Energy Management EEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To conserve and optimize building energy use and minimize air emissions, including greenhouse gases, associated with energy consumption at the site.

Action: Prepare an Energy Management Plan to conserve and optimize building energy use, minimize air emissions and coordinate and maximize the utilization of any site generated energy resources. The Plan shall include an energy use budget for the project for the first year of operation (building shall be a minimum of 50% occupied with unoccupied areas and building systems normalized for full occupancy) and broken down by major energy consumption category (i.e., heating, cooling, lighting, fan energy, pump energy, etc.). Consider base building systems apart from occupancy with allowances for interconnections. After each year of operation, the actual utilization of energy shall be recorded and compared to this baseline energy use budget with appropriate adjustments for deviations in occupancy, base building conditions and climate norms. Significant deviations shall be evaluated and a detailed explanation for the probable cause of the deviation recorded in the updated plan. Strategies for reducing energy consumption below the first year of operation, as defined above, shall be identified and described.

The Energy Management Plan shall include a similar itemization of any site generated energy resources, including a budget for each component, and annual updates of actual performance. The Plan shall identify measures and strategies for increasing utilization of clean on-site energy above the first year of operation, as defined above.

Review opportunities for coordinated site strategies to conserve energy. Provide a matrix outlining additional costs and savings, available incentives, benefits and impacts from, for instance, a co-generation plant, river water cooling, building integrated PV, fuel cells and other strategies.

Related Guidelines: EEQ-2, EEQ-3, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8

Introduction/Context

The world-wide demand for energy continues to increase at a rapid pace. The majority of this electricity is still produced by methods that rely on the consumption of non-renewable carbon-based fuel sources such as coal, oil, and natural gas. As these resources are continually depleted, their value and purchase cost is quickly rising. Observation of the steady increase in the price of gasoline over the past few years clearly indicates the magnitude of this problem to everyone including the average consumer. The environmental costs of increased energy usage and increased burning of fossil fuels to generate power are also of great importance. Conservation is the first major step needed to curtail this expanding dilemma. Beyond reducing energy usage, the use of more efficient and less ecologically detrimental sources for energy will further reduce both its financial and environmental costs. Effective incorporation of on-site energy sources reduces the need for utility capacity growth in dense urban areas during peak periods, while providing standby generation assets for emergency operation. Coordination of on-site generation assets with a commodity energy purchasing plan can further reduce site energy costs. The Energy Management Plan provides a tool to accomplish these goals and manage these costs, through both design and continued evaluation.

Relevant Issues

Ecological

The benefits of energy savings for the eco-system are widely acknowledged. Energy efficiency of human activities reduces the need for the energy conversion processes that add pollution to the environment. Beyond conservation, society can further promote the transition to less environmentally damaging methods of electricity generation that avoid the by-products of traditional production. The burning of fossil fuels releases mercury compounds and particulate matter which cause health problems, particularly of the respiratory system. When consumed, fossil fuels also release carbon dioxide, methane and various nitrogen oxides all of which contribute to the greenhouse effect causing global warming. Sulfur dioxide, also produced by the combustion of fossil fuels, is a major contributing factor to acid rain. While generation of electricity with nuclear fission avoids the immediate discharge of pollutants into the atmosphere, it creates the danger of catastrophic accidents and generates nuclear waste products whose thousand year toxicity results in intractable waste disposal systems. The reduction of energy society's energy needs is critical to the preservation of a clean and healthy planet. Moreover, the use of more efficient and benign energy sources, ideally renewable ones, to meet the balance of our energy needs will further help this cause.

Economic

Good energy management improves project economics both for the project bottom line and for the community. Energy efficiency has long been recognized as a viable method of reducing project operating costs. Coordination of energy efficiency measures with on-site generation assets through a design optimization process utilizing computerized energy simulation, can reduce not only project operating costs, but also the generation and transmission infrastructure upgrade costs, entailed by the project, that would otherwise be borne by the community.

Neighborhood

The improvement of water and air quality as conventional electricity generation decreases is a major benefit for the health and well being of society as a whole. Lessened pollutants from power plants will also result in cleaner buildings due to reduced airborne particulate matter which sullies facades, and acid rain, which corrodes building materials as well as affecting water quality. A reduction in energy demand, especially during peak hours, also increases electrical security, lessening the likelihood of major power failures. On-site utilization of waste heat from the generation process can further reduce operating costs, along with reducing the environmental burden of fossil fuel use for generation of low-grade heat.

Methodology

Design Strategies

From a general perspective, the strategies incorporated into the management plan fall into four areas. These areas include energy use conservation, site generation, renewable energy and ongoing management strategies.

The USGBC has identified several products and protocols which offer useful energy management strategies. The Commissioned Systems Manual required by LEED Credit EA3 is an indexed systems manual that provides a resource for sequence of operations for all equipment, operating instructions for all energy and water saving features and systems, functional performance test results, seasonal guidelines, sensor calibration recommendations, line diagrams of commissioned systems, troubleshooting tables and ongoing maintenance guidelines. The measurement and verification protocols identified as part of LEED Credit EA5 offer several paths to verification of equipment operation. These should aid in energy use conservation and ongoing management strategies.

On-site generation is a powerful tool for reducing project energy costs, societal infrastructure costs and environmental damage. On-site generation, especially when coupled with heat recovery for combined heat and power (CHP) applications, offers excellent economic return for many project types. The energy efficiency creating these costs, further reduces fuel consumption required to meet the project electricity demands. On-site generation further reduced the need of central generation and transmission upgrades necessary to support the electric requirements of the project.

On-site energy generation using a renewable source is even more advantageous from both a financial and ecological standpoint. Since renewable energy sources by definition are inexhaustible, their cost is largely associated with initial infrastructure and ongoing maintenance. As technology progresses these costs will be comparable if not less to those of more traditional, e.g. fossil fuel based, electricity production.

Means and Methods

Develop and execute the energy management plan (EEQ-1-P) This plan should include such strategies as energy use conservation, peak load reduction, on-site (and renewable) power generation, and continuing energy management.

Working with a building's energy profile in a holistic fashion is a crtical part of the design and decision making process. Potential interrelationships between different conservation strategies can make the individual techniques much more productive. Improvements in the building façade that lessen a buildings thermal load can permit the design of smaller HVAC systems which, in turn, use less energy to operate.

Explore the potential for on-site electricity generation with both renewable and non-renewable energy sources. While most didtributed generation applications utilize conventional fossil fuels, some operations have utilized renewable fuels, such as land-fill ort sewer treatment generated gas, or bio-fuels. For a more thorough discussion of renewable energy please see EEQ-5.

Fuel Cells are another potential method for on-site electricity production. However, in their current state of development, they are not as viable as some of the other systems described above. Ongoing research is trying to find the most effective and clean method for supplying the hydrogen fuel that these cells need to operate. Current technologies use fuel reformers that take hydrocarbon-based fuels like natural gas and liberate their hydrogen. This has the negative side effect of releasing as much global-warming causing carbon dioxide as if the natural gas was simply burned to generate heat in a more conventional power plant. The fuel cell does have a benefit though, because it converts the fuel more efficiently and produces more electricity per unit of carbon dioxide released than combustion does.

Avoid using high-grade energy sources, such as electricity or chemical fuels to create low temperature heat for space heating or domestic hot water. Meet heating requirements from the recovered heat of energy conversion from chemical fuels to electricity or by utilizing heat pump technologies to extract heat from local environmental sources, such as the earth or surface water. Examples of small scale cogeneration include the use of micro-turbines as the heat source for domestic hot water. Electricity is generated as a by-product of the water heating process. Examples of heating with heat pump technology include ground source heat pumps, river or lake water source heat pumps, and domestic water heaters that provide domestic hot water while providing the useful by-product of space-cooling.

Photovoltaics convert only a portion of solar radiation to electricity with the balance of the energy being emitted as heat. Some systems have been configured to capture this heat for domestic hot water or space-heating end-uses. The waste heat from electricity generation with biomass fuels can also be captured and. Geothermal power systems present a similar opportunity. After the steam they create is used to produce electricity, it can be used for building conditioning or hot water production

Case Studies

Please note that, although the case studies discussed below involved existing buildings, they are still quite relevant to this topic. Because the concept of comparing a well-designed building's energy performance to a base-case scenario may seem abstract to many, taking a look at a "before and after" study showing the effect of specific energy management strategies on an existing building may be quite useful.

<u>U.S. Department of Defense Naval Facilities Engineering Command Washington, DC</u>

In its model energy program, the Naval Facilities Engineering Command (NAVFAC) demonstrated outstanding overall performance in energy management and conserved over 900 billion British Thermal Units (Btu) in the last year. The NAVFAC Energy Program used alternative financing mechanisms to fund energy efficiency improvements that produce significant guaranteed energy cost savings; installed renewable energy technologies and highly energy-efficient cogeneration plants, reducing dependence on power from the electric grid; and developed internet-based energy reporting tools to better track (and ultimately reduce) energy use and costs.

United States Postal Service Pacific Area Energy Management Program California, Nevada, Arizona, Hawaii and the Pacific Islands
The USPS Pacific Area Strategic Energy Management Plan enabled the USPS to save millions of dollars in energy costs, significantly reduce electricity consumption and improve the environment. The plan created a framework that includes an effective administrative structure, energy management tools for data collection and reporting to management and staff, performance goals, contractual vehicles, and implementation tools to evaluate and complete numerous energy efficiency projects.

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

Standards have not been provided for this Guideline.

Bibliography

ASHRAE/IESNA. ASHRAE/IESNA 90.1-1999: Energy Standard for Buildings Except Low-Rise Residential. Atlanta: ASHRAE/IESNA, 1999.

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Objective

The Energy Management Plan is designed to conserve and optimize building energy use, minimize air emissions and coordinate and maximize the utilization of any site generated energy resources. The plan provides for an integrated consideration of site energy generation and requirements, renewable alternatives and transition plans to full renewables, proximity of off-site energy generators, emissions, secondary energy sources (waste heat) and energy potentials within site waste products. The plan also outlines energy monitoring and reporting requirements of the PANYNJ and New York State (Executive Order 111).

Plan Components

I. Project Description (Plan Summary)

A. Provide a physical description of project with emphasis on energy systems. Include energy conservation opportunities, potential site energy sources, regional renewable and non renewable energy sources and site energy requirements.

II. Energy Resources/Requirements Inventory

A. Provide a detailed inventory of available on-site and off-site Renewable Energy Resources. These include Solar-Electric (Photovoltaic), low-impact hydroelectric, wind, tidal, geothermal, and bio-mass/bio-gas.
B. Provide a detailed inventory of available on-site and off-site non-Renewable Energy Resources.
C. Provide detailed accounting of site energy requirements with demand timetable. Accounting should be coordinated with the Measurement and Verification protocol instituted at the site. If the Measurement and Verification protocol is designed to facilitate recording of energy end-use components, such as lighting, heating, cooling, air movement, heat rejection, pumping, receptacles, etc, individual budgets can be established for these components and then verified over time. Breakdown of energy use into end-use components will greatly facilitate identification of system and component malfunctions in the energy systems.

III. Energy Management Strategies

A. The Plan shall include an energy use budget for the project for the first year of operation (building shall be a minimum of 50% occupied with unoccupied areas and building systems normalized for full occupancy) and broken down by major energy consumption category (i.e., heating, cooling, lighting, fan energy, pump energy, etc.). Consider base building systems apart from occupancy with allowances for interconnections. After each year of operation, the actual utilization of energy shall be recorded and compared to this baseline energy use budget with appropriate adjustments for deviations in occupancy, base building conditions and climate norms. Significant deviations shall be evaluated and a detailed explanation for the probable cause of the deviation recorded in the updated plan.

B. Utilize full DOE-2 building energy model to optimize building energy use and investigate energy reducing alternatives.
C. Provide full and continuous monitoring of building energy systems.
D. Strategies for reducing energy consumption beyond the first year of operation, as defined above, shall be identified and described.
E. The Energy Management Plan shall include a similar itemization of any site generated energy resources, including a budget for each component, and annual updates of actual performance. The Plan shall identify measures and strategies for increasing utilization of clean on-site energy above the first year of operation, as defined above.
F. Review opportunities for coordinated site strategies to conserve energy. Provide matrix outlining additional costs and savings, available incentives, benefits and impacts from, for instance, a co-generation plant, river water cooling, building integrated PV, fuel cells and other strategies.

IV. Targets

Establish and describe project targets for the following

A. First year of operation.
B. 5 year and 10 year plans.
C. Year 2010 per the requirements of EO-111

V. Evaluation

See III.A. (*Note: The following Annual Energy Report is completed by PANYNJ, not the leaseholders of the site. It is provided here as a verification of the standard of energy management in effect under EO-111, and, by extension, the WTC Site.*

A. Annual Energy Report requirements as required by New York State under Executive Order 111
   1. Filing on December 1st of each year for the previous fiscal year (April 1st-March 30th) with NYSERDA.
   2. The target is a 30% reduction in energy consumption based on the Energy Use Index (EUI), which is calculated by dividing the total BTU's consumed by the total square footage and comparing it to a baseline year of 1989-90.
   3. There is a one-page form for this report that must be completed. It includes information on:
      a) The types of energy used and how much of each
      b) The reported energy use last year, the percent change and the use in the base year
      c) The total peak electrical demand in megawatts
      d) The amount of renewable power used in kilowatt/hours
      e) Compliance with EPA Energy Star criteria.

VI. References

<http://www.tcet.state.tx.us/PDF/052102Tech_Conf/Building%20Technologies/David%20Claridge.PDF>

<http://www.hvac.okstate.edu/pdfs/bs01/BS01_0335_342.pdf>

<http://www.eere.energy.gov/femp/operations_maintenance/commissioning_guidebook.cfm >

(Note: this is an excellent commissioning reference. The following link brings up the introductory chapter; the bookmarks then bring up succeeding chapters. This document blends commissioning into energy management, showing that they are just different phases of the same thing, and that the most successful strategy for energy management is continuous commissioning, where you continuously monitor whether systems and equipment are operating as intended.)

<http://www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm>

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Energy Management

EEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
An Energy Management Plan is attached and follows the requirements outlined by Guideline Document EEQ-1-P: Energy Management Plan.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Purpose: To implement a Building Commissioning Plan.

Action: Engage an independent commissioning authority to prepare and execute a commissioning plan. Implement fundamental, best practice building commissioning procedures. Include design phase reviews, contractor submittal reviews, pre-functional and functional testing (including seasonal testing), training, Operations & Maintenance manuals and post occupancy review. Provide Building Commissioning Plan consistent with the requirements of NY State Green Building Tax Credit (NYSGBTC) 638.8.

Related Guidelines: EEQ-1, EEQ-3, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8, IEQ-4, IEQ-7, IEQ-8

LEED™ 2.1 Requirement: EQ Prerequisite 1 (see Submittal Template)

Introduction/Context
The goal of Building Commissioning is to ensure that the building, its systems and its equipment are delivered to the building owner fully functional and in accordance with the design intent. The Commissioning Authority is responsible for the Commissioning process and must be independent from both the Design team and the Contractor. Fundamental building commissioning is required by New York State EO-111 and is a prerequisite under the LEED™ Green Building Rating System. Additional commissioning, as defined in LEED Green Building Rating System Energy and Atmosphere, Credit 3, is not required by this guideline. The requirements of the Green Building Tax Credit, for commercial buildings, which require only commissioning of the base building systems, are extender under this guideline to include all energy using equipment and systems, even those installed during tenant improvement of the property.

Relevant Issues

Ecological

The direct result of commissioning is that the building systems provide exactly the required operating environment with the least expenditure of energy and water. By insuring that each piece of equipment is exactly as specified and that the equipment is being controlled according to the specified sequences of operation, commissioning assures that building operation minimizes waste and maximizes efficiency.

Economic

The economic benefits of building commissioning have consistently exceeded the actual cost of commissioning within the first year or first couple of years of operation. These economic benefits fall into a number of categories which incorporate both immediate first cost savings, or value capture, and future operating costs and capital replacement costs. The first category of cost savings involves verification of contractor delivery and correct installation of required products and systems. Often, the commissioning process identifies deficiencies in the construction delivered by the contractor and provides a reliable verification that the contractor has delivered all that was required by his contract.

The second category of economic benefits results from accelerated delivery of a fully functioning building. In conventional non-commissioning building hand-over from contractor to owner, the owner is typically involved in a protracted problem identification process. Because functionality of the individual building systems and components has not been rigorously explored, only through operation and use over time is the full range of operating sequences explored. Often this process can go on for years, with the contractor on call to correct deficiencies as they appear. This call-back process is inefficient and rarely results in timely corrections. For many owners and tenants this loss of functionality is also an economic loss.

The third category of economic benefit has to do with operating cost reductions, both in terms of energy use and maintenance. Correct initial set-up of equipment and systems results no only in more efficient alteration, it also results in more reliable operation. Detailed and complete conveyance of operations information to the owner's operating staff decreases required outside intervention necessary to achieve acceptable operation.

A final category of economic benefit from commissioning is the longer equipment life usually achieved by systems that benefit from complete and correct initial set-up and from complete education of operating personnel. The initial set-up and education process sets the course for a long and relatively trouble-free system life. The commissioning documents, furthermore, provide a vehicle for transferring facilities information across the generation of operators, insuring that personnel changeover does not result in deterioration of systems operating knowledge. Maintenance, adjustment, calibration and operations information are memorialized for use throughout the life off the facility.

Neighborhood

The commissioning process is a proven way for a building owner to confirm that the building, as delivered, is fully functional and calibrated to meet the stated systems performance requirements. The entire community benefits from a building that is fully-functional from the day it opens. Reduced energy use by such a building has positive effects for a neighborhood, including the availability of a greater electrical supply during peak demand periods and reduced health impacts, as well as reduced costs and fewer emissions associated with power plant operations. Greater satisfaction experienced by building occupants in a building with well-coordinated systems, and their ability to enjoy a healthier and more productive workplace, also benefits the population as a whole.

Methodology

Design Strategies

Follow one of the national standards for commissioning, such as Portland Energy Conservation, Inc. (PECI) or ASHRAE.

Means and Methods

Engage the Commissioning Authority at the beginning of Design Development

Make the commissioning Authority an active member off the design team.

Utilize the directed third party peer reviews described in LEED Credit EA3 to insure that the design documents match the design intent. Utilize the expertise of the Commissioning Authority as a resource for the detailed design of the project.

Utilize the Commissioning Authority in the preconstruction meeting to insure that General Contractor and subcontractors are aware of expectations for the project.

Plan for a Continuous Commissioning program utilizing a calibrated building energy simulation model coordination with the building measurement and verification protocol.

Case Studies

Marion County Courthouse Square, Salem, Oregon

The city of Salem wanted to be sure that their new transit mall facility would be a good example of sustainability. They decided to use the LEED certification process as a tool to evaluate the success of this goal and were required to have the new building commissioned as part of that endeavor. Putting this new facility through the commissioning process yielded benefits that were above and beyond simply qualifying for LEED certification. During this process, an independent commissioning *agent recommended 101 improvements, of varying importance, to make the building perform up to the standards of its designers' original intent. 13 of these recommendations were considered to be critical action items that required correction in order for the building to perform as desired by its client and design team. Some of these issues included inaccurate flow and temperature sensors, excessive operation of cooling units, improper control of supply air temperatures, malfunctioning economizer cycle, and outside air volume control difficulties. The commissioning process also revealed incorrect operation of the heating system, leading to an inability of the system to warm the lobby on cold days. Through the commissioning process all of these issues were both discovered and corrected before the building was permanently inhabited. Occupant comfort and efficient operation were achieved from the moment of building occupancy, avoiding the traditional break-in period of occupant complaints, expensive operation, and equipment failures.*

North Clackamas High School, Clackamass, Oregon
This LEED Silver certified building underwent a valuable commission process in preparation for hosting its 1,850-member student body. The process began early in the construction phase and was completed shortly after the building's opening. The commissioning review exposed 75 concerns, 15 of which were serious. These major issues included improperly calibrated static pressure controllers, faulty carbon dioxide sensors, excessive running of pumps and exhaust fans, the need for damper adjustment and repair, and incorrect lighting control sequences. The resolution of these deficiencies resulted in a reduction of electricity usage of roughly 35,800 kWh/year and a reduction of natural gas usage of about 6,100 therms/year. This translates to an annual energy savings of $7,700. Besides economic benefits, the correction of these issues as a result of the commissioning process also helped create a school that is much more comfortable for students and teachers and has fewer maintenance issues (that would likely result in occupant complaints) for its staff to cope with.

Reference

Definitions

Commissioning Agent – the organization that performs the actual commissioning tests, including the operating performance test, calibration testing, and owner education

Commissioning Authority – the organization that manages the commissioning process, establishing the scopes of work for all participants, scheduling major activities, and providing documentation of all commissioning activities.

Operating Performance Test – Programmed run-throughs of all operating cycles of equipment within a system to demonstrate the functionality of the equipment, controls, and the system as a whole throughout the range of its operation. Operating performance tests are created for each system with written, repeatable test procedures, with expected system responses and acceptance criteria.

Standards

Standards have not been included for this Guideline.

Bibliography

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The Building Commissioning Handbook , The Association of Higher Education Facilities Officers (APPA), written by John Heinz and Rick Casault, 1996. APPA, 1643 Prince Street, Alexandria, VA 22314.

Engineering and Design Systems Commissioning Procedures U.S. Army Corps of Engineers, 1995 (ER 1110-345-723). U.S. Army Corps of Engineers, 1995 (ER 1110-345-723).

Portland Energy Conservation Inc. Model Building Commissioning Plan and Guide Specifications. Portland, PECI, 1998.

U.S. Department of Energy. Federal Energy Management Program Building Commissioning Guide. Mar. 1994. July 2004 <http://sustainable.state.fl.us/fdi/edesign/news/9707/cx-guide.htm>

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Objective

The USGBC defines Building Commissioning as, “A systematic process to ensure that all building systems perform interactively according to the Contract Documents, the Design Intent and the Owners Operational Needs.” It is a process that ideally begins in the Pre-design phase, continues through Design and Construction and concludes with Acceptance by the Owner. The purpose of this Plan is to outline and provide a framework for the Building Commissioning Process.

Plan Components

The Building Commissioning Plan components identified below have been made consistent with the requirements of NY State Green Building Tax Credit (NYSGBTC) 638.8 and the intent of the LEED Prerequisite on Fundamental Building Commissioning.

I. Selection of Commissioning Agent and Identification of Commissioning Team

A. According to USGBC requirements the Commissioning Authority “can be from a design team firm, as long as that person is not responsible for project design, supervision or construction management.”

B. The team will include the owner, users, occupants, operations and maintenance staff, design professionals and contractors.

C. The Commissioning Authority has the responsibility to insure that all of the required steps of the commissioning process are completed. He will direct the design team to furnish the information necessary for the commissioning process and will direct the commissioning agent to perform those tests, demonstrations, and other activities to document the conformance of the constructed project with the Design Intent document and the construction documents.

II. Pre-Design

A. Document owner's requirements and design intent.
B. Prepare outline of Commissioning Plan.
C. Define systems to be commissioned and roles of each stakeholder in the commissioning process.
D. Define Owner’s goals and expectations to be included in the Design Intent document.
E. Prepare Basis of Design document outline including building program, design codes and standards, environmental conditions and assumptions

III. Design Phase

A. Review the Basis of Design narrative and add, zone occupancy, systems and processes, commissioning criteria and control logic or sequence of operation, as the design progresses.

B. Prepare and update the building Energy Model including the building envelope and mechanical system assumptions and verify anticipated building energy baseline.
C. Perform commissioning-focused design review.
D. Provide the Commissioning Specification that identifies the scope of commissioning, and the responsibilities of Owner, Engineers, Contractor(s), and Commissioning Authority.
E. Update Commissioning Plan.

IV. Construction Phase

A. Document that all tasks identified in the Commissioning Plan are carried out in a complete and timely manner including the following construction phase tasks:
   1. Verify and document procedures for cleaning and testing of HVAC piping and ductwork, and review and approval of Final Report.
   2. Verify and document functionality of HVAC system controls, interlocks, monitoring, and alarms.
   3. Verify and document calibration of valve and damper operators, limit switches, and sensors.
   4. Identify observed construction deficiencies and provide progress reports For corrective activities.
   5. Verify and document accuracy of Testing, Adjusting and Balancing contractor. This will be accomplished by testing 20% of control valves, and all pumps, air handling units, chillers, and auxiliary boiler.

B. Provide repeatability testing and performance verification procedures of all systems and equipment.
C. Review reference manuals for operation, maintenance, and monitoring of all systems and equipment and append as required to provide a complete and functional document.

V. Acceptance Phase

A. Prerequisites to Acceptance Phase
   Before the acceptance procedures can start, the following shall be observed and documented:
   1. HVAC systems and associated subsystems have been completed, calibrated, and started up and are believed to be operating in accordance with contract documents.
   2. Automatic control systems have been completed and calibrated and are believed to be operating in accordance with contract documents.
   3. Testing, adjusting, and balancing procedures have been completed, and all TAB reports have been submitted and reviewed and discrepancies corrected and accepted.
   4. A statement shall be issued certifying that all work has been completed and equipment and systems are operational in accordance with contract documents

B. Verification
   Verification comprises a full range of checks and tests to determine that all components, equipment, systems, and interfaces between systems operate in accordance with contract documents. This includes all operating modes, all interlocks, all control responses, and all specified responses to abnormal or

emergency conditions. Verification of the proper operation of the control system also includes verifying the interface of the control system with the TAB criteria and the response of monitoring and control system controllers and sensors. Verification of operating modes, etc., can be done concurrently with controllers and sensors. Verification will also validate the TAB report. Depending upon the scope of the project, previously agreed upon percentages of different devices will be subjected to the verification process. The Verification process shall be complete before Final Acceptance can occur.

1. The field verification of the final TAB report will be directed and witnessed and the results certified.
2. Verification of the water flows reported by the TAB Report for the chilled water supply to the air handling units and cooling coils. The Commissioning Agent shall verify that the actual water flows reported to these devices is correct to within 10% of the reported values. A failure of the Commissioning Agent's test shall require that the TAB rebalance all water flows to all air handling equipment.
3. Verification of the air flows to the occupied spaces. The Commissioning Agent shall verify that the actual air flows to the occupied spaces are correct to within 10% of the reported values.
4. Verification of the calibration of the controls and instrumentation for the automatic temperature control system. The Commissioning Agent shall verify the calibration of the specified percentage of the thermostats, regulators, temperature and pressure sensors, and flow metering devices installed. This representative sample shall be accurate to within +/- 10% to the setpoint. A failure of more than 5% of tested devices to meet the test criteria shall be cause for a determination of failure and a requirement for the Contractor to recalibrate all instruments.
5. Verification of sequence of control function. The Commissioning Agent shall randomly select one control sequence of operation for each system and verify that it functions in accordance with the specified sequence of operation and provides the appropriate control function. A failure of more than 5% of the randomly selected tested controls shall require that the automatic temperature control contractor re-verify all controls.
6. Verification of the proper installation insulation for ducting and piping. The Commissioning Agent should randomly check insulation thickness, existence of a continuous vapor barrier, and acceptable conditions at pipe and duct support points. Any observed deficiencies must be immediately repaired.
7. Verification of steam trap operation. AS specified percentage of the steam traps should be checked to insure their proper function and to verify that they are not leaking. Because of the limited number of traps for this system, 50% of the traps should be checked.
8. Verification of the controls for the lighting systems. The Commissioning Agent should check both the room occupancy sensors for proper action in controlling room lighting based on room occupancy, and the photo sensors designed to shut down artificial lighting when natural lighting is available. The

testing should cover the specified percentage of the installed occupancy and lighting sensors, and a failure of 10% of these tested devices to function per design will require all such devices to be recalibrated by the contractor.

9. Verification Report. The final tabulated checklist data sheets shall be assembled in a verification report and submitted to the commissioning team for review. The verification report shall document any unresolved deficiencies and may suggest a method of correction. The Commissioning Authority shall determine if verification is complete and whether the HVAC system is functioning in accordance with the contract documents.

10. Certificate of Readiness. A Certificate of Readiness shall be issued stating that all equipment, systems, and controls are now complete and ready for functional performance testing to begin. This certificate shall be supported by completed pre-start / start-up checklists, signed by the responsible parties, and the final verification report.

C. Functional Performance Testing

Functional performance testing should progress from tests of individual components of the central equipment and systems, including chillers, cooling towers, boilers, and pumping systems, to tests of the systems that distribute the HVAC services throughout the building. The extent of these tests, as well as details of the services to be tested, shall be in accordance with the contract documents. *(Please note that these are typically dynamic tests involving predicted performance, observation of system response, and independent verification.)*

D. Training

Training prepares the building operators to take possession of the building and to operate it in the fashion for which it was designed. The training process should convey both the information necessary for building operation and the rationale that governed the design. After training, the building operators should understand, not only building operation, but also why the design is the way it is. To achieve that end, training should include not only constructors and vendors, but also members of the design team. Documents transferred during the training process should include not only the operations and maintenance manuals from the vendors, but also the Basis of Design from the Design team, along with transcripts of the Functional Performance Testing.

E. Final Acceptance

To conclude the acceptance phase, as-built documentation must be compiled, the Commissioning Report and Systems Manual must be completed and submitted, and recommendation for acceptance of the facility determined. It is possible that some acceptance procedures (such as off-season tests) may not have yet been completed, but this should not impede final acceptance.

Building Commissioning

EEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:
SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	● Ⓔ	● Ⓔ	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 1: Fundamental Building Systems Commissioning)*
A Commissioning Plan is attached and incorporates the requirements of the Green Building Tax Credit 638.8 (f), LEED Fundamental Building Commissioning Prerequisite and the requirements of EEQ-2-P.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Optimize Energy Performance EEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To optimize the performance of building energy systems

Action: Optimize the performance of building energy systems through the utilization of a full DOE-2.1E, DOE-2.2, or Energy Plus building energy model to compare alternative strategies for energy efficiency (kwh) peak load reduction (kW) and reduced use of fossil fuels. Integrate with the Energy Management Plan. This is to include the full analysis of architectural and mechanical decisions in relationship to building energy expenditures. Achieve a minimum of 20% decrease in energy cost above ASHRAE 90.1-1999. This savings reflects both tower and office tenant build-out potentials. Tenant build-out potential (as demonstrated in a typical tenant build-out) will be modeled in the same integrated exercise and the economic results provided to potential tenants in support of the preferred build-out. Include full list of energy conserving opportunities available to tenants.

Provide daylight dimming and occupancy sensors on light fixtures where appropriate. All light fixtures to use high efficiency ballasts and low mercury/low lead, long life lamps. Specify recyclable lamps. Utilize energy efficient equipment, which meets or exceeds the following; NEMA premium efficiency motors, variable speed systems for all fans, pumps and motors and ENERGY STAR® products. Comply with FEMP levels for commercial products not rated by ENERGY STAR®. Provide a high performance building envelope, including minimized thermal bridging, superior insulation, air infiltration barrier and insulated wavelength selective glazing (to improve daylight transmission). Provide envelope construction details consistent with NYSGBTC 638.7(d)(2). Use air-side and water-side economizers, as appropriate.

Related Guidelines: EEQ-1, EEQ-2, EEQ-4, EEQ-5, EEQ-6, EEQ-7, EEQ-8

LEED™ 2.1 Requirement: EQ Prerequisite 2 (see Submittal Template)
Potential LEED™ 2.1 Credits: 2 possible with EA cr. 1.1, &1.2. (see Submittal Template)

Introduction/Context

Building Energy use accounts for approximately 40% of the annual energy use in the United States. Savings of up to 50%, as compared to buildings that just comply with energy code, have been demonstrated by individual high performance buildings. Many of these highly energy-efficient designs utilize off-the-shelf systems, components and design strategies, with no reduction in amenity or functionality. Achievement of these savings requires a knowledgeable design team with an integrated design approach, a flexible and sophisticated owner and a dedication to the energy efficiency goal.

Relevant Issues

Ecological

Building energy use contributes to all of the environmental problems of our energy intensive society. Generation of electrical energy and combustion of hydrocarbon fuels contributes to global warming and to air pollution from the by-products of combustion SO_2, NO_X, CO_2, heavy metals, mercury, and other particulate by-products..

Economic

Energy conservation in buildings often represents a very low-risk, high return investment for owners. Improvements in building energy efficiency of up to 20% can be obtained with very little additional first cost, merely by employing good design standards. Significant energy operating cost savings, over 30%, can be obtained by instituting measures that provide simple payback periods of less than 5 years. When taken together, the first-cost of heating, cooling and electrical load reduction measures is offset by reduced system size, complexity and cost, often resulting in significant operating cost savings at little additional first cost.

Neighborhood

Energy-efficiency resulting in more comfortable indoor environments can increase worker satisfaction and greatly enhance productivity. Some companies use this as a strategic recruiting tool. Energy-efficiency measures reduce demand, resulting in lower and more stable energy prices. Reduced energy use limits the consumption of finite natural resources and mitigates emissions that cause water and air pollution.

Methodology

Design Strategies

Optimized building energy performance requires an integrated design effort involving all disciplines of the design team. While individual energy conservation measures may be proprietary to a single discipline, their implementation and performance typically interacts with many other elements of the building which fall into the purview of multiple disciplines. In general, the strategy to optimize energy performance can be organized into the following sequence of activities:

1. Minimize heating, cooling, ventilation, lighting and electrical loads.
2. Select systems to meet the resulting loads in an optimally efficient fashion, especially during non-peak, or part-load operation.
3. Select system components for maximum energy efficiency.
4. Design control sequences to minimize system operations.

While these steps seem sequential, in fact, the process is interactive and iterative, and many of the solutions initially may seem counter-intuitive. The energy optimization design task is best informed by a comprehensive design assistance activity utilizing computerized building energy analysis and other forms of computer simulation and calculation appropriate for the particular design. The computer analyses provide numerical results for the individual design alternatives, and further examination of these results can provide insight into the optimal direction of the design efforts.

Means and Methods

Several strategies are known to be effective in office and commercial buildings for the cost-effective reduction of building energy costs. These include:

- Energy Star office equipment with automatic low-energy "sleep mode" when equipment is not in use.
- Maximum efficiency lamps, ballasts and light fixtures to exceed ASHRAE Standard 90.1-2004 lighting power density requirements. The maximum power density for lighting for open office applications in this standard is 1.1 Watts per square foot.
- Recyclable, low mercury/low-lead long-life lamps
- Daylight Responsive lighting control
- Demand controlled ventilation
- Optimized building envelope, including high performance windows with selective low-e coated glass and thermally broken frames..Window systems should be selected with an assembly U-value of no greater than 0.45 and a SHGC, Solar Heat Gain Coefficient, of no more than 0.36
- Variable speed pumps, fans, water chillers, and refrigeration compressors.
- All electric motors to be NEMA premium efficiency rated.
- Highest efficiency equipment including water chillers, and other refrigeration devices, pumps, fans and air-handling units. Water cooled water chillers should be selected with a maximum power draw of 0.55 kiloWatts per ton at ARI conditions. Other water cooled refrigeration devices should be selected at less than 0.7 kiloWatts per ton. Air cooled refrigeration devices should be selected at no more than 1.05 kiloWatts per ton. Packaged water cooled refrigeration devices should be selected with an EER of at least 13. Pumps should be selected with a minimum mechanical efficiency of 70%, while fans should be selected with a minimum mechanical efficiency of 65%.
- High temperature difference thermal transport systems, such as low temperature air delivery and large temperature difference chilled and hot water supply systems. Low temperature air delivery (supply air temperatures below 50°F) can significantly reduce fan energy for air conditioning at the expense of a minor increase in refrigeration energy. The resulting decrease in air handling unit and ductwork sizes can significantly reduce air conditioning system first costs and the required architectural accommodations for these systems.
- Optimized design of thermal transport systems to reduce pressure drop and thermal losses. Examples include use of large radius elbow, where possible in ductwork, attention to ductwork configuration immediately downstream of fans to minimize "System Effect", and selection of pipe sizes and accessories to minimize pressure drop.
- Separation of ventilation and dehumidification functions from sensible heating and cooling functions.
- More efficient thermal comfort delivery systems, such as radiant heating/cooling, and displacement ventilation. Such systems rely upon natural heat transfer forces such as convection and radiation, rather than upon forced air to transfer thermal energy to the occupied space.
- Occupancy sensor controlled lighting, and, in some cases, air conditioning.

- Combined Heat and Power (CHP)
- Electric peak demand control
- Building automation systems with optimal start-stop algorithms, equipment optimization algorithms, and malfunction detection algorithms.
- High-performance chillers
- High-performance glazing/windows

Several of these measures may seem may seem straightforward and unilateral, others are more complex, with off-setting and counter-intuitive interactions among multiple energy efficiency measures. For example, with respect to the building envelope, certain measures, such as minimized thermal bridging, superior insulation, air infiltration barriers and insulated, wavelength selective glazing should be optimized within the allowances of the building budget. Products should be selected at some point of diminishing returns, where further improvement would not be cost effective. Other envelope characteristics, such as the ratio of the building perimeter to the usable area of the floor plate and the percentage of glass in the envelope have a more complex impact on building energy cost. These variables do not demonstrate a simple linear relationship with building energy efficiency, having interactions among themselves that significantly alter their impact on building energy consumption. For example, while an optimally energy efficient building would have a relatively large percentage of its floor area daylit, this increase in daylit floor area is best achieved by elongating the building perimeter to bring more floor area close to the window wall, rather than by increasing the glass height to bring daylight more deeply into the floor plate. The optimal trade-off between glass and opaque wall, perimeter length and floor area will be particular to each project and must be determined through computer simulations.

A common design management technique for the design of energy efficient buildings is called energy budgeting. This technique sets aside a first cost budget allowance line-item for energy efficiency measures early in the design process, based upon the capitalized value of the maximum achievable energy cost savings for the project. When additional first cost energy efficiency items are validated and incorporated into the project as the design progresses, the additional first cost of the items are withdrawn from the energy efficiency allowance and installed into the appropriate place in the cost budget. Because each energy efficiency measure must at least meet the specific economic criteria upon which the capitalization of the budget was based, the total first cost addition of energy efficiency measures will always be less than the budget allowance and the combined economic performance of all of the approved measures will be better than the capitalization criteria.

Because of the innovative nature of some of the energy efficiency solutions that might arise from these design efforts, full commissioning is considered a must for these high performance buildings.

Case Studies

<u>The Plaza at PPL Center, Allentown ,PA</u>
The building has energy, and consequently, cost savings of 30% compared with a minimally code compliant building. Building envelope energy efficiency measures include brises-soleils and canopies to shade the south façade of the building, and high-performance glazing, walls, and roofs to reduce conductive gains and losses.

Lighting controls reduce lighting energy more than 30% during the day, while occupancy sensors further reduce lighting energy in support rooms without daylight. HVAC energy efficiency measures include: an enthalpy wheel to recover heat and humidity from exhaust air to precondition incoming ventilation air; carbon dioxide sensors to control the flow of outdoor air directly to spaces where it is needed; an ice-storage system to allow small chillers to run only at peak efficiency, and smart controls to carefully regulate building system operation.

The William Jefferson Clinton Presidential Center, Little Rock, AR
The building has energy cost savings of 33% compared with a minimally code compliant building. Building envelope energy efficiency measures include external shading devices on the west side of the building and high performance glass. Photocells control ambient lighting in response to daylight levels. HVAC energy efficiency measures include radiant heating and cooling floors, displacement ventilation, demand controlled ventilation and desiccant dehumidification. The building includes a 50 KW photovoltaic array. The percentage of total energy provided through the photovoltaic system is significantly increased by the rigorous energy efficiency program that dramatically reduced overall building energy costs.

Reference

Definitions

Assembly U-Value – the thermal transmission value of the window and framing system, acting together as a whole. The assembly U-value increase three dimensional thermal conductions effects between glazing and framing members.

Combined heat and power – Generation of electricity on site with collection and beneficial use of waste heat from the generation process.

Daylight responsive Lighting Control – control of electric lighting in the space to maintain specific lighting levels, taking into account the contribution of daylight to maintenance of those lighting levels.

Demand Controlled Ventilation – Control of ventilation rates to the space in response to occupancy levels. Typically this is accomplished by maintaining a constant concentration differential of carbon dioxide between the ventilation air and the interior air. Given that humans operating a fixed metabolic level generate carbon dioxide at a constant rate per unit of body weight, maintaining a constant concentration differential maintains a constant ventilation rate per pound of human body.

EER – Energy Efficiency Ratio – the ratio of BTU's of cooling output from a refrigeration device to Watts of electricity input.

Electric Peak Demand Control – control of electric devices or dispatch of distributed generation assets to maintain a fixed limit of maximum electric demand for a facility. Electric demand control often results in de-energizing discretionary electric loads during periods of high electric demand.

FEMP is shorthand for the Federal Energy Management Program, an endeavor of the U.S. Department of Energy. This program is intended to reduce the cost and environmental impact of the federal government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy and improving utility management decisions at federal sites.

NEMA is shorthand for the National Electrical Manufacture's Association.

Selective Low-e coated glass – Glass with applied coatings that selectively transmit visible light while absorbing or reflecting the non-visible portions of the solar spectrum. Non-visible components, including ultra-violet and near infra-red radiation account for about 55% of the energy of sunlight. Rejection of these non-visible components reduces solar heat gain, while maintaining daylight transmission through the glass.

Solar Heat Gain Coefficient – The fraction of incident solar heat gain that is transmitted through a glazing system

System Effect – Pressure drop in a ductwork system that is caused by the geometry of the ductwork system immediately downstream of the fan discharge. Air flow at the fan outlet is typically at a high velocity and is typically asymmetric across the discharge throat as a function of fan rotation. Incorrect configuration of ductwork at this outlet can result in very large pressure drops.

Thermal Transport System - the means for conveying heat energy around the building. Typical heat transfer fluids include air and water.

Standards

ASHRAE/IESNA. ASHRAE/IESNA 90.1-1999: Energy Standard for Buildings Except Low-Rise Residential. Atlanta: ASHRAE/IESNA, 1999.

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Optimize Energy Performance EEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
Building energy systems have been optimized through the use of a full energy model (created with either DOE-2.1E or Energy Plus). During this process alternative strategies for energy efficiency, peak load reduction, and increased use of renewable energy were compared. A full analysis of architectural and mechanical decisions have also been studied in relationship to building energy expenditures. The results of the above studies have been integrated with the energy management plan and are attached.

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 2 and Credit 1: Optimize Energy Performance – 20%)*
This certifies that the project will achieve a minimum of a 20% decrease in energy cost above ASHRAE 90.1-1999. The attached energy model supports this statement.

☐ **Required Component:**
The optimization of lighting has been studied. Where effective, daylight dimming and occupancy sensors have been provided on light fixtures. All light fixtures use high efficiency ballasts and low mercury/low lead, long life lamps. Recyclable lamps have been specified.

☐ **Required Component:**
Energy efficient equipment has been specified that meets or exceeds the following: NEMA premium efficiency motors, variable speed systems for all fans, pumps, and motors, AND Energy Star® products where feasible. All commercial products not rated by Energy Star® comply with FEMP.

☐ **Required Component:**
A high performance building envelope has been provided that includes minimized thermal bridging, superior insulation, air infiltration barriers, and insulated, wavelength selective glazing. Typical envelope construction details are attached and consistent with NYSGBTC 638.7(d)(2).

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 1: Optimize Energy Performance – 25%-60% {potential for 8 additional points})*
This certifies that the project will achieve a minimum of a ___% decrease in energy cost above ASHRAE 90.1-1999 and is expected to qualify for ___ additional points (above and beyond the 3 awarded points for a 25% decrease) under *LEED™ 2.1 Energy and Atmosphere Credit 1: Optimize Energy Performance*. The attached energy model supports this statement.

Name ______________________	Signature ______________________
Company ______________________	Role in Project ______________________
Date ______________________	

Ozone Layer Protection EEQ-4

Purpose: To reduce emission of ozone depleting chemicals.

Action: Specify building HVAC systems with zero levels of CFC refrigerants, and provide plan for future elimination of HCFCs and Halon in HVAC and refrigeration equipment and fire suppression systems. Avoid insulation materials that utilize chlorine-based gases.

Related Guidelines: EEQ-1, EEQ-3, MEQ-1

LEED™ 2.1 Requirement: EQ Prerequisite 3 (see Submittal Template)

Introduction/Context

In 1930 a team at DuPont synthesized a new family of refrigerants to replace sulfur dioxide and ammonia, which had been in use since the advent of mechanical cooling. This creation of a family of synthetic gases called chlorofluorocarbons (CFCs) provided the standard refrigerants for HVAC and other refrigeration systems. The refrigeration industry and the production of CFCs increased rapidly following World War II and nobody realized that these gases might be environmentally problematic until 1974. At that time scientists began to hypothesize that if liberated chlorine atoms reach the stratosphere, they could attack the ozone molecules that protect the Earth from ultraviolet radiation. At this point in history CFCs were the only known mechanism by which chlorine could make it to the upper atmosphere due to their molecular stability. This theory did not create much concern among the members of the scientific community until the hole in the ozone layer above Antarctica was noticed in 1985. This discovery caused much alarm and ultimately led to an international treaty, The Montreal Protocol on Substances that Deplete the Ozone Layer, in 1987. This treaty was amended several times as different options for replacements for CFCs became viable. The treaty called for the cessation of both production and consumption of compounds that damage the ozone layer by the year 2000. This included CFCs, halons, carbon tetrachloride, and methyl chloroform. (The phase-out date for methyl chloroform is actually 2005) By the beginning of 1996, the production of CFCs and most other “Class I” ozone depleting substances was banned in the United States as well as a majority of the other industrialized nations around the world. In the building industry this mostly affects HVAC, refrigeration, and fire-suppression systems, as well as the manufacture of thermal insulation.

Modern refrigeration systems are designed to prevent the discharge of refrigerants into the atmosphere through the use of high efficiency purge systems, which purge water and air from the system while leaking very little refrigerant. Regulations require the recycling and recapture of refrigerants when refrigeration devices are serviced or retired. The LEED Technical and Scientific Advisory Committee (TSAC) has authored a document that will be incorporated into LEED 2.2 to modify LEED Credit EA-4. Under the new procedure, the point in Credit EA-4, which currently is awarded for complete avoidance of HCFCs, can now be earned, even when using HCFCs, if procedures and equipment are utilized to prevent discharge of the refrigerant and if the more energy efficient characteristics of the HCFC refrigerants are fully utilized.

Hydrofluorocarbons (HFCS), which do not cause ozone destruction, have been proposed as more long-term replacements for CFCs and HCFCs

Relevant Issues

Ecological

The escape of CFCs from equipment into the atmosphere creates conditions that cause environmental harm. When CFCs reach the stratosphere, they react chemically with ozone molecules, destroying them. This has causes a thinning of the ozone layer, which serves as the ultraviolet radiation shield for Earth, and eventually a hole appears. Without this shield, increased ultraviolet radiation strikes the Earth's surface where it causes severe problems for people, such as skin cancer. UV radiation also damages other living systems, for example, disrupting the aquatic food chain, 'burning' the soft tissue of amphibians, altering plant-insect interactions, changing the growth patterns of fungi, and reducing the productivity of agricultural plants. CFCs are also greenhouse gases. They linger in the upper atmosphere and trap heat on Earth, rather than letting it escape to outer space. Over time CFCs contribute to global warming, which has deleterious effects on the planet's overall climate.

HCFCs, one of the interim replacements for CFCs, have a half-life of CFCs and less potential for destroying ozone and exacerbating the greenhouse effect. This can be quantified by comparing the global warming potential (GWP) and the ozone depletion potential (ODP) of specific chemical compounds. For example, CFC-502, one of the least environmentally destructive CFC refrigerants, has a GWP of 4,600 and an ODP of 0.221, while HCFC-123, a comparable refrigerant, has much lower values – a GWP of 1,700 and an ODP of 0.04. Hydrofluorocarbons (HFCs), another refrigerant replacement option have no chlorine molecules and most have an ODP of 0. However, many HFCs actually have a higher GWP than their HCFC counterparts. For example, HFC-404A has a GWP of 3,900 compared to the 1,700 GWP of HCFC-123. In addition, some HCFC refrigerants are inherently more energy efficient than their less environmentally damaging HFC replacements. This has the unfortunate effect of forcing a choice between the lesser of two evils, the destruction of the ozone layer or less energy efficiency..

Halons are extreme offenders in terms of ozone destruction. Some varieties of the gas destroy ten times as much ozone as CFCs. For example, one of the Halons with a low GWP, Halon 1211 has an ODP of 3.0! Some Halons also contribute significantly to global warming, while others have virtually no impact: e.g. Halon 1211 has a negligible GWP, while Halon 1301 has a GWP of 5,600.

The chlorine molecules present in certain gases used in the manufacture of specific types of building insulation also destroy stratospheric ozone.

Economic
As the ozone layer diminishes, greater levels of ultraviolet radiation are able to strike earth with damaging consequences. Effects such as the reduction of crop yields and damage to the ecosystem's natural food cycle have significant economic implications. Negative health effects for humans exposed to UV radiation lead to increased medical costs. Although there are financial implications associated with the removal of cheap, available ozone depleting chemicals from industry, these costs will be quickly off-set by avoiding UV radiation damage.

CFCs were once the cheapest gases to use for refrigerants. However, because CFC production in the United States was banned in 1995, most non-CFC HVAC and refrigeration systems available today (using HCFCs and HFCs) are not significantly higher in cost than their CFC predecessors. However the decreased efficiency of some of these replacement refrigerants may increase a building's electricity needs and operational costs. Since some HCFC refrigerants are inherently more energy efficient than their HFC replacements, this may result in a conflict between ecological and economic goals.

Currently, alternatives to Halon fire suppression systems are all more costly. Common replacement gases for Halon in a "total flooding" gaseous system includes HFCs. These systems cost anywhere from twice to three times as much as a Halon system, depending upon which specific HFC is specified. Systems that use non-chlorine-based gases, such as HFCs and other inert gases, cost even more than that. Alternatives to "total flooding" gaseous systems, such as fine water mist systems, also have a cost impact, equivalent to non-CFC-based systems.

Measures to reduce ozone depletion from the insulation industry include alternative manufacture practices and the use of alternative types of insulation. Many common types of solid foam insulation begin as liquids that are expanded and dried during the manufacturing process using CFC or HCFC gases. Other types of granular insulation that are "blown" into cavities use these damaging gases as delivery agents. However, most of the large chemical companies and insulation manufacturers are now developing air expansion and water blowing technologies that will eliminate the need for ODMs in their processes.

While these environmentally superior techniques are being developed, there are currently two economic disadvantages. A large capital investment is required to convert plants to use these alternative technologies. In some cases, more environmentally benign production techniques cannot produce insulation with as high of an R-value as those using ozone-destroying and greenhouse gases. This means that more insulation is required for an application, at added cost. Technology can be incorporated into the production line to capture and recycle ozone-depleting gases that are used to foam insulation materials. However, this too adds additional cost to the manufacturing process, which is passed on to the consumer. Use of alternative types of insulation may be a more cost-effective strategy. Effort must be spent to find a balance between environmental stewardship, economy and function when selecting building insulation.

Neighborhood

The stratospheric ozone layer protects Earth's inhabitants from ultraviolet radiation. When people are overexposed to UV rays, their risk of developing serious medical problems including skin cancer, cataracts, and weakened immune systems is greatly increased. Over-exposure to UV rays adversely affects wildlife, and is considered to be a major factor in the die-out of many amphibians and whole families of frog and newt species. This begins to create a biodiversity 'gap', which is a serious event in the natural world and ultimately for all life on earth. Many crop yields are significantly lower as a result of exposure to extreme levels of ultraviolet rays. Preventing the use of ozone-destroying substances can help avoid these problems.

Greenhouse gases cause global warming and drastic climate change worldwide. Increased summer temperatures present health risks for elderly people and those susceptible to heat stroke. Violent storms and extreme weather often result from these temperature changes, causing destruction to property, woodlands and crops, as well as causing storm-related deaths. By reducing the use of chemicals, especially chlorine, which contributes to the greenhouse effect, quality of life can be better protected.

Methodology

Design Strategies

Zero use of CFC-based refrigerants in the building will satisfy the requirements of LEED^{TM} 2.1 EA Prerequisite 3. Design a plan to eliminate the use of other ozone-depleting substances such as HCFCs and Halons from building HVAC, refrigeration, and fire suppression systems in the near future (i.e. earlier than required by the Montreal Protocol) Specify insulation materials that are not manufactured using chlorine gas.

Means and Methods

The interim replacements for CFCs in building HVAC and refrigeration systems have been mostly HCFCs. These continue to cause damage to the ozone layer, although their lifespan in the stratosphere is only half that of CFCs (some 80 years). Hydrofluorocarbons (HFCS), which do not cause ozone destruction, have been proposed as long-term replacements for CFCs and HCFCs, in spite of losses in efficiency with their use. Although HCFCs typically operate as heat transfer mechanisms (similar to CFCs), some of the newer HFCs are designed to avoid this problem. The increased energy use caused by less efficient refrigerants exacerbates environmental problems rather than eliminating them. (For example the generation of extra electricity to counteract these inefficiencies, is associated with greenhouse gas emissions from power plants.) Industry is struggling to find refrigerants that are both environmentally safe and as energy efficient as their predecessors, and in the meantime, is working to improve the performance of available replacement refrigerants.

Halons have been used in fire suppression systems because they are very effective at suffocating most types of fires, do not conduct electricity, disperse rapidly without leaving residue, and are not toxic to humans in short exposure periods. However because of their extremely high ozone-destroying properties, The Montreal Protocol calls for their phase-out. There are various parallel studies being conducted to produce viable options for the replacement of Halon in "total flooding" style fire suppression systems. One option is to replace the Halon with another gas. Current commercially viable replacement gases are either HFCs or inert gases. HFCs are known greenhouse gases and thus may not be ideal. Inert gas options such as Argotec and Inergen do not have this problem, but are not as efficient at extinguishing fires, and have large technical limitations and costs. Another option that may be viable in certain applications is the use of a water mist system. This type of system is environmentally benign, but not effective in all fire-extinguishing environments, especially those where electrical conductivity is a hazard. Water mist systems have much larger capital costs. Other promising alternatives are being studied by leading industrial companies, however none are currently on the market.

Chlorine-based chemicals used in the production of some types of insulation destroy ozone. These chemicals are used as foaming agents for insulation types that contain components that must be expanded or extruded such as extruded polystyrene, polyurethane, polyisocyanurate, and phenolic and urethane foams. Both CFCs (non-banned) and HCFCS have served as foaming agents. To avoid ozone-depletion, companies have tried to adjust their manufacturing methods in different ways. Some have shifted to alternative foaming agents like HFCs and hydrocarbons. Although not destructive to stratospheric ozone, these agents have the disadvantage of exacerbating the greenhouse effect. Icynene is an insulation product that uses carbon dioxide and water to foam the insulation. Unfortunately, this has the side effect of reducing its R-Value, thus extra insulation must be specified to achieve the same thermal insulation level. Air-Krete is an inorganic foam insulation made from magnesium oxide and foamed under pressure with compressed air. Although it is inert, emits low VOCs, and is non-combustible, Air-Krete must be foamed in place and is very brittle.

Case Studies

1. Green on the Grand Office Building, Kitchener, Ontario

    This office building has an air-conditioning system without CFCs or a cooling tower. The building's construction used no CFCs and minimal HCFCs. Waste heat from a central, gas-fired chiller is sent to a landscaping pond in lieu of a rooftop cooling tower. Heat is lost to the water through evaporation and the need for CFCs typically used in conjunction with a cooling tower is eliminated. This building's energy use is extremely low, 28% of that described by ASHRAE 90.1 as an average usage profile.

2. LCRA TESNCO Dalcahu Service Center, Austin TX

    This existing industrial site was converted to an office space and public conference center. The HVAC system was designed to use no CFCs or HCFCs in any of its cooling equipment.

Reference

Definitions

Chlorofluorocarbons (CFCs) are synthetic compounds (once used as refrigerants) that destroy ozone molecules in the stratosphere.

GWP (Global Warming Potential) is an index describing the relative warming potential of a greenhouse gas as compared to the same mass of carbon dioxide: The lower the number, the less environmentally damaging the gas.

Halons are ozone depleting compounds used in fire suppression systems.

Hydrochlorofluorocarbons (HCFCs) perform similarly to CFC's but cause far less damage to the ozone layer.

Hydrofluorocarbons (HFCs) are refrigerants that do not destroy ozone because they lack chlorine atoms. Many of these substances act as greenhouse gases and contribute to global warming

ODP (Ozone Depletion Potential) represents how actively a particular gas destroys ozone once in the stratosphere. The lower the number, the less environmentally damaging the gas.

Refrigerants are elements of the refrigeration cycle that transfer heat.

(*Refer to TSAC 2004 for a list of various refrigerants and their ODP and GWP values)

Standards

Standards have not been included for this guideline.

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Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Prerequisite 3: CFC Reduction in HVAC&R Equipment)*
This certifies that building HVAC systems specified for this project contain zero levels of CFC refrigerants.

☐ **Required Component:**
The attached plan provides for the future elimination of HCFC's and Halons in HVAC and refrigeration equipment AND fire suppression systems.

☐ **Required Component:**
The use of insulation materials that contain chlorine based gases has been avoided.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Renewable Energy EEQ-5
Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To meet a portion of site energy requirements with on site and/or purchased renewable energy sources and institute a plan for transition as renewables become more cost-effective.

.

Action: Utilize site generated and/or purchased renewable energy for a percentage of total building energy use. Provide transition plan for future conversion to renewables. Purchase or generate on-site a minimum of 20% of overall annual electric energy requirements with renewables by 2010 consistent with NY State EO-111's evolving requirements and capabilities. Provide infrastructure to integrate technology into building systems, when possible.

Related Guidelines: UEQ-8, SEQ-1, EEQ-1, EEQ-3

Potential LEED™ 2.1 Credits: 3 possible with EA cr. 2.1, 2.2, & 2.3. (see Submittal Template)

Introduction/Context

Renewable energy is a free-source of energy, produced through harnessing natural, renewable resources in a manner that does not pollute. It includes technologies based on the power of the sun, wind and Earth's internal heat. Small-scale, low-impact hydroelectric generation, using methods that do not adversely affect the body of water on which they operate, can also be considered a means of renewable energy. Systems that convert organic matter (biomass) into usable energy and hydrogen fuel cells are two other renewable energy potentials. All of these methods avoid the negative environmental impacts of more traditional power production such as burning fossil fuels or nuclear fission.

Renewable energy can either be purchased through power utilities or generated on-site. Some electric companies produce a percentage of their total output through renewable technologies. In fact many states have passed laws to require this. In September of 2004 The New York Public Service Commission (PSC) voted to require that at least 25% of the electricity sold to consumers in New York State be generated through renewable resources by 2013. In the meantime a building can support commercial renewable energy systems even if their local utility does not yet provide any direct renewable energy options. Building owners can purchase "Green-Tags" or Renewable Energy Certificates that represent an amount of renewable power generated elsewhere in the power grid. Although this will not have a direct effect on the local environment, it has positive ramifications for the field of renewable energy as a whole. Purchased renewable energy must comply with Green-E or other recognized standards for renewable energy providers. On-site renewable power has added economic and ecological advantages due to the elimination of transmission needs and potential independence of the regional power grid. Potentials for renewable energy generation vary by regional climate and site location. The technologies needed to produce this energy are becoming increasingly available and economically viable.

Relevant Issues

Ecological
Traditional means of electricity generation have serious negative environmental effects. Fossil fuel burning plants deplete coal, oil, and natural gas resources. The gases released from these plants contribute to health problems for people, smog, acid rain, and the greenhouse effect. Nuclear power plants generate toxic waste that must be stored in highly protected areas for thousands of years. Both of these types of power plants contribute to negative water quality, both through contamination and thermal pollution. Although somewhat cleaner, hydroelectric power plants cause damage to the aquatic ecosystems involved. The use of these plants affects both the food chain and the availability of water for people to use in their daily lives. For example a large dam can prevent fish from reproducing and dry out a river that was once used for irrigation of crops and drinking water. Low-impact hydroelectric plants, which don't involve night pumping, have far fewer negative consequences. Concerns have been expressed about the potential for wind turbines to harm birds. Careful study of this problem has resulted in new, safer forms for turbines. These operate at speeds that can efficiently generate power but also let birds pass through unharmed. Biomass energy systems have an added advantage as they can divert large amounts of wood-based construction and land-clearing debris from landfills. Hydrogen fuel cell technology, when perfected, will produce water and heat as its only by-products.

Economic
By generating power on-site through renewable means energy costs can be reduced. Although there are initial infrastructure costs the avoidance of utility charges and peak hour demand charges can quickly pay back those funds. Federal and state programs exist through which developers can obtain financial assistance such as tax credits and low-interest loans to support the installation of an on-site renewable energy system. Where programs exist, building owners can sell excess electricity generated by their systems back to the local utility company at competitive rates. This 'bonus' energy may help the utility company to meet their peak demand, especially during heavy usage periods which usually occur in mid-summer. The costs of renewable energy technologies are continually decreasing with advances in efficiencies and production methods. In 2003, 744.1 MegaWatts worth of PV Cells were produced worldwide with 13% of that in the United States. During the past five years the capacity of wind-power generation in the United States has bloomed from 1,800 MW to about 6,400 MW installed in 30 states nationwide. Geothermal systems are still relatively expensive and considered a niche market by some. However, certain site conditions, such as available space for the required boreholes, may make geothermal systems competitive.

Neighborhood
The improvement of water and air quality as conventional electricity generation decreases is a major benefit to all people. Self-sufficient power, along with reduced transmission losses created by local generation, helps avoid overloads on the national grid that have the potential to cause wide-reaching blackouts. Dependence on these types of local power sources may contribute to the avoidance of loss of

computer data, as well as revenue, due to down-time experienced during a power outage on the national electrical grid. If local renewable energy systems are designed carefully to avoid negative side effects (such as noise from wind turbines), they clearly provide for a more secure source of energy and less dependence on foreign oil, providing benefit for all members of the community -- those that share directly in the resource and beyond.

Methodology

Design Strategies

Meet a total percentage of building electricity needs by either purchasing or generating renewable energy on-site. 1, 2, or 3 LEED™ 2.1 credits can be obtained if the percentage of on-site renewable generation equals 5, 10, or 20 respectively. By the year 2010, 20% of the overall annual electric energy of the project must be met by renewable energy sources. This is consistent with NY State's EO-111's evolving requirements. A plan should be devised to facilitate future transition to larger amounts of renewable power. The infrastructure to integrate these future renewable technologies needs to be built into the project at its inception to avoid higher installation costs in the future. This will greatly reduce the capital investment needed to install a renewable energy system at a later time.

Green power can be purchased to help meet the building's energy needs. If the local power utility does not provide a significant portion of their generation portfolio through renewable means, Green Tags can be purchased from third party agencies to support the production of renewable energy elsewhere in the power grid. One LEED™ 2.1 credit can be achieved through the purchase of Green Power. In order to satisfy the requirements of LEED™ 2.1 EA credit 6 at least 50% of a building's electricity must be purchased from a provider using renewable sources for its generation and, at minimum, the building owner must commit to a two-year contract for the purchase of Green Power. For the purposes of this LEED™ 2.1 credit, renewable sources are defined by the Center for Resource Solutions Green-e standards.

Means and Methods

Photovoltaic cells convert sunlight directly into electricity. These cells can be placed in an array that tracks the sun's movements or integrated into the façade (building integrated PV) or other portions of a building. Since photovoltaic cells produce direct current, converters must be used to transform their output into the alternating current used by standard plug-in equipment. Because PV cells generate their peak power during the hottest parts of a sunny day, when many people are turning on air conditioners, they help offset demand loads from the power utility. Batteries must be used to store electricity generated by a PV system for nighttime use, although some buildings use a hybrid system relying on fuel cells or wind power during the dark evening hours. There are many different types of photovoltaic cells. Crystalline silicon is the leading commercial material, although thin film cells are becoming very popular since they use less material, cost less and are beginning to become as efficient. Photovoltaics are expensive to produce as the semi-conducting materials from which they are made have high costs. As technologies advance and manufacturing costs are reduced, the price of PV systems continues to fall. The use of any on-site power source such as PV has the added advantage of reducing the need for transmission infrastructure. Building-Integrated PV systems save money since they replace traditional building assemblies with ones that serve a dual function. One example of this is glazing, ether spandrel or even vision, which incorporates integrated PV cells. There are also financial incentives to promote the incorporation of on-site PV systems. These include tax credits, low interest loans, grants, special utility rates, and the opportunity for net metering where the site sells power back to the power company. Because of their performance and ability for easy integration into a project, PV systems are the leading contender in the market for on-site renewable energy systems today.

Wind energy is very popular in Europe and is now coming of age in the United States. Wind power systems use turbines to convert wind into electricity. Innovations in wind turbines that make them more efficient are now boosting this already expanding industry. It provides clean, renewable energy and can be harnessed on scales varying from large power plant wind farms to smaller on-site power generation. In regions with reliable wind currents, wind power is the most economical of all the renewable energy systems. Wind turbines can be deployed on open land in a windy area adjacent to a site, in the sea, or they can be integrated into the building itself. Some architects are attempting to sculpt buildings so that aerodynamic flow directs wind into a power-generating turbine. The American Wind Energy Association estimates that, with government support, small on-site wind turbines could contribute 3% of the overall annual U.S. power consumption as early as 2020. Some states have financial incentive programs to aid building developers in obtaining the capital costs to build on-site wind installations. It is clear that the integration of building and wind power technology is an evolving frontier that will have large ramifications in the near future.

Small-scale, low-impact hydroelectric plants can be an ecologically responsible and renewable energy source. Large-scale hydroelectric power systems provide a substantial percentage of the U.S. power supply. Those that do not involve off-peak or night-time pumping are essentially emission-free, but have several negative environmental consequences. Hydroelectric plants often have adverse effects on water quality and quantity for areas downstream of their installation. Another detriment is that fish are frequently injured or killed when passing through a plant's turbines. Small-scale low-impact hydro systems, that do not use off-peak pumping, generally do not create these hazards. Any hydroelectric system that generates 30 MW or less is considered small-scale. Typically these plants do not require a dam to stop the entire body of water. This prevents them from having such a large effect on downstream water and provides areas for aquatic life to bypass the installation.

Electricity can be produced using plant material in a biomass system. Of the four technologies available, only the gasification type is truly non-polluting. In this system methane gas produced during the breakdown of biomass is used to supply hydrogen fuel cells. In 2002, roughly 9,700 megawatts of electricity was generated in the United States using biomass. Almost 6,000 MW of that came from forest products and agricultural waste, 3,000 MW from municipal solid waste and 500 MW from other sources such as landfill gas. Most of this electricity was generated by burning the biomass to create steam and drive turbines in place of the coal used in coal-fired plants. (Coal fired plants still make up a large percentage of U.S. power production today). Although the incineration of biomass does not produce the sulfur dioxide and nitrous oxides that burning coal does, it still releases carbon dioxide, a major greenhouse gas. To the extent, however, that the biomass will be left to natural biodegradation processes, leading eventually to oxidation, that carbon dioxide would have been generated anyway.

Geothermal power generation uses heat from deep within the Earth to turn a turbine and produce electricity. The United States currently has geothermal power installations that produce about 2,800 MW annually. The high initial costs associated with building a geothermal power installation have limited their use. However current research into making geothermal plants more efficient and cost-effective should help promote this technology.

Case Studies

DEP Cambria Office Building, Ebensburg, PA

This building uses two types of on-site renewable energy systems. It employs ground-source heat pumps that are linked through a closed-loop geothermal well field to supply both heating and cooling for the HVAC system as well as hot water for building use. The building also has a 14.3 kW PV installation located on its south-facing sloped roof. This system provided 28% of the building's total energy costs. Some of the PV panels used are mounted on solar tracking devices.

Ford Motor Company Dagenheim Engine Plant, London, England

Two 85 meter high wind turbines will produce 100% of the power requirements for Ford's new Clean Room Assembly Hall and Diesel Engine Plant in Dagenheim England.

Genzyme Center, Cambridge MA

This building uses renewable energy production strategies. Two small photovoltaic arrays on the building's roof generate 20 kWp peak output (15,000 kWh per year) and help further reduce peak demand on-site. All of the building's purchased electricity has been provided through Green-e certified renewable sources. This ensures that the amount of power being bought for the building is being displaced somewhere in the power grid by the use of renewable generation methods. This building also uses a Combined Heat and Power (CHP) system. Although this type of electricity generation is not powered by a renewable source it does represent somewhat of a renewable heating strategy for the building. The central heating and cooling systems are powered with steam from an adjacent power plant. The steam is used in absorption chillers for summer cooling and in heat exchangers for winter heating. This steam is a byproduct of the power plant's normal operation and is being put to good use by the Genzyme Center. As long as this plant continues to make electricity, the symbiotic heating system of the Genzyme Center will have a "renewable" source of energy. An additional advantage is that, with this system, peak summer electrical demand is low and doesn't burden an aging electrical grid.

Reference

Definitions

Geothermal Energy Systems use heat from the earth to produce electricity.

Green Power refers to electricity that is produced by a system that does not contribute to environmental pollution.

Photovoltaic Systems convert light (typically from the sun) energy to electrical energy.

Renewable Energy is produced by a source that is infinite (will never run out)

Standards

Green-E Standard for Purchased Renewable Energy

This standard insures that purchases of renewable energy conform to the following characteristics:

- 50% or more of the electricity supply comes from one or more of these eligible renewable resources: solar electric, wind, geothermal, biomass, and small or certified low-impact hydro facilities,
- if a portion of the electricity is non-renewable, the average air emissions are equal to or lower than those produced by conventional electricity alone,
- there is no direct support of nuclear power, (because of the amorphous nature of the national power grid there is always a possibility that a miniscule portion of the electricity being used may have somehow come from a nuclear plant) and
- the product meets the Green-e new renewable requirement.

To comply with this standard, renewable energy providers are subjected to the following requirements:

- make full disclosure of the percentage and type of renewable resources in their electricity product;
- present product pricing and contract terms in a standardized format, for easy comparison;
- submit their marketing materials for review twice a year so Green-e can ensure they are not making false or misleading claims; and
- undergo an annual independent Process Audit to verify product content claims and ensure enough renewable power has been purchased to meet customer demand.

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Objective

The Renewable Energy Transition Plan is designed to ensure that a plan is in place for eventual transition of site energy requirements to full renewables and projects are designed to facilitate this transition. NY State EO-111 requires that 20% of overall annual electric energy requirements are satisfied with renewables by the year 2010.

Plan Components

I. Project Description (Plan Summary)

A. Describe project energy requirements and use of renewable energy to satisfy these requirements.

II. Management strategies

A. Provide a detailed inventory of available on-site and off-site Renewable Energy Resources (this should coincide with the inventory provided for PLAN EEQ-1). Including the potentials for purchasing Green-e Certified power.

B. Provide calculations confirming that 20% of overall annual electric energy demand (of the buildings that exist at the time) will be met by renewable energy after 2010.

C. Describe characteristics and features of the currently designed infrastructure that can accommodate or can be modified to accommodate integration of renewable energy technologies that may be available or cost effective in the future. Give preference to site generated renewables.

III. Targets

Establish and describe project targets for the following

A. First year of operation.
B. 2010
C. 2025
D. 2055

IV. Evaluation

Evaluate the cost implications (in current dollars) of converting conventional, high performance systems in place at the beginning of building operations to Renewable Energy systems, and quantify anticipated energy conservation and cost savings as a result of the switch to renewables.

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Renewable Energy EEQ-5-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●

☐ **Required Component:**
A transition plan for future conversion to renewable energy is attached. It specifies that a minimum of 20% of overall annual electric energy requirements will be met through renewable means by the year 2010, consistent with NY State EO-111's evolving requirements and capabilities. The design includes infrastructure to integrate this technology into building systems, where possible.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.1: Renewable Energy – 5%)*
This certifies that renewable energy as defined by LEED will supply at least 5% of total building energy use at completion of construction.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.2: Renewable Energy – 10%)*
This certifies that renewable energy as defined by LEED will supply at least 10% of total building energy use at completion of construction.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 2.3: Renewable Energy – 20%)*
This certifies that renewable energy as defined by LEED will supply at least 20% of total building energy use on completion of construction.

**Please note, for the purposes of satisfying LEED™ credit requirements, "Renewable Energy" includes energy systems such as solar, wind, geothermal, low-impact hydroelectric, biomass and bio-gas (draft version of LEED™ V. 2.2)*

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 6: Green Power)*
This certifies that at least 50% of a building's electricity will be purchased from a provider using renewable sources for its generation and the building owner has committed to a minimum two-year contract for the purchase of Green Power.

**Please note, for the purposes of this LEED™ 2.1 credit, renewable sources are defined by the Center for Resource Solutions Green-e standards.*

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

Energy Systems Control and Maintenance EEQ-6
Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide for ongoing verification of initial operation and energy utilization of building energy systems.

Action: Provide a computerized, fully integrated Building Management System (BMS) with energy and fluid flow measurement capabilities for all major energy consuming systems. Institute a maintenance plan for ongoing measurement, verification and maintenance of equipment efficiencies and resource utilization. Provide programmable controls. Install permanent monitoring systems to track energy performance. Provide for maintenance and operational continuity through manuals and education. Install continuous metering equipment for a representative sample of lighting systems, motors, drives, chiller efficiencies, and trending of economizer and heat recovery equipment cycles, air distribution pressures and volumes and boiler efficiencies. Integrate the above systems into the Building Commissioning Plan.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, IEQ-1, IEQ-3, IEQ4, IEQ-7, IEQ-10, IEQ-12

Potential LEED™ 2.1 Credit: 1 possible with EA cr. 5. (see Submittal Template)

Introduction/Context

With the complexity of the site, incorporating rail stations, hotels, performing arts center, office towers, underground malls, street level shops, restaurants, and cafes, comes a diverse set of energy systems and requirements. Managing systems performance while achieving lower energy costs will be a complex task for the WTC Redevelopment, requiring the wise use of technology, well defined process, and a skilled staff.

The WTC Redevelopment Project will mark its position in Lower Manhattan, as well as the world, as a leader in energy performance for the built environment. On-going verification and continuous improvement of a building's energy performance is a visible means of taking responsibility for the consequences of its design of the development and the buildings therein, both initially and as facility usage changes over time.

EO-111 sets a target for energy savings (20% improvement over code), but does not provide specific guidance regarding on-going verification. It does however reference NYSGBTC, in particular, Section 638.8 Commissioning which provides requirements for a Systems and Energy Management Manual, and Training. International Performance Measurement and Verification Protocol Volume III and ASHRAE Guideline 14 (see References) provide the means to develop a program for on-going verification of operation and energy utilization of building energy systems. The measurement system installed within the building shall be sufficient to conform with the requirements of LEED version 2.1, Energy and Atmosphere Credit 5, for IPMVP, method D.

Relevant Issues

Ecological

Natural resources are limited. A sustainable future requires that we take responsibility for their use to support today's and tomorrow's needs. Energy, water, and materials use are all embedded in our building designs. With the longevity of buildings and their systems, we are committed to that level of use for decades. It is critical that building and building system design are optimized to deliver their intended services with minimal use of resources – minimal impact on the environment.

With optimum use of energy and water resources incorporated into the building design, verification is required to demonstrate actual performance delivery in the building as constructed. However, energy and water optimization in building operation is not a static issue. From the day the building is turned over to its occupants, it starts to change. Variations include change of use, occupants, staff, equipment (as it ages), utility structures, and technology. The results of these changes may offer new opportunities for optimization that were not available at the time of the initial design development.

The components of systems control and maintenance must be dynamic. On-going measurement, analysis and improvement over the building life cycle is required to achieve optimization of energy and water use.

Economic

Energy and water savings are clearly understood benefits of green building design and operation. One analysis places the 20-Year Net Present Value of Energy and Water Savings at $5.80 per square foot and $0.50 per square foot respectively. These savings derived from average extra costs of building green estimated to be from $3.00 to $5.00 per square foot (averaging 1.5% to 2% of the total construction cost). Energy and water savings may indeed be sufficient to cover the cost premium of building green without attempting hard measurement of Operations & Maintenance Savings or the Productivity and Health Value of building green.

For new construction, energy and water savings are projections. Actual delivery of financial gain requires the formulation of a baseline and an on-going process of measurement, analysis, and improvement as the building evolves. The process begun in design and construction continues through commissioning of the building and its operation to support continued financial benefits through process improvement, development of staff, and shared knowledge in the broader community of practice.

This is a continuous learning process with the knowledge developed contributing to Operations & Maintenance savings realized by green buildings. The analysis cited above estimates the net present value of those O&M Savings of Green Buildings at $8.50 per square foot. This savings is in addition to the energy and water savings and derived from the same investment premium.

The Net Present Value of the operating costs' savings for building green has, therefore, been estimated to be more than three times the first cost required to obtain this level of performance. Because the return on investment of the green building features will equal or exceed the return on investment of the basic building project, green features represent an opportunity for further investment without the necessity of an additional building project. In other words, the green building features will increase a building's value.

Neighborhood

Intelligent energy systems control yields energy-efficiency cost benefits, as well as controllable comfort levels within the building, resulting in satisfaction and well-being among the building occupants. The energy-efficiency results in lower and more stable energy prices. Better management of energy use limits waste and the needless consumption of finite natural resources. It also reduced emissions from power plants that cause environmental pollution and lead to increased health problems for members of the wider community.

Methodology

Design Strategies

- Integrate the control, monitoring, and metering functions of a BMS in the M&V Plan for building energy and water systems
- Verify building and system energy performance and refine the energy baseline as a component of the commissioning process
- Embed energy system M&V in a facility management continuous improvement process

Means and Methods

<u>Measurement & Verification (M&V)</u>
The on-going measurement and verification of performance for energy and water utilization requires a sound framework on which to base the performance assessment. IPMVP Volume III provides an overall guide for application to new construction. The basic calculation is simply:

<u>Energy Savings = Projected Baseline Energy Use – Post-construction Energy Use</u>
For new construction, 'Energy Savings' provides a focus on those aspects of the new building that are intended to contribute to exceptional performance. The energy use baseline is hypothetical for new construction since no history is available. Post-construction energy use is the actual delivered performance, verified initially at commissioning, and the subject of on-going measurement over the life of the building. This calculation provides the framework for the development of the M&V Plan.

The value of on-going measurement and verification of energy and water use lies in its contribution to the decision-making process of facility staff. Three main issues in developing the detail of the M&V Plan are:

- Appropriateness – are the baseline and measured energy use meaningful in the context of the operation of this building e.g. energy codes, industry standards, issues of importance to this building
- Rigor – is the detail appropriate for the M&V methods and analytical tools that will be used; does the cost/benefit of the detail suit the objectives of the M&V program
- Repeatability – are the baseline and energy use measurements consistent and repeatable, allowing performance comparisons on a broader scale.

Addressing these issues provides guidance for the selection of information to be included in the M&V Plan. IPMVP further provides four M&V Options:

- <u>Option A Partially Measured Retrofit Isolation</u>: Projected baseline energy use is determined by calculating hypothetical energy performance of the baseline under post-construction operating conditions

- <u>Option B Retrofit Isolation</u>: Projected baseline energy use is determined by calculating hypothetical energy use of the baseline under measured post-construction operating conditions

- <u>Option C Whole Facility</u>: Projected baseline energy use determined by measuring the whole-building energy use of similar buildings without the energy conserving measures of interest in the new construction

- <u>Option D Calibrated Simulation</u>: Projected baseline energy use determined by energy simulation of the baseline under the operating conditions of the M&V period.

For the purpose of this guide, Option A has no value, since stipulation of savings offers no information to the staff decision-making process. Options B & C offer solutions of some value at the level of individual energy conserving measure, system level and whole building comparison.

However, Option D provides a whole building approach that can be directly linked to the design of the M&V Plan. Option D guided by appropriateness, rigor, and repeatability, provides an insight to the interrelated energy conserving measures of importance, to the systems level of performance, and, in aggregate, whole building performance. The M&V Plan, using the simulation models, provides the specification of information sources: utility bills, system sub-metering, and BMS information points. This coupled with technical guidance from ASHRAE Guideline 14 provides the basis for specification of BMS features and functions.

<u>Commissioning</u>
The commissioning process associated with measurement and verification of energy and water systems performance goes beyond verification of feature and function of the BMS. There is also the initial verification of performance following the M&V Option selected. Analysis of the energy use of the first year can be used to refine the understanding of building operation and thereby update the baseline for on-going verification of performance. (IPMVP Volume III 4.5.8 Option D: Savings Estimation)

Continuous Improvement

The design, installation and commissioning of BMS technology and Energy Control and Management process should reflect the continuous improvement process employed by facility management. This may be a form of Total Quality Management or a Six Sigma process. The key role of the BMS is providing those measurements that support the analysis from which improvements are developed and implemented.

For example, the GSA Workplace 20.20 program is developing the GSA facility process within the framework of a Balanced Scorecard. This brings a business context to facility decisions. That would appear to be a desirable position if high performance green buildings are to become known for their contributions to business.

Case Studies

State Office Buildings, Santa Fe, New Mexico

In the wake of a severe flood caused by leaking pipes that damaged components of the HVAC system at one of the State Office Buildings, the New Mexico Building Services Division decided to take advantage of the situation and have a new building automation system installed. Working with Trane, they not only replaced the equipment in the flood-damaged building, but extended the new building automation system to other state office buildings in the complex with new fiber-optic cabling run through existing underground utility tunnels. The new system, which consists of centrally controlled chillers and distributed variable air volume boxes with direct digital control, provides enhanced thermal comfort and vastly improves building control Instead of running around checking thermostats, building maintenance staff can not concentrate on responding to other occupant needs. A laptop workstation and remote communications software allow staff to check the buildings' status in real-time and even troubleshoot problems from off-site. Not only does this system greatly increase maintenance staff productivity and occupant comfort, it is also responsible for energy savings because it provides ongoing monitoring of the HVAC system's performance. The State Energy, Minerals, and Natural Resources Department credits the new system with an annual savings of $140,000 in gas and electricity. (Trane 2005)

Reference

Definitions

Baseline is a complete set of assumed conditions of design, use, operation, and occupancy of a building. It is typically based on an energy efficiency standard or guideline.

Building Management System (BMS) is a computer-based system that can be programmed to control and monitor the operations of energy consuming equipment in a facility.

Measurement and Verification (M&V) is the process of determining energy or water savings using one of the four IPMVP Options.

Metering is meant to indicate the collection of energy and water consumption data over time at a facility through the use of measurement devices.

Monitoring is the collection of data, both for consumption and for operating conditions and parameters, at a facility over time for the purpose of savings and performance analysis e.g. energy or water consumption, temperature, humidity, hours of operation.

Projected Baseline Energy Use is the baseline energy use or demand calculated using post-construction operating conditions.

Simulation Model is an assembly of computerized algorithms that calculate energy use for specified time intervals at the systems and the whole building level based on engineering equations and user-defined parameters.

Standards

"International Performance Measurement & Verification Protocol (IPMVP): Volume I Concepts and Options for Determining Energy Savings 2001", Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

International Performance Measurement & Verification Protocol(IPMVP): Volume III Concepts and Options for Determining Energy Savings in New Construction, April 2003, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

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NYSGBTC 638.8 Commissioning; identifies the contents of the Systems and Energy Management Manual, Training requirements.

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Energy Systems Control and Maintenance EEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
A Systems and Energy Management Manual is attached, which describes the integration of the BMS and energy systems, as installed for the applications listed under Guideline EEQ-6, with scope and content as described in Green Building Tax Credit 638.8 (k) (2). Incorporate the measurement and validation Options B, C, or D of IPMVP 2001 in the manual and BMS implementation strategy.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Energy and Atmosphere Credit 5: Measurement and Verification.)*
Where appropriate, the scope of applications has been extended to include indoor water risers, outdoor irrigation systems.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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End User Metering EEQ-7

Purpose: Maximize tenant incentives to conserve energy.

Action: Include electrical distribution infrastructure required to allow end-user metering of tenants, including electricity use (kWh) and demand (kW) metering. Provide examples of existing incentive programs to tenants.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-5, EEQ-6

Introduction/Context

The benefits associated with End User Metering stem primarily from ensuring the end user is accountable for the energy they use. When tenants are required to pay for the energy they consume, the typical New York City "missing incentive" is restored in support of resourceful and efficient tenant design.

The New York State Energy Research and Development Authority (NYSERDA), is a strong advocate of end user metering "In master-metered building situations (without submetering), individual users are not charged separately for utilities in proportion to their consumption levels. Instead, the total utility costs are apportioned by square footage, number of rooms, or other pre-engineered formulas. As a result, the occupants do not receive the type of price signal associated with the individual commodity use whereby costs vary directly with consumption. Studies have indicated that users in these master-metered buildings tend to consume much more energy than occupants with individual energy meters."

A basic concept of economics is expressed by the term elasticity. This term refers to a user's variation in appetite for a product based upon its cost. Some users may be relatively inelastic and their rate of consumption will vary little as the price of the product varies. Other users will be highly elastic, and when prices rise, their consumption will be highly curtailed. Sub-metering or end user metering allows each tenant to exercise their individual energy consumption elasticity by charging them for their consumption.. End-use metering thereby ensures a more equitable distribution of utility costs and rewards energy-conserving users. End user metering also removes energy-cost volatility from the landlord's lease-expense budget. End-use metering allows each tenant to express the variations and flexibility in the timing of their individual energy consumption. For some relatively inelastic tenants, energy consumption may be little affected by individual metering, but for others, energy savings may be significant. Providing individual meters, furthermore, also anticipates new developments in electricity rate structures as the electricity supply market becomes more de-regulated. A number of utilities are developing real time electric rates under which the customer pays for the actual cost of delivering electricity at any point in time. These rates take into account both the cost of generation and the capital cost associated with meeting the overall system demand at the point (accounts for increased transmission infrastructure needed). Individual tenant-meters will allow each tenant to respond appropriately to these time-varying electric rates directly expressing their ability to shift operating schedules in order to benefit from lower utility costs.

Relevant Issues

Ecological

End-use metering results in lower energy consumption by many users. As such, it accrues major ecological benefits as it reduces the need for electricity generation. Today a high percentage of the generation of electrical energy is via the combustion of hydrocarbon fuels, which contribute to global warming and to air pollution from the by-products of combustion SO_2, NO_X, CO_2, heavy metals, mercury, and other particulate by-products.

Economic

End-use metering results in lower energy consumption by many users. As such, it often represents a very low-risk, high return investment for owners. Significant energy operating cost savings can be obtained by instituting measures that provide simple payback periods of less than 5 years. When taken together, the first-cost of end-use metering infrastructure is offset by reduced system size, complexity and cost, often resulting in significant operating cost savings at little additional first cost.

Neighborhood

End-use metering encourages accountability for energy use behavior. It prevents specific users from abusing the system through excessive consumption, where the costs are prorated among the entire tenant population. As a result of sub-metering, where the electrical costs may be the responsibility of each tenant's own consumption, conservative usage patterns become more apparent among all tenants. The resultant energy-efficiency reduces electricity demand, resulting in lower and more stable energy prices. Reduced energy use limits the consumption of finite natural resources and mitigates emissions that cause water and air pollution.

Methodology

Design Strategies

In certain occupancies, such as residential and some retail, each tenant has direct service from the utility with an individual meter and energy billing directly from the utility. In other occupancies, such as office, individual utility metering may not be feasible. For those applications, the landlord provides sub-meters by which energy costs may be allocated to tenants by use. Sub-meters may monitor both consumption and peak demand, so that these separate portions of the facility electricity cost may be allocated to each tenant.

Means and Methods

Landlords choosing to sub-meter tenants may elect to use incremental systems so that a greater portion of the tenants requirements' for building services are provided through sub-metered circuits. For example, packaged water cooled air conditioning units place the electrical consumption of the compressors that provide cooling for the tenant onto the sub-meter, as opposed to a central chilled water system, in which the compressors of the water chiller are fed through the main building meter. In general, electricity is the only utility service that is sub-metered. Steam services typically have a central meter, and are not sub-metered, as is the case with water service. For some facilities with central chilled water systems, Btu meters are provided on the chilled water service to each tenant, allowing the energy and operating costs of providing the chilled water to be allocated by usage. Btu meters typically are expensive, and require periodic calibration, so that their usage is limited. One limitation for this strategy, however, is that under current Consolidated Edison rate structures, completely sub-metered buildings purchase electricity under a different and higher rate than do buildings that have only a master meter and no sub-meters. Consolidated Edison considers allocation of energy costs by sub-metering to be resale of electricity and mandates that such installations utilize their purchase for resale rate.

Case Studies

Central Building Utilities Metering System, Yale University, New Haven, Connecticut.
The various sectors of Yale's campus are connected to an array of utilities including electrical, steam/condensate, and chilled water. Some of these utilities are provided from the campus' central cogeneration plant, while a portion of the electricity is generated and purchased from a local power plant. A complex metering system was required to track the utility usage on this campus, not only because of the multiple sources of generation, but also because of Yale New Haven Hospital which is an independent organization that shares space and utilities with the Yale School of Medicine. The Central Building Utilities Metering System provides real-time monitoring, on line diagnostics, and report generation for billing, energy management, and utilities systems engineering. Engineers and managers have direct access to all information regarding the flow of utilities on the campus. This system is an invaluable analytical tool, providing essential data for operation, troubleshooting, engineering, billing, and energy conservation. Energy savings are supported by this metering system because it promotes end-user awareness of their energy usage, optimization of power plant operations, flattening of peak demand, and continuous monitoring of the systems performance. (Boed 1999)

Brewery Block 4, Portland, Oregon
This building is home to market-rate commercial office space and saves 23.5% in electricity over the goals laid out by ASHRAE Standard 90.1. In order to accomplish this, the structure was designed with various energy saving strategies in mind. One such feature was the ability for end-use metering. The chilled water used for cooling, electricity, and natural gas are all delivered through sub-meters that track the quantities used by each office and retail tenant. This gives the building's owner the ability to charge each tenant for the precise amount of utilities they actually use and consequently encourages these tenants to conserve and practice energy efficiency to save money. (US DOE 2004)

Reference

Definitions

Definitions have not been included for this Guideline.

Standards

The Public Service Commission of New York State issues standards for utility submeters.

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End User Metering EEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
	●	●	●	●	

☐ **Required Component:**
The electrical distribution infrastructure required to allow end-user metering of tenants, including electricity use and demand metering, has been provided.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Purpose: To reduce peak electrical demand and required equipment capacities through storage of heat or cooling potential.

Action: Utilize thermal storage media to meet peak heating and cooling loads while minimizing building peak demands on site energy infrastructure. Thermal storage media may be actively charged or discharged, such as with ice or chilled water storage, or passively charged and discharged as with ground sink or ground water storage

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-5, EEQ-6

Introduction/Context

Commercial buildings are notoriously poor customers of the energy distribution infrastructure. They tend to place large peak demands on the infrastructure simultaneously with one another, and then spend long periods of time, overnight, in particular, and for office buildings, weekends and holidays, drawing little from the utility grid. Hospitals, industrial buildings, or even multi-family housing operate with more continuous requirements for energy. This “peaky” behavior reduces the number of hours of use over which the capitalization required to serve these buildings may be amortized. The capitalization involved is not only monetary, it is also environmental. The rights of way and siting for the utility infrastructure, power plants, transmission lines, electrical substations, gas pipelines, etc., all have environmental consequences, as land is diverted from more sustainable or functional use.

By placing these high intermittent demands on the utility infrastructure, commercial buildings force utilities to operate in a much less efficient and more polluting fashion. Commercial buildings tend to have their highest power demands on the hottest days of the year, when electric generating and transmission equipment is most burdened. Utilities tend to utilize their least efficient and most polluting generating assets to help meet these demands so that this equipment can remain idle for the rest of the time. A survey of the major public utilities reveals that approximately 90% of the pollution from electric generation is emitted by only 50% of the plants. Gas turbines, which now supply a significant portion of the electricity in the United States, and a preponderance of the generation during peak periods, rapidly lose efficiency as exterior temperatures climb. A typical utility-class gas turbine will drop from 30% efficiency at 75°F to 26% efficiency at 95°F. In fact, many utilities employ refrigeration machines to chill the incoming combustion air to the turbines, because of the resulting large gains in efficiency. Because of lower temperatures for the inlet combustion air, gas turbines operate between 10% and 20% more efficiently at night.

Utilities recognize the impact of building peak electrical demands upon their infrastructure by charging buildings for their peak power draw. Electric rate structures charge for both the amount of energy used by the building and its peak electrical draw. Some rate structures, generally classified as "Time of Day Rates" charge buildings for peak demands that occur within the time frame that the utility is experiencing the peak demand upon its resources. Economic analysis of the feasibility of thermal storage systems should recognize all rate structures that may apply to the building.

The impact of peak demands on capitalized equipment applies within the building also. In New York City, refrigeration plants for commercial buildings typically demonstrate between 1200 and 1600 equivalent full load hours of operation per year. In effect, cooling capacity is lying idle between 80 and 85% of the hours of the year. Through use of thermal storage systems, equipment capacity can be cut in half by increasing the hours of utilization of this smaller equipment. The decreased peak electric demand of this smaller equipment lessens the pressure on utilities to construct more generation and distribution capacity.

Passive thermal storage is also effective in spreading the requirements for heating and cooling over time and reducing peak demands. Architecturally massive construction, ground coupling and groundwater heat sinks all can be used to reduce peak conditioning demands. The efficiency of conventional air conditioning systems can be increased by rejecting heat, not the outside air at peak summer temperatures, but to ground water, river water, or the earth itself, at temperatures moderated by the thermal capacitance of the heat sink.

Thermal storage can also be incorporated in to projects by actively controlling the temperature of the structural mass of the building. In this application, the building mass becomes the mechanism for thermal delivery to spaces through convection and radiation, and the mass of the building stores thermal conditioning potential for delivery to the space over time.

Relevant Issues

Ecological

Reducing the peak electrical and heating requirements of buildings reduces the need for the construction of energy infrastructure. Reducing peak electric demand on hot summer days decreases the utilization of more polluting less, efficient generation assets. Shifting demand from hot summer days to cooler summer nights decreases the amount of fuel consumed by the combustion turbines that meet this demand.

Thermal shifting or storage always has a negative effect on one or more of our shared natural systems (air, ground water, river water, etc.). The utilization of river water for cooling has been a strategy from day one at the World Trade Center. Hudson River marine environmental impacts are inherently of concern. The dynamic reversals of the river's flow associated with the tidal interface and the immediate transition to the broader boundaries of New York Harbor do create a more dynamic, diffuse and unique interface when compared to the similar sites at the river's edge.

The net ecological gains resulting from enhanced system efficiencies have, to date, been felt to outweigh these thermal impacts.

Economic

Because most commercial buildings buy electricity based not only upon the total amount of electrical energy consumed, but also upon the peak power demand in each month, reduction in peak demand can result in energy cost savings, even as total energy consumption may increase slightly. The monthly electric bills for a commercial building in New York are about equally divided between energy charges and demand charges. Most thermal storage systems provide significant electrical demand reduction with only a small increase in energy consumption due to increased storage. Thus, a 20% reduction in peak demand, easily achievable with an active thermal storage system, accompanied by a small 2 or 3% increase in energy consumption results in a significant cost savings for the owner. In most commercial buildings, significant energy cost savings are more readily achievable with a better return on investment through demand reduction than through improvements in equipment efficiency.

Neighborhood

Above and beyond the community benefits of reduced energy usage as established in previous Guidelines, the use of thermal storage strategies at the World Trade Center Redevelopment site also has the potential to enhance public spaces. One example of this would be the integration of thermal storage with site fountains. The heat rejected to the water in these fountains could keep them from freezing and let them run for longer periods of the year, adding aesthetic value to the site's public spaces.

Methodology

Design Strategies

High mass architectural construction has been an effective strategy for mitigating temperature extremes since humans lived in caves. Historical architecture, such as Indian Pueblos, Moroccan mud-houses, and massive stone houses, continued the development of that strategy. In recent times, passive solar houses have made use of massive construction to mitigate peak heating and cooling loads over time. The strategy is also effective for commercial buildings, and includes not only massive above-ground construction, but also sub-surface construction to take advantage of the thermal mass of the earth.

Ice thermal storage is a known technology that is currently experiencing a renaissance as electric peak demand charges rise. A refrigeration plant, operating during off-peak hours, recharges the ice bank storage, which is discharged during the day to help meet peak cooling loads. Some additional energy is consumed by ice making as opposed to conventional cooling and by conduction losses from the ice bank. The availability of very low temperature water to make very low temperature supply air also makes possible pumping and fanpower savings that more than offset the parasitic energy use from ice making. First cost savings from fan, ductwork, and pipe size reductions enabled by the availability of low temperatures often more than offset the cost of the thermal storage.

Chilled water thermal storage operates similarly to ice storage, except that parasitic losses are much reduced. The size of the chilled water storage tank, however, is many times greater than the size of the ice tank. Because very low temperatures are not available, energy and first cost savings from fan and pump reductions are also not available.

High mass construction can be used to actively condition the spaces of a building. Piping imbedded in the internal finish surfaces of a space can be used to add or extract heat from the massive element over time keeping the surface temperature of the mass close to comfort requirements. To the extent that the surface area of the internal mass dominates the radiant environment of the space, this technique can provide the bulk of sensible conditioning to the space. While abrupt peak loads might overwhelm the thermal capacity of conventional building systems to maintain consistent space temperatures, the thermal mass of the structural conditioning system limits the rate of space temperature change. The structural conditioning system can then continue to act after peak loads have subsided to return the mass to its desired temperature. Because of the mass of the object, large amounts of heat gain or loss result in only small changes in temperature.

Rejection of refrigeration waste heat to low temperature sources always results in an increase in efficiency of the refrigeration plant. Low temperature heat sinks are often available in the earth and in surface water. Tidal surface water and running water, such as rivers or streams, create the best heat sinks because water warmed by the building’s reject heat is carried away from the site and replaced by fresh, un-warmed water. Rejection of heat into the ground, or extraction of heat can be an effective strategy, especially for smaller buildings or conditioning plants. Plants that work in only one mode (heat rejection, or heat extraction), however, tend to thermally pollute the ground source/sink, creating a local area of altered temperature that, over the years, becomes a less effective resource. Plants that switch from heat rejection to heat addition over the annual cycle tend to be more successful in utilizing the ground thermal resource over time.

Means and Methods

- Use an ice storage system to meet building peak cooling load, with smaller chillers and reduced peak electric demand
- Use chilled water storage to reduce chiller size and peak electric demand to meet building peak cooling load
- Use high mass building construction such as heavy weight concrete to reduce and postpone building peak cooling load
- Utilize subsurface thermal tempering capability of underground walls and floors or even earth covered roofs to reduce building peak cooling loads
- Utilize actively heated and cooled massive slabs to store heating and cooling.
- Utilize ground source heat rejection (geothermal wells) to reduce condensing temperature and increase efficiency of chiller and decrease electric load during peak cooling demand

- Utilize surface water heat rejection (e.g. Memorial Fountain river water) to reduce condensing temperature, increase efficiency of chillers, and decrease electric load during peak cooling demand periods.

Case Studies

1155 Avenue of the Americas, New York, NY
This office building incorporates an ice storage system to reduce required peak cooling capacity and peak electrical demand

World Financial Center, New York, NY
This 5 building office complex incorporates a one million gallon chilled water storage system to reduce required peak cooling capacity and peak electrical demand. The central plant for these buildings also draws its cooling water from the East River. The water is taken from the river through an inlet that prevents fish and debris from entering the cooling system.

Foundation House, New York, NY
This office building in Manhattan utilizes two 1550 foot standing column wells for heat rejection from its air conditioning plant and as a heat source when that plant is working in the heat pump mode.

Kensington Branch Library, Brooklyn, New York
This building incorporates an open loop ground source heat pump with both extraction and re-injection wells to provide a heat source/sink for its heat pump system.

IBT Corporate Headquarters, Santa Monica, CA
This office building in Los Angeles features a radiant cooling floor in its all glass lobby to cope with the intense solar heat gain the enters the space. The mass of the floor mitigates the intensity of the peak cooling load, allowing the chilled water system pipes embedded in the floor to remove the absorbed solar heat gain over time.

Pier 1, San Francisco, CA
This remodeled office building in a former pier on the San Francisco Embarcadero features both a radiant heating/cooling floor and closed loop heat exchangers to the San Francisco Bay. The radiant floor system keeps temperatures within the space at comfort levels. The bay heat exchangers allow the building's air conditioning system to reject heat at very low temperatures to increase energy efficiency.

Reference

Standards

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Thermal Energy Storage

EEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
○	○	○	○	○	○

☐ **Required Component:**
Mechanical systems have utilized bedrock, water cisterns, ice storage or other means to bank thermal energy and offset peak demand charges. A system description in the form of engineering drawings, calculations and specifications is attached.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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