Electrical systems	Running motors when not required	Waste	D6,1,1
	Loads with large variations serviced by constant speed motors	Inefficiency	D6.1.6
	Idling equipment	Waste	D6.1.7
	Constant-speed primary chilled-water pumps above 3.785 kW (5 hp)	Inefficiency	D6.2.2
	Constant-speed condenser water pumps	Inefficiency	D6.2.3
	Transformer taps not set at proper settings	Inefficiency	
	Duplication or excessive metering of use	Inefficiency	
Processes	Operating exhaust systems when no plating operations are occurring and other times when not required	Waste	D7.2.2
	Using continuous operating welding exhaust	Waste	D7.4.1
	Running foundry exhaust systems when not required	Waste	D7.7.1
	Inoperable, uncalibrated, or poorly adjusted furnace and burners controls	Inefficiency	D7.8.3
	More than 20% excess oxygen in flue gases	Inefficiency	D7.8.12
	Furnace or oven cycling on and off at low loads	Inefficiency	D7.8.13
	Furnaces with continuously lit pilot.	Waste	D7.8.14
	No automatic stack damper	Inefficiency	D7.8.15