LEED AP O+M TRAINING

June 2, 2009

Session 3 of 5

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ENERGY AND ATMOSPHERE

EA Overview

- 39% of energy generated and 74% of electricity produced in U.S. is consumed by buildings
- One megawatt (MW) of electricity generated from coal releases an average
  - 2,249 lbs of carbon dioxide
  - 13 lbs of sulfur dioxide
  - 6 lbs of nitrogen oxides
  - Emissions created by extracting and processing coal to produce energy

EA Overview

- Energy costs are a large portion of overall operating expenses of buildings
  - 2005 average energy cost
    - $1.19/SF for commercial building
    - $1.51/SF for an office building

EA Overview

- Green Buildings address energy cost issues
  - Reduce the amount of energy required to operate a building
    - Save 5% - 20% with low cost measures
  - Use more benign forms of energy
    - Solar
    - Wind
    - Thermal Storage

EA Overview

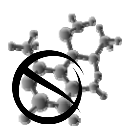
- Energy consumption can be dramatically reduced by economical (including no-cost or low-cost) practices including actions by building occupants, improved building operating strategies, and equipment upgrades

EA Overview

- Monitoring & Improving Building Energy Performance
  - Study conducted at Lawrence Berkley National Lab suggests that commissioning and improved operations could save 20% of the energy used by existing buildings
  - "You can't manage what you can't measure"

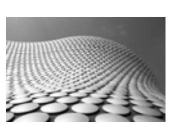
EA Overview

- Eliminating CFCs…
  - CFC = Chlorofluorocarbons
  - From Refrigerants
  - Destroys ozone molecules in the stratosphere
  - Banning use of CFC's in refrigerants mitigates climate change



EA Overview

- LEED EB O+M does …
  - <u>Not prescribe</u> approaches
  - Uses a <u>performance based approach</u>
    - Tailoring of energy reduction measures
    - Each building is unique



EAp1 – Energy Efficiency Best Management Practices

Planning, Documentation & Opportunity Assessment

EAp1 – Energy Efficiency Best Management Practices

- Intent
  - **Continuity** of information
  - Maintain **energy-efficient** operating strategies
  - Provide a **foundation** for training and system analysis

EAp1 – Energy Efficiency Best Management Practices

- Requirements & Documentation Guidance
  - Develop a **building operating plan** that provides details on how the building is to be operated and maintained
  - Document the current **sequence of operations**
  - Develop a **systems narrative** that briefly describes the mechanical and electrical systems and equipment

Sample Building Operating Plan

	AHU Unit	AHU - 1	AHU - 2	AHU - 3	AHU - 4
Space Information	Name of Area Served	1st, NW, A-H, 1-3	1st, NW, A-D, 4-10	1st, SW, G-K, 4-9	2nd, N-Center, High Bay Vest
	Tenant and Function	Office space	Office space, lounge, breakroom	Office space	Office space
	# of People	199	210	207	90
	Square Footage	20300	2075	2470	37560
BOP Review and Update for each Space	Latest BOP Review	[illegible]	[illegible]	[illegible]	[illegible]
	Describe Any BOP Changes	None	None	None	Occupied Temp Setpoints
	Reasons for BOP Change				Occupant complaints
Indoor Air Quality	Filtration - MERV	7	7	7	7
	Filter Replacement	Semi-Annual	Semi-Annual	Semi-Annual	Semi-Annual
Tenant Occupancy Schedule	Monday - Friday	0400 - 0000	0400 - 0000	0400 - 0000	0400 - 0000
	Saturday	Off	Off	0600 - 1600	Off
	Sunday	Off	Off	Off	Off
	Holiday	Off	Off	Off	Off
Custodial Crew	Monday - Friday	0600 - 0030	0600 - 0030	0600 - 0030	0600 - 0030
	Overrides				
HVAC Schedule	Monday - Friday	0300 - 0000	0400 - 0000	0400 - 0000	0400 - 0000
	Saturday	Off	Off	Off	Off
	Sunday	Off	Off	Off	Off
	Holiday	Off	Off	Off	Off
	Regular Overrides	N/A	N/A	N/A	N/A
Occupied Setpoints	Summer Temps (F)	75	75	75	74
	Winter Temps (F)	69	69	67	68
Unoccupied Setpoints	Summer Temps (F)	85	85	85	85
	Winter Temps (F)	55	55	55	55
Lighting	Task Lights	N/A	N/A	N/A	X
	Manual	N/A	N/A	N/A	N/A
	Timed Control	0500 - 0000	0000 - 0000	M-F 0000 - 0000 Sat 0600 - 1700	0400 - 0000
	Occupancy Sensor	N/A	N/A	N/A	N/A
	Daylight	N/A	N/A	N/A	N/A

Sample Systems Narrative

Overview:
XX Tower is a 21 story multi-tenant facility. The main space types on each floor of the building include a building core area (corridors), a tenant common area (general office), private offices, restrooms, and data centers.

Air Distribution System
21 separate VFD Air Handling Units serve each floor; each unit contains electric resistance heating, chilled water coils, and a supply fan. AHUs are found on each floor in the mechanical room next to the freight elevator. Fixed Outside Air (OA) dampers lead to a central shaft fed by two 17,500 cfm OA fans. Each AHU includes CHW coils fed by the Central Plant. There are 30 pneumatic VAV boxes on each floor, 12 of which are located in perimeter zones; only perimeter VAV boxes include electric strip heat.

Chilled Water System
The chilled water system consists of two centrifugal chillers, a Thermal Energy Storage (TES) unit, 2 condenser pumps, 2 primary pumps, 2 secondary pumps, and a depletion pump. The two chillers include a 550 ton York (VSD) and a 400 ton Trane. During summer nights, the 400,000 gal stratified chilled water tank is charged for thermal energy storage.

The condenser water loop consists of two pumps and two cooling towers with single speed fans. 26 supplemental water source heat pumps with their own circulating pumps connect to the building's chilled water loop to serve tenant data centers; operation and maintenance for all such units are the responsibility of the tenant.

Domestic Hot Water
A 30 gal electric storage tank is located on every third floor for DHW in bathrooms. All tenants have also installed their own electric tankless water heaters in their kitchen; tenants are responsible for the maintenance and operation of these units.

Lighting
All private offices, tenant common space, conference rooms, and restrooms on each floor have occupancy sensors. The building is on a timed switch linked into the BAS that shuts lights off at 8pm; tenants can call for a 1 hr override in their tenant space if needed. The janitorial and security staff also turn off lights as they sweep the building; all lights are off by 11pm.

Lights on the bottom two floors of the parking garage are ON 24/7; other floors of the parking garage are ON from 6am to midnight. Exterior SW landscaping lights are on a timer to be ON from dark to midnight. Aircraft warning lights are on 24/7.

Building Automation System (BAS)
A Siemens Apogee BAS controls the chillers, TES, AHUs, and lighting.

Sample Sequence of Operations

SEQUENCE OF OPERATION

EAp1 – Energy Efficiency Best Management Practices

- Requirements, Documentation Guidance & Approach
  - Summarize and document the adherence to the **equipment preventive maintenance plan & schedule**
  - Conduct an energy audit the meets the requirements of the **ASHRAE Level 1 walk-through analysis…**

EAp1 – Energy Efficiency Best Management Practices

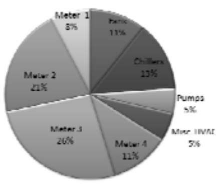
- Referenced Standard- **ASHRAE Level 1**
  - Analyze and evaluate a building's energy performance and consumption
  - Walk-through analysis & visual survey
  - Analyzing energy bills
  - Gather data, derive performance indicators,
  - Identify no-cost and low-cost measures to improve energy performance

EAp1 – Energy Efficiency Best Management Practices

- Referenced Standard- **ASHRAE Level 1**
  - *ASHRAE Procedures for Commercial Building Energy Audits*
    - Publication –procedures for audit
  - *2007 ASHRAE Handbook*
    - Publication – design & operation

EAp1 – Energy Efficiency Best Management Practices

- Submittal Documentation:
  - **Energy End Use Profile** - a breakdown of total annual energy consumption, summary of project's site energy utilization index



EAp1 – Energy Efficiency Best Management Practices

- Submittal Documentation:
  - A list of **potential low cost/no cost energy** efficiency and conservation upgrades

ECM #	ECM Name	Base Description	ECM Description	Annual Electric Cost Saving	Implement Cost	Implement Assistance Cost	Total Cost	Simple Payback (years)
1	Pump VFD	Plant operates with low CHW/CDW delta T	VFD modulates speed to maintain design delta T	$ 23,332	$ 17,390	$ 1,160	$ 18,550	0.8
2	After Hours Fan Operation	Main supply and return fans operate 24/7	Schedule fan operation for occupied hours only, unless overriden	$ 58,732	$ 1,160	$ 1,160	$ 2,320	0.0
3	Constant duct static pressure setpoint	Fans operate to maintain constant duct static pressure set point	program DSP reset schedule, linear reset from design cfm/DSP setpoint to 50% DSP @ 50% flow	$ 9,819	$ 8,320	$ 1,160	$ 9,480	0.9
			All Findings	$ 91,883	$ 26,870	$ 3,480	$ 30,350	0.3

EAp1 – Energy Efficiency Best Management Practices

- Points- Required Prerequisite
- Calculations:
  - Energy and Cost Indices calculations using ASHRAE Standard 105 methods:
    - Energy Utilization index (EUI)
    - Cost Index
    - Cost Index including water

EAp1 – Energy Efficiency Best Management Practices

Equation 1

- Energy Utilization index (EUI)

EUI (kBtu/ft2/yr) =

Total kBtu/Gross Floor Area

EAp1 – Energy Efficiency Best Management Practices

Equation 2

- Cost Index Calculation

Cost Index (kBtu/ft2/yr) =

Annual Energy Cost/Gross Floor Area

EAp1 – Energy Efficiency Best Management Practices

Equation 3

- Cost Index Calculation + Water

Cost Index Including Water (kBtu/ft2/yr) =

Annual Energy Cost + Total Water/

Gross Floor Area

EAp1 – Energy Efficiency Best Management Practices

- Approach enables…
  - Understanding by building operation staff of building's energy performance
  - Establishment of metrics and energy goals
  - Development of steps to meet goals

EAp2

Minimum Energy Efficiency

EAp2 – Minimum Energy Efficiency

- Intent - Establish the **minimum level of operating energy efficiency** performance for the building and systems
- Requirements –
  - Case 1: Earn an ENERGY STAR rating of at least 69
  - Case 2: If not eligible for ENERGY STAR, demonstrate energy efficiency with Option 1 or Option 2

EAp2 – Minimum Energy Efficiency

- Documentation Guidance: See EAc1
- Points- Required Prerequisite
- Calculations: see EAc1

EAc1

Optimize Energy Efficiency

EAc1– Optimize Energy Efficiency

- Intent: Achieve increasing levels of operating energy performance relative to typical buildings of similar type to reduce environmental and economic impacts associated with excessive energy use
- Points: 1-18, Exemplary Performance

EAc1– Optimize Energy Efficiency

- Requirements
  - CASE 1- Projects Eligible for Energy Star Rating
    - Enter into Portfolio Manager all data necessary to generate an energy performance rating
    - 12 Space Types
    - Energy Star Label is not a requirement – 75
    - Points start accumulating with a score of 71

EAc1– Optimize Energy Efficiency

- Requirements, cont'd
  - CASE 2- Projects not eligible for ENERGY STAR rating
    - Option 1: demonstrate energy efficiency in at least the 21st percentile
    - Option 2: Use the alternative method in the Reference Guide AND achieve energy efficiency demonstrated by properly calibrated energy meters in the project building

EAc1– Optimize Energy Efficiency

- Implementation, Approach & Submittal Documentation
  - Provide performance period; calculate site's EUI energy use based on 12 continuous months and ENERGY STAR, building gross square footage, production of on-site renewable energy

EAc1– Optimize Energy Efficiency

- Calculations
  - Use whole building energy metering to discern whole-building energy usage for every fuel type (electricity, natural gas, fuel oil, diesel fuel, district steam or hot water, district chilled water, propane, liquid propane, and wood); Assemble 12 months of energy use data and use ENERGY STAR Portfolio Manager to organize it

EAc1– Optimize Energy Efficiency

- Case 1: Projects Eligible for Energy Star ENERGY STAR Rating
  - Copies of the Portfolio Manager Web Pages
    - Provide ENERGY STAR program award certificate
    - Building's energy use intensities
    - ENERGY STAR performance rating
    - Space usage types, and value for space attributes

EAc1– Optimize Energy Efficiency

- Case 1: Projects Eligible for Energy Star ENERGY STAR Rating
  - OR **share access** to ENERGY STAR account with USGBC master account
    - Explain variables used to generate ENERGY STAR rating
    - Summarize monthly energy use for building and provide copies of energy bills representing at least three months of performance period

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating - Option 1: Efficiency at Least 21%
  - Demonstrate energy efficiency in at least the 21st percentile
  - Complete the Case 2 calculator

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating - Option 1: Efficiency at Least 21%
  - Adjusted Benchmark Score
    - Explain why building is ineligible for a rating using Portfolio Manager
    - Summarize monthly energy use over performance period OR share access with USGBC

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating Option 2: Alternative Score
  - 3 Options: 2A, 2B, 2C
  - Input information provided by Portfolio Manager

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating Option 2A: Streamlined Baseline (2pts max)
  - Enter energy use during Performance Period into Portfolio Manager
  - Enter the "weather-normalized source energy intensity" produced by Portfolio Manager into the template's offline calculator

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating Option 2B: Energy Baseline Including Historical Data (7pts max)
  - Enter at least 3 consecutive years of historical energy use data into Portfolio Manager
  - Enter the "weather normalized source energy intensity" for each year into the template's offline calculator
  - Adjust for changes in schedules or occupant activities, if appropriate

EAc1– Optimize Energy Efficiency

- Case 2: Projects Not Eligible for Energy Star Rating Option 2C: Comparable Buildings (18pts max)
  - Provide historical data from Option 2B AND
  - Provide energy use data for at least 3 other buildings with similar uses over at least a 2-year period
  - Enter the energy use intensities into the template's offline calculator

EAc1– Optimize Energy Efficiency

- Normalizing the Baseline
  - Portfolio Manager allows for normalization of the project building data based on weather conditions during each year; as well as changes to occupancy, changes in schedules, and other variables

EAc1– Optimize Energy Efficiency

- Referenced Standard:
  - ENERGY STAR Portfolio Manager-tools for calculating the ENERGY STAR performance rating, which is a federal program helping business and individuals protect the environment with superior energy efficiency

EAc2.1

Existing Building Commissioning: Investigation & Analysis

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Intent:
  - Use a systematic process to develop an understanding of the operation of the building's major energy-using systems
  - Develop options for optimizing energy performance
  - Develop a plan to achieve energy savings
- Points - 2

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Option 1: Commissioning Process-
  - Recommissioning plan, major energy systems
  - Conduct the investigation and analysis
  - Document energy-use breakdown
  - List problems and offer solutions
  - List capital improvements and document cost-benefit analysis of each

Sample Commissioning Investigation

299,116 Projects	2008 Approx. Cost	2009 Approx. Cost	2010 Approx. Cost	2011 Approx. Cost	2012 Approx. Cost	2013 Approx. Cost	2014 Approx. Cost	2015 Approx. Cost	2016 Approx. Cost	2017 Approx. Cost	2018 Approx. Cost	Totals
Building Energy Retrofit												
Lighting & Ballast Retrofit										$150,000		$0
Building Upgrades												
Paint Exterior Façade												$0
Infra-Red Scan Electrical System	$5,500											$5,500
Replace Domestic Water System	$7,500											$7,500
Carpet & Wallcovering		$20,000	$20,000	$20,000								$60,000
Restroom Fixture Replacement							$6,000					$0
Sump Pump Replacement												$0
Polish Interior Marble	$13,000		$8,500				$8,500					$21,500
Replace Restroom Mirrors												$0
Roof Replacement											$90,000	$0
Parking Structure												
Parking Control Equipment												$0
Refurbish Elevator Cabs		$15,000										$15,000
Sint System												$0
Painting Subterranean Garage												$0
Re-stripe						$15,000						$15,000
Expansion Joints			$6,000	$6,000								$12,000
Central Plant HVAC Upgrade												
Controls Upgrade			$12,000									$12,000
Cooling Tower Refurbishment	$45,000											$45,000
Chiller Rebuild/Replacement					$90,000	$90,000	$90,000	$90,000	$90,000			$90,000
Re-build Chilled Water Pumps			$5,000									$5,000
Re-configure Condenser water piping, series to parallel					$16,000	$16,000	$16,000					$16,000
Common Area												
Paint Stairwells		$8,000						$8,000				$8,000
Security												
Customer Service PDA's												$0
Upgrade Camera System Bldg. & P/S												$0
Fire Life Safety Upgrade	$69,000	$69,000	$69,000	$69,000	$69,000							$345,000
Pull Stations												$0
Recoverable Cost Total	$140,000	$112,000	$120,500	$95,000	$175,000	$121,000	$120,500	$98,000	$90,000	$150,000	$90,000	$763,500
Recoverable Cost Per Sq. Ft.	$0.47	$0.37	$0.40	$0.32	$0.59	$0.40	$0.40	$0.33	$0.30	$0.50	$0.30	$2.55
Non-Recoverable Cost Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$9
Totals	$140,000	$112,000	$120,500	$95,000	$175,000	$121,000	$120,500	$98,000	$90,000	$150,000	$90,000	$763,500

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Option 2: ASHRAE Level II, Energy Audit
  - Conduct an energy audit to ASHRAE Level II standards
  - Document energy-use breakdown
  - Perform a savings and cost analysis
  - List capital improvements that will provide cost-effective energy savings; document cost/benefit analysis of each

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Referenced Standard: ASHRAE Level II, Energy Audit: Energy Survey and Analysis: a detailed analysis that includes a breakdown of energy distribution within the building
- Points: 2 points

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Documentation Guidance:
  - Perform an investigation and analysis of building systems, through commissioning or ASHRAE Level II audit
  - Analyze building systems that consume energy- create a breakdown of energy end uses
  - List operational issues and capital improvements, with estimated costs and anticipated savings, that will improve energy performance and occupant comfort

EAc2.1 – Existing Building Commissioning: Investigation & Analysis

- Calculations:
  - Calculations required for the Level II audit are detailed in ASHRAE "Procedures for Commercial Building Energy Audits" (RP-669, SP-56)

EAc2.2 – Existing Building Commissioning: Implementation

EAc2.2 – Existing Building Commissioning: Implementation

- Intent: Implement minor improvements and identify planned capital projects to ensure that major energy-using systems are repaired, operated, and maintained effectively to optimize energy performance

EAc2.2 – Existing Building Commissioning: Implementation

- Requirements:
  - Implement no- or low-cost improvements and create a plan for major upgrades
  - Provide training of sustainable building operations topics for building management
  - Demonstrate the observed/anticipated financial costs and benefits of implemented measures

EAc2.2 – Existing Building Commissioning: Implementation

- Requirements (cont'd):
  - Update the building operating plan to reflect changes in operational/equipment run-time schedules, design set-points, and lighting levels
- Approach:
  - Use findings from master list generated in EAc2.1 to implement improvements

EAc2.2 – Existing Building Commissioning: Implementation

- Approach (cont):
  - Implement immediate, cost-effective measures to improve operations, efficiency, and occupant comfort
  - Calculate cost/benefit analyses for deficiencies rectified
  - Establish management/ownership's long term priorities
  - Provide management staff the skills and knowledge to enact sustainable operations

EAc2.2 – Existing Building Commissioning: Implementation

- Calculations:
  - Simple payback period: length of time required to recoup initial investment
  - Rate of return: ratio of cost-savings generated relative to amount of money invested
  - Cost-benefit ratio: total financial return for each dollar invested in operation improvements and upgrades
- Points: 2 points

EAc2.2 – Existing Building Commissioning: Implementation

- Referenced Standard: None
- Documentation Guidance:
  - Perform cost/savings analysis of all improvements and minor repairs
  - Track all no- or low-cost operational improvements and include cost savings per improvement
  - Update building operating plans to reflect improvements
  - Summarize the training of management staff and the material covered

EAc2.3

Existing Building Commissioning: Ongoing Commissioning

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Intent: use commissioning to address changes in facility occupancy, use, maintenance, and repair. Make periodic adjustments and reviews of building operating systems and procedures for optimal energy efficiency and service provision

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Requirements:
  - Implement an ongoing commissioning program including: planning, testing, performance verification, corrective action, measurement, and documentation
  - Create a written plan that summarizes the overall commissioning cycle (no more than 24 month cycle)

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Requirements (cont'd):
  - Complete at least half the scope of work in the first commissioning cycle prior to the date of application for LEED 2009
  - Update the building operating plan or systems narrative as necessary to reflect changes to occupancy schedule, equipment schedule, other specifications

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Approach:
  - Ongoing commissioning program must integrate a detailed plan for system testing, performance verification, corrective action, and ongoing measurement.
  - Emphasize a systems-wide approach, defined by a basis in performance testing

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Approach (cont'd):
  - Create a detailed schedule for the completion of the overall commissioning cycle- identify procedures for responding to deviations from preferred performance
  - Regularly review and revise the plan to reflect changes/upgrades, etc.

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Referenced Standard: None
- Points: 2 points
- Calculations: None

EAc2.3 – Existing Building Commissioning: Ongoing Commissioning

- Documentation Guidance:
  - Create an ongoing commissioning cycle based on the equipment list, include a schedule of diagnostic testing and response steps for each commissioned piece
  - As improvements are made, update the BOP
  - Record data and costs for completed phases of commissioning, indicating the total budget, the task completed, and associated costs

EAc3.1

Performance Measurement: Building Automation System

EAc3.1 – Performance Measurement: Building Automation System

- Intent: Provide information to support ongoing accountability and optimization of building energy performance and identify opportunities for additional energy savings investments

EAc3.1 – Performance Measurement: Building Automation System

- Requirements:
  - Have in place a computer-based building automation system (BAS) that monitors and controls key building systems (heating, cooling, light, etc.)
  - Have a preventive maintenance program in place to ensure BAS components are tested/repaired/replaced
  - Demonstrate that the BAS is being used to inform decisions

EAc3.1 – Performance Measurement: Building Automation System

- Approach:
  - Use a computer-based BAS to achieve optimal levels of occupant comfort while maximizing energy efficiency
  - Calibrate sensors regularly, measuring components such as: outside air temperature, mixed air temperature, return air temperature, etc.
  - Maintain a BAS preventive maintenance program: inspect components, verify schedules/setpoints, check gauges/sensors, etc.

EAc3.1 – Performance Measurement: Building Automation System

- Implementation:
  - Use a BAS to achieve optimal levels of occupant comfort while maximizing the energy efficiency
  - Properly maintain BAS to ensure efficiency
  - Calibrate sensors, valves, and dampers
  - Conduct inspections, verify setpoints, check gauges, and check sensors
- Points: 1 point

EAc3.1 – Performance Measurement: Building Automation System

- Referenced Standard: None
- Documentation Guidance:
  - Maintain documentation of BAS operation and function
  - Retain periodic BAS reports indicating system is operating per the programming
  - Maintain a written record of PM practices
  - Document decisions informed by BAS data

EAc3.2-3

Performance Measurement: System-Level Metering

EAc3.2 – Performance Measurement: System-Level Metering

- Intent: Provide accurate energy-use information to support energy management and identify opportunities for additional energy-saving improvements
- Referenced Standard: None
- Points: 1-2 Points

EAc3.2 – Performance Measurement: System-Level Metering

- Requirements:
  - Develop a breakdown of energy use in the building
  - Demonstrate system-level metering covering at least 40% (1point) or 80% (2 points) of the total expected annual energy consumption
  - Demonstrate that the number of the largest energy-use categories from the breakdown report are metered at least 80%
  - Log all sub-metering data & analyze for trends

EAc3.2 – Performance Measurement: System-Level Metering

- Approach:
  - Analyze and develop a breakdown of the building's energy use for major energy use applications
  - Compile for each major energy subsystem: expected annual energy consumption, % of total annual energy use; % of energy consumption sub-metered
  - Install permanent, continuous, automatic, electronic meters
  - Use metering data to improve system performance

EAc3.2 – Performance Measurement: System-Level Metering

- Calculations:
  - Use energy breakdown data to determine if metering level is acceptable
  - Report energy use in kBtu for all applications
  - For each major end-use, determine expected annual energy consumption, sum to find total annual energy use
  - Calculate % of total annual energy use of each subsystem
  - Determine the load of each system

EAc3.2 – Performance Measurement: System-Level Metering

- Documentation Guidance:
  - List the type and location of system-level meters
  - Track energy use on an individual system level
  - Maintain documentation of the metering operation and function
  - Maintain a written record of preventive maintenance practices relating to system-level metering
  - Prepare an energy use breakdown report

EAc4.1-4

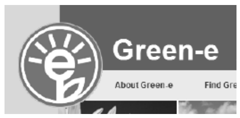
On-Site and Off-Site Renewable Energy

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Intent: Encourage and recognize increasing levels of on-site and off-site renewable energy to reduce environmental impacts associated with fossil fuel energy use

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Utilize on-site or off-site renewable energy systems, as defined by the **Center for Resource Solutions (CRS) Green-e requirements** (Referenced Standard) www.green-e.org



EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Requirements (cont'd):
  - If the green power is not Green-e certified, equivalence must exist for both major Green-e program components:

1. Current **green power performance standards** and
2. **Independent verification** that standards are being met by green power supplier

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Requirements (cont'd):
- Points: 1-6 Points, Exemplary Performance eligible:

On-site: 3%, 4.5%, 6%, 7.5%, 9%, 12%

Off-site: 25%, 37.5%, 50%, 62.5%, 75%, 100%

EAc4.1-4 – On-Site and Off-Site Renewable Energy

On-site approach:

- **<u>Eligible</u> On-site Systems:**
  - Photovoltaic system
  - Wind energy system
  - Solar thermal system
  - Geothermal energy systems
  - Low-impact hydroelectric power systems
  - Wave and tidal power systems

EAc4.1-4 – On-Site and Off-Site Renewable Energy

On-site approach:

- **<u>Eligible</u> On-site Systems:**
  - Biofuel-base systems – allowed fuels:
    - Untreated wood waste including mill residues
    - Agricultural crops or waste
    - Animal waste and other organic waste
    - Landfill gas

EAc4.1-4 – On-Site and Off-Site Renewable Energy

On-site approach:

- **<u>Ineligible</u> On-site Systems**
  - Architectural features
  - Passive solar strategies
  - Daylighting strategies
  - Geoexchange systems (ground-source heat pumps)

EAc4.1-4 – On-Site and Off-Site Renewable Energy

Off-site approach:

- Purchase or commit to purchase renewable energy or renewable energy certificates (RECs)

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Calculations:
  - Determine **annual energy** use of entire building and site; **then % or energy use from renewable** energy sources
  - Convert both On-Site & Off-Site renewable energy-convert to Mbtu (million Btu), calculate % of total energy use
  - Combination of on-site and off-site renewable energy- any combination to earn 6 points

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Calculations for Combination:

Convert the on-site renewable energy to the **equivalent of the off-site renewable energy:**

$$\text{\% of Off-site Equivalency} = \text{\% On-site Renewable Energy} \times \frac{25\%}{3\%}$$

EAc4.1-4 – On-Site and Off-Site Renewable Energy

This example is if your on-site renewable energy is 2% of the total:

$$\mathbf{16.67\%} = 2\% \times \frac{25\%}{3\%}$$

Use 16.67% of the Off-site Equivalency to get credit for the 2% generated on-site.

EAc4.1-4 – On-Site and Off-Site Renewable Energy

- Documentation Guidance:
  - Provide **photos or other documentation** of any installed on-site renewable energy systems
  - Sign a **2 year contract** for the purchase of off-site renewable energy
  - **Track annual energy use,** indicating alternative sources
  - **List the alternative energy sources** used for the project building

EAp3

Refrigerant Management: Ozone Protection

EAp3 – Refrigerant Management: Ozone Protection

- Intent: reduce stratospheric ozone depletion
- Requirements:
  - Do not use CFC-based refrigerants in HVAC&R systems unless replacement/conversion is not **economically feasible** or is already scheduled
  - Small units (less than .5 lbs of refrigerant) are exempt

EAp3 – Refrigerant Management: Ozone Protection

- Approach:
  - Eliminate CFCs
  - Perform **economic analysis** of feasibility of replacement/conversion
  - Payback = more than 10 years = exempt
  - Minimize refrigerant leakage
    - Less than 5% annual leakage allowed
    - Life of unit less than 30% of charge

EAp3 – Refrigerant Management: Ozone Protection

- Points: Required Prerequisite
- Referenced Standard:
  - **EPA Clean Air Act, Title VI, Section 608-** provides regulations on the use and recycling of ozone-depleting compounds

EAp3 – Refrigerant Management: Ozone Protection

- Documentation Guidance:
  - Where applicable, develop and track the phase-out plan
  - Retain manufacturers' documentation demonstrating the type of refrigerant used

EAp3 – Refrigerant Management: Ozone Protection

- Submittal Documentation OPTION I:
  - Provide USGBC final LEED review for new building;
  - If a **CFC phase-out plan was performed,** list the components already phased out

EAp3 – Refrigerant Management: Ozone Protection

- Submittal Documentation OPTION 2:
  - Project building **uses no CFC-based refrigerants** in base systems:
  - List year of installation
  - **Or conversion of all base building systems;** provide building's refrigerant management program, OR provide manufactures data showing refrigerant use for each base building system

EAp3 – Refrigerant Management: Ozone Protection

- Submittal Documentation OPTION 3
  - Project building **uses CFC-based refrigerants** in base systems:
  - Provide building's **refrigerant management program** listing refrigerant use for each building, including those with CFCs and those without; OR
  - Provide **manufacturer's data** showing refrigerant AND provide CFC phase-out plan implemented during performance period

EAp3 – Refrigerant Management: Ozone Protection

- Calculation:

Simple payback of **replacement** =
Cost of replacement / sum of annual cost avoidance for energy savings resulting from replacement

Simple payback of **conversion** =
Cost of conversion/ sum of annual cost avoidance for energy savings resulting from conversion

EAp3 – Refrigerant Management: Ozone Protection

- Calculations:

Annual Leakage rate:

lbs refrigerant added/lbs refrigerant in full charge) X (365 days/year/Te) X 100%

Where Te (time elapsed) = the shorter of 365 (1 year) or number of days since refrigerant was last added.

EAc5

Refrigerant Management

EAc5 – Enhanced Refrigerant Management

- Intent: Reduce ozone depletion and support early compliance with the **Montreal Protocol** while minimizing direct contributions to global climate change
- Referenced Standard: None
- Points: 1 Point

EAc5 – Enhanced Refrigerant Management

- Requirements:
  - Option 1: Do not use refrigerants in base building HVAC&R systems
  - Option 2: select refrigerants that minimize the emission of compounds that contribute to ozone depletion/global warming, AND do not operate fire-suppression systems that contain ozone-depleting substances

EAc5 – Enhanced Refrigerant Management

- Approach:
  - Do not use refrigerants
  - Use only natural refrigerants
  - Select refrigerants with low ozone-depletion and global-warming potentials
  - Minimize refrigerant leakage
  - Select equipment with efficient refrigerant charge
  - Select equipment with long service life
  - Choose appropriate fire-suppression systems

EAc5 – Enhanced Refrigerant Management

- Calculations:
  - Annual Leakage Rate
  - Lifecycle Ozone Depletion Potential (LCODP)
  - Lifecycle Direct Global Warming Potential (LDGWP)
  - Refrigerant Atmospheric Impact
  - Average Refrigerant Atmospheric Impact

EAc5 – Enhanced Refrigerant Management

- Documentation Guidance:
  - List base building systems containing refrigerants and the associated type of refrigerant. Include ODP and GWP
  - Retain manufacturers' documentation indicating the type and quantity of refrigerant used
  - Track annual refrigerant leakage rates

Related Supplemental Reading

The Treatment by LEED® of the Environmental Impact of HVAC Refrigerants

Understand **trade off** between **ozone depletion** & **global warming** potential as it relates to the hydrochlorofluorocarobons (HCFCs) and the Hydrofluorocarbons (HFCs)

REFRIGERANT	ODP	GWP	APPLICATION
Cholorofluorocarbons - phasing out			
CFC-11	1.000	4,680	Centrifugal chillers
CFC-12	1.000	10,720	Refrigerantors, chillers
Hydrocholorofluorocarbons			
HCFC-22	0.040	1,780	Centrifugal chillers
HCFC-123	0.020	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	$< 4x10^{-4}$	12,240	ultra-low temperature
HFC-134a	$< 1.5x10^{-5}$	76	CFC-12 or HCFC-22 replacement
Natural Refridgerants			
CO_2	0.000	1	n/a - not efficent
NH3	0.000	0	n/a - not efficent
Propane	0.000	3	n/a - not efficent

EAc6

Emissions Reduction Reporting

EAc6 – Emissions Reduction Reporting

- Intent: Document the emissions reduction benefits of building efficiency measures
- Requirements:
  - Identify building performance parameters that reduce conventional energy use and emissions, quantify those reductions, and report them to a formal tracking program

EAc6 – Emissions Reduction Reporting

- Approach:
  - Track and calculate greenhouse gas emissions from every type of building energy use
  - Compare emissions with past levels or with national medians
  - Understand the reductions generated by various actions
  - Credit encourages participation in third-party voluntary reporting or certification programs

EAc6 – Emissions Reduction Reporting

- Calculations:
  - To show reduction in emissions from baseline year:
    - Emissions for the performance period year
    - Emissions for the baseline year
    - Reduction in emissions from baseline year to performance year
  - To compare GHG emissions with an ENERGY STAR building:
    - Emissions for performance period year

EAc6 – Emissions Reduction Reporting

Calculations (cont'd)
- Emissions for a baseline building (use Portfolio Manager)
- Reductions in emissions from the baseline building

- Referenced Standard: None
- Points: 1 Point

EAc6 – Emissions Reduction Reporting

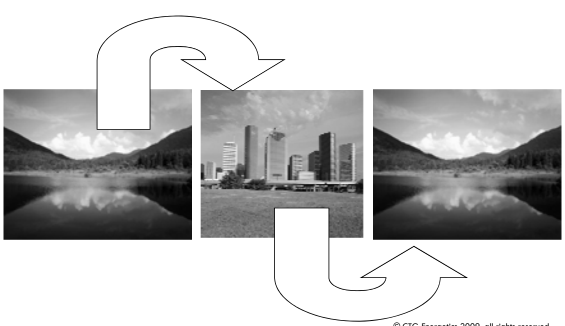
- Documentation Guidance:
  - Collect annual utility data and energy consumption data from any on-site operations that generate emissions
  - Perform comparisons on emissions reductions from year to year
  - Report emissions through formal participation in a third-party voluntary reporting agency, certification program, or through technically sound independent calculations

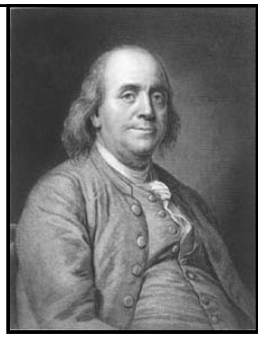
Questions…

15 Minute Break…

LEED O&M–WATER EFFICIENCY

Water Use in Buildings





“When the well's dry, we know the worth of water.”

Benjamin Franklin

Introduction

- Americans’ use of public water supply increasing
- Water is withdrawn, used, treated, and discharged
- Discharged water problematic
- EPA statistics about unsafe waters
- Large volume water use increases maintenance and life-cycle costs for building operation

Introduction

- More efficient water use reduces costs
- Efficiency measures can easily reduce water use in average commercial buildings by **30%** or more
- Conservation strategies cost options:
  - No-cost
  - Rapid-payback
  - Cost-effective under specific circumstances.

Measures used for water efficiency:

- **Monitor water consumption performance**
  - Track water consumption alongside energy use
  - Make integrated management decisions
- **Reduce indoor potable water consumption**
  - Use alternative water sources for non-potable uses
  - Install building upgrades to reduce potable water use

Measures used for water efficiency:

- **Reduce water consumption**
  - Save energy and improve environmental well-being
  - Reduce energy costs
  - Benefit human health and welfare
  - Lower water levels can concentrate contaminants
- **Practice water-efficient landscaping**
  - Maintain or reestablish native plans
  - Reduce irrigation and number of chemicals in water supply

Water Use – the reality

- Each day, 5 billion gallons of water is used to flush toilets
- Since the 1940's water levels dropped in underground aquifers (throughout the US) more than 150 feet
- Americans use an average of 100 gallons of water each day - enough to fill 1,600 drinking glasses
- A recent government survey showed at least 36 states are anticipating local, regional, or statewide water shortages by 2013

What can we do?

- A 10% reduction in total US commercial building water use (consumption for all uses) would result in a savings of more than 2 trillion gallons of water each year
- In a typical 100,000 sq ft office building, installation of low flow plumbing fixtures and automatic controls would result in at least 1 million gallons of water per year savings

Water Efficiency (WE)

- Limit landscape water
- Use water-conserving plumbing fixtures and appliances
- Consider water recovery and re-use systems

WEp1 & WEc2

Minimum/Additional
Indoor Plumbing
Fixture Efficiency

WEp1/C2 - Indoor Plumbing Fixture and Fitting Efficiency

- **Intent WEp1**
  - Reduce indoor fixture and fitting water use to reduce burdens on water supply and wastewater systems
- **Intent WEc2.1-2.5**
  - Maximize indoor plumbing fixture and fitting efficiency to reduce use of potable water and burden on municipal water supply and wastewater systems

WEp1/C2 - Indoor Plumbing Fixture and Fitting Efficiency

- WEp1 – Required – Equal to or below baseline
- WEc2.1 – 2.5
  - Percentage above the baseline
    - 10% = 1 point
    - 15% = 2 points
    - 20% = 3 points
    - 25% = 4 points
    - 30% = 5 points
- IO c1 - Exemplary Performance = 35%

Baseline Calculation

- Need:
  - IPC/UPC Plumbing Codes
  - Number of FTE (Full Time Equivalent) Occupants
  - Number of flush and flow fixtures in facility
    - Broken down by notably different uses
  - Date of substantial completion or plumbing renovation
    - Broken down if staggered

WEp1/c2 - Baseline

Referenced Standard- Uniform Plumbing Code (UPC) 2006 or International Plumbing Code (IPC) 2006- defines maximum flow rates and consumption for fixtures and fittings

UPC/IPC Codes 2006

- Substantial completion or plumbing renovation
  - 1993 or later – 120%
  - Prior to1993 – 160%

UPC/IPC Standards (Baseline)

Table 1. UPC and IPC Standards for Plumbing Fixture Water Use

Fixture	UPC and IPC Standards	EPA WaterSense Standards
Water closets (gallons per flush, gpf)	1.60	1.28
Urinals (gpf)	1.00	0.5[a]
Showerheads (gallons per minute, gpm*)	2.50	1.5--2.0[b]
Public lavatory faucets and aerators (gpm**)	0.5	
Private lavatory faucets and aerators (gpm**)	2.2	1.5
Public metering lavatory faucets (gallons per metering cycle)	0.25	
Kitchen and janitor sink faucets	2.20	
Metering faucets (gallons per cycle)	0.25	

FTE Calculations

- Determine Full Time Equivalent Occupants (FTE)
- Each occupant working an eight hour period = 1
- Each part time worker = hours per day / 8
- Include shifts for all workers
- Calculate transient occupants
- Count estimated retail, student, residential

⇨ *NOTE: FTE needs to be consistent for all credits*

Default Fixture Use by Occupancy Type

Table 3. Default Fixture Uses, by Occupancy Type

Fixture Type	FTE	Student/Visitor	Retail Customer	Resident
	Uses/Day			
Water Closet				
— Female	3	0.5	0.2	5
— Male	1	0.1	0.1	5
Urinal				
— Female	0	0	0	n/a
— Male	2	0.4	0.1	n/a
Lavatory Faucet — duration 15 sec; 12 sec with autocontrol — residential, duration 60 sec	3	0.5	0.2	5
Shower — duration 300 sec — residential, duration 480 sec	0.1	0	0	1
Kitchen Sink, — duration 15 sec — residential, duration 60 sec	1 n/a	0 n/a	0 n/a	n/a 4

Water Fixture Inventory

- Inventory of quantity & type of each fixture
  - Urinals
  - Toilets
  - Restroom sinks
  - Breakroom/kitchen sinks
  - Showers
  - Janitor sinks

Water Use Assumptions – for calculation

- Toilets
  - Females flush the toilet 3 times per day
  - Males flush the toilet 1 time per day
- Urinals - Males flush the urinal 2 times per day
- Sinks - All occupants use the sink 3 times per day (15 seconds each time)
- Showers -10% of occupants use the shower each day (300 seconds each time)
- 50/50 Ratio for Men/Women - default

Calculation

- Enter all of the data for the baseline calculation into LEED template to get your calculated baseline (Template populates the 120% or 160%)
- Know the actual flush and flow rates for all installed fixtures for the **Installed** Calculation
- Enter the actual flush and flow rates

$$\text{Percentage Reduction} = \frac{\text{Baseline} - \text{Installed}}{\text{Baseline}} \times 100$$

Sample Project Calculations

Table 4.1: Fixture Group Definitions

				Occupants (users) in Group					Gender Ratio	
Group Name	# of Fixtures Installed or Completely Replaced before January 1st, 1993	# of Fixtures Installed or Completely Replaced on or after January 1st, 1993	Annual Days of Operation	Full-Time Employees	Students/ Visitors	Retail Customers	Residents	Other	% Female	% Male
Floors 1-2	20	0	260	100	0	0	0	0	50 %	50 %
Floors 3-10	0	80	260	900	0	0	0	0	50 %	50 %
Total	20	80								

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Sample Project Calculations

Table 4.2: Flush Fixture Data

Enter flush fixture data for each fixture group defined in Table 4.1.

							Annual Water Consumption, kGal	
Fixture Group	Fixture ID (Optional)	Fixture Family	Fixture Type	Daily Uses	Baseline Flush Rate (GPF)	Installed Flush Rate (GPF)	IPC/UPC Baseline	Performance Case
Floors 1-2		Water Closet	Older WC fixtures	200	1.6 GPF	3.5 GPF	83.2 kGal	182 kGal
Floors 3-10		Water Closet	IPC/UPC Equivalent Water Closet	1,800	1.6 GPF	1.6 GPF	748.8 kGal	748.8 kGal
Floors 1-2		Urinal	Older Urinal	100	1 GPF	1.5 GPF	26 kGal	39 kGal
Floors 3-10		Urinal	IPC/UPC Equivalent Urinal	900	1 GPF	1 GPF	234 kGal	234 kGal

(Flush) IPC/UPC Baseline kGal/yr	1,092
(Flush) Calculated Water Consumption kGal/yr	1,203.8

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Sample Project Calculations

Fixture Group	Fixture ID (Optional)	Fixture Family	Fixture Type	Daily Uses	Duration (seconds)	Baseline Flow Rate (GPM)	Installed Flow Rate (GPM)	Annual Water Consumption, kGal: IPC/UPC Baseline	Annual Water Consumption, kGal: Performance Case
Floors 1-2		Public Lavatory Fa	IPC/UPC Equivalent Lavatory	300	15 sec	0.5 GPM	0.5 GPM	9.75 kGal	9.75 kGal
Floors 3-10		Public Lavatory Fa	IPC/UPC Equivalent Lavatory	2,700	12 sec	0.5 GPM	0.5 GPM	70.2 kGal	70.2 kGal
Floors 1-2		Kitchen Sink	IPC/UPC Equivalent Kitchen Sink	100	15 sec	2.2 GPM	2.2 GPM	14.3 kGal	14.3 kGal
Floors 3-10		Kitchen Sink	IPC/UPC Equivalent Kitchen Sink	900	15 sec	2.2 GPM	2.2 GPM	128.7 kGal	128.7 kGal
Floors 1-2		Shower	IPC/UPC Equivalent Shower	10	300 sec	2.5 GPM	2.5 GPM	32.5 kGal	32.5 kGal

(Flow) IPC/UPC Baseline kGal/yr	255.45
(Flow) Calculated Water Consumption kGal/yr	255.45

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Table 4.4 Summary Statistics

Number of fixtures installed before 1 January 1993	20
Number of fixtures installed on or after 1 January 1993	80
LEED EB:O&M Performance Baseline Multiplier	128 %
LEED-EB: O&M Baseline Annual Volume [kgal] (128 % of IPC/UPC Baseline)	1,724.736
Total Calculated Fixture Water Use Annual Volume, Performance Case [kgal]	1,459.25
Performance Case percent difference from LEED-EB: O&M Baseline Case[1] (used for determining WEc2 compliance)	**15.39 %**
Number of Building Occupants[2]	1,000
Fixture Water Annual Use [kgal] per Building Occupant	1.45925
Building Square Footage [SF]	200,000 SF
Fixture Water Annual Use [gal] per Building Square Foot	0.00729625

Sample Project Calculations - Prereq

LEED for Existing Buildings: Operations & Maintenance
Certification Submittal Template
WE Prerequisite 1: Minimum Indoor Plumbing Fixture and Fitting Efficiency

Project Name: SAMPLE PROJECT

WEp1: Minimum Indoor Plumbing Fixture and Fitting Efficiency Compliance Documented Y

Opportunities for Improvement

- Which fixtures exceed the baseline fixtures?

Fixture	Baseline Flush/Flow volume	Your flush/flow volume
Toilet	1.6	
Urinal	1.0	
Restroom sink	.5	
Breakroom Sink	2.2	
Shower	2.5	

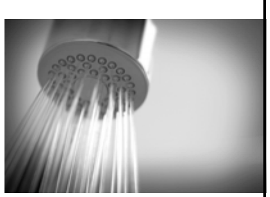
- Target those areas for improvement opportunities

WEp1/c2 - Indoor Plumbing Fixture and Fitting Efficiency

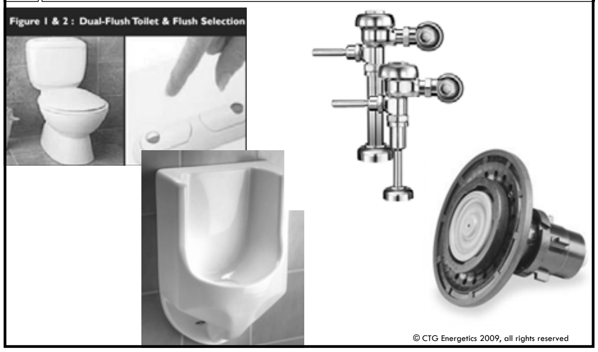
Requirements and Approach

- Train maintenance staff in operations and maintenance of specialized equipment.
- Educate building occupants on different technologies
- Develop and implement an economic assessment of conversion to high-performance plumbing fixtures
- Consider consulting WaterSense, an EPA program about products and programs
- Retrofit or replace existing fixtures and features with high-efficiency fixtures
- Collect, stores, and use gray water

WEp1/C2 - Indoor Plumbing Fixture and Fitting Efficiency



Water Conserving Fixtures



Sample Project Calculations - Modified

Table 4.2: Flush Fixture Data

Enter flush fixture data for each fixture group defined in Table 4.1.

Fixture Group	Fixture ID (Optional)	Fixture Family	Fixture Type	Daily Uses	Baseline Flush Rate (GPF)	Installed Flush Rate (GPF)	Annual Water Consumption, kGal: IPC/UPC Baseline	Annual Water Consumption, kGal: Performance Case
Floors 1-2		Water Closet	Older WC fixtures modified	200	1.6 GPF	3 GPF	83.2 kGal	156 kGal
Floors 3-10		Water Closet	IPC/UPC Equivalent Water Closet	1,800	1.6 GPF	1.6 GPF	748.8 kGal	748.8 kGal
Floors 1-2		Urinal	Older Urinal modified	100	1 GPF	0.8 GPF	26 kGal	20.8 kGal
Floors 3-10		Urinal	Newer Urinal Modified	900	1 GPF	0.5 GPF	234 kGal	117 kGal

(Flush) IPC/UPC Baseline kGal/yr	1,092
(Flush) Calculated Water Consumption kGal/yr	1,042.6

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Sample Project Calculations - Modified

Fixture Group	Fixture ID (Optional)	Fixture Family	Fixture Type	Daily Uses	Duration (seconds)	Baseline Flow Rate (GPM)	Installed Flow Rate (GPM)	Annual Water Consumption, kGal: IPC/UPC Baseline	Annual Water Consumption, kGal: Performance Case
Floors 1-2		Public Lavatory Fa	IPC/UPC Equivalent Lavatory	300	15 sec	0.5 GPM	0.5 GPM	9.75 kGal	9.75 kGal
Floors 3-10		Public Lavatory Fa	IPC/UPC Equivalent Lavatory	2,700	12 sec	0.5 GPM	0.5 GPM	70.2 kGal	70.2 kGal
Floors 1-2		Kitchen Sink	IPC/UPC Equivalent Kitchen Sink	100	15 sec	2.2 GPM	2.2 GPM	14.3 kGal	14.3 kGal
Floors 3-10		Kitchen Sink	IPC/UPC Equivalent Kitchen Sink	900	15 sec	2.2 GPM	2.2 GPM	128.7 kGal	128.7 kGal
Floors 1-2		Shower	Low-Flow Shower	10	300 sec	2.5 GPM	1.8 GPM	32.5 kGal	23.4 kGal

(Flow) IPC/UPC Baseline kGal/yr	255.45
(Flow) Calculated Water Consumption kGal/yr	246.35

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Table 4.4 Summary Statistics

Number of fixtures installed before 1 January 1993	20
Number of fixtures installed on or after 1 January 1993	80
LEED EB:O&M Performance Baseline Multiplier	128 %
LEED-EB: O&M Baseline Annual Volume [kgal] (128 % of IPC/UPC Baseline)	1,724.736
Total Calculated Fixture Water Use Annual Volume, Performance Case [kgal]	1,288.95
Performance Case percent difference from LEED-EB: O&M Baseline Case$_1$ (used for determining WEc2 compliance)	**25.27 %**
Number of Building Occupants$_2$	1,000
Fixture Water Annual Use [kgal] per Building Occupant	1.28895
Building Square Footage [SF]	200,000 SF
Fixture Water Annual Use [gal] per Building Square Foot	0.00644475

Water Savings = Cost Savings

- C&W at Adobe Towers water management program saved more than $30k per year and provided a 22% return on investment
- A commercial office building in Boston replaced existing 3.5 gpf toilets with low-flow 1.6 gpf toilets
  - Reduced water use by 15%
  - Initial cost of $32,000
  - Estimated annual savings of $22,800 and 1.4 year payback
- An office building in Boston installed 30 efficient aerators
  - Reduced water use by 190.000 gallons per year
  - Initial cost $300
  - Estimated savings of $1,250 per year with a simple 2 month payback

WEc1.1 and 1.2

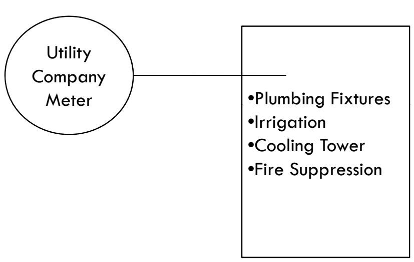
Water Performance Measurement

"YOU CANNOT MANAGE WHAT YOU CANNOT MEASURE"

WEc1.1-2 – Water Performance Measurement

- **Intent:** Measure building and subsystem water performance over time to understand consumption patterns and identify opportunities for additional water savings

Water Metering Diagram - A



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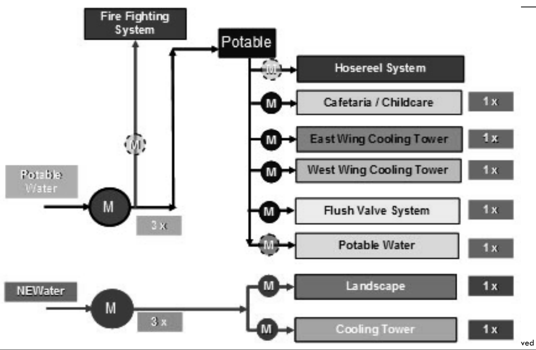
Water Meter Diagram - B



WE c1.1 - Water Performance Measurement

Requirements

WEc1.1 (1 point) Metering: install permanent water meters measuring potable water use

WEc1.2 – Water Performance Measurement

Requirements

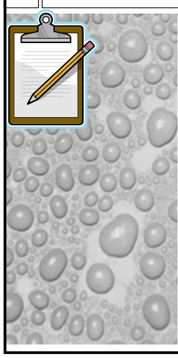
WEc1.2 (1 point) Submetering: fulfill WEc1.1 and have permanent meter for one more water system

- Irrigation
- Indoor Plumbing Fixtures
- Cooling Towers
- Domestic Hot Water
- Other Process

WEc1.1-2 – Water Performance Measurement

- Metering must be continuous
- Logged weekly
- Calculated/assessed monthly and annually
- Meters must be calibrated

WEc1.1-2 – Water Performance Measurement



- **Approach and Implementation**
  - Install permanent water meters
  - Install submeters for high-water-use applications
  - Continually compile and assess data
  - Understand the building's history
  - Keep meters well-calibrated
- **Referenced Standard**- none

WEc3

Water Efficient Landscaping

WEc3 – Water-Efficient Landscaping

Intent

- Limit or eliminate the use of potable water or other natural surface or subsurface resources on or near the project site for landscape irrigation

WEc3 – Water-Efficient Landscaping

- Requirements to be considered
  - 5% or more of Building Site Area
    - Building footprint
    - Hardscape
    - Parking footprint
  - Include
    - Planters
    - Garden areas
    - Green roofs

WEc3 – Water-Efficient Landscaping

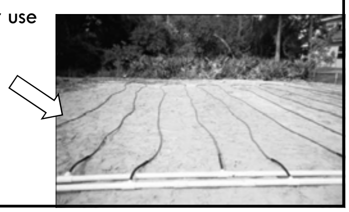
- WEc3.1 – 3.5
  - Percentage above the baseline
    - 50% = 1 point
    - 62.5% = 2 points
    - 75% = 3 points
    - 87.5% = 4 points
    - 100% = 5 points
- Exemplary Performance - Not an option

WEc3- Water Efficient Landscaping

- Strategies
  - Landscaping choices
  - Efficient irrigation policies and practices
  - Advanced and high-efficiency irrigation systems
  - Non-potable water use
  - Performance tools

WEc3- Water Efficient Landscaping

- Strategies
  - Landscaping choices
  - Efficient irrigation policies and practices
  - Advanced and high-efficiency irrigation systems
  - Non-potable water use
  - Performance tools



WEc3 – Water-Efficient Landscaping

Requirements

- Option A: Step 1-Establish baseline. Step 2-Establish metered irrigation water use. Step 3- Calculate percentage reduction
- **Option B: Step 1-Create installed case. Step 2-Create baseline case. Step 3-Calculate percentage reduction in total irrigation water use AND percentage reduction of potable water use for irrigation**
- Option C: metrics from independent tools require conversion to percentage reduction

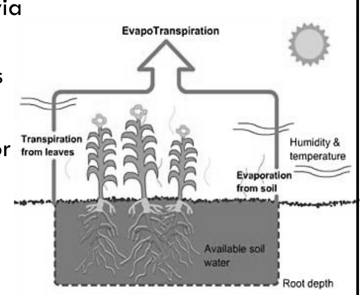
Landscape Factors

Table 1. Landscape Factors

Vegetation type	Species Factor (k_s)			Density Factor (k_d)			Microclimate Factor (k_{mc})		
	Low	Average	High	Low	Average	High	Low	Average	High
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Groundcover	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed trees, shrubs, groundcover	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turf grass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

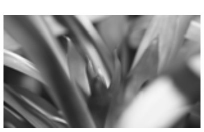
Landscape Coefficient

Volume of water lost via evapotranspiration
- Landscape species
- Planting density
- Microclimate factor



Reductions Attributed to a Combination of…

- Plant species factor


High


Medium


Low

Reductions Attributed to a Combination of….

- Plant density factor

High

Low

Reductions Attributed to a Combination of….

- Microclimate factor

High

Low

Reductions Attributed to a Combination of….

- Irrigation efficiency

High

Low

Reductions Attributed to a Combination of….

Captured rainwater

Recycled wastewater

Utility provided non-potable

Photo by Prakash Patel, courtesy of SmithGroup
Drawing courtesy of Queensland Government

Baseline Sample

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Avg 0.5	Avg 1.0	High 1.3	**0.7**	5.28	Sprinkler	10,134
Turfgrass	4,800	Avg 0.7	Avg 1.0	High 1.2	**0.8**	6.82	Sprinkler	52,384
						Net GPWA [gal]		**62,518**

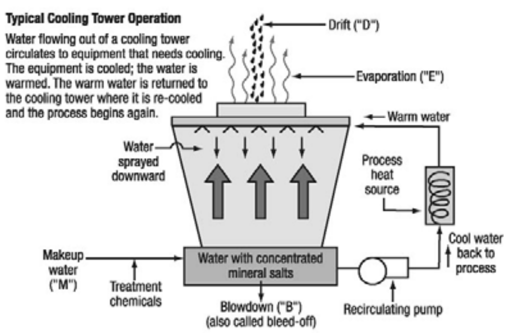
Design Sample

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Low 0.2	Avg 1.0	High 1.3	**0.3**	2.11	Drip	2,815
Mixed	3,900	Low 0.2	Avg 1.1	High 1.4	**0.3**	2.50	Drip	10,837
Turfgrass	900	Avg 0.7	Avg 1.0	High 1.2	**0.8**	6.82	Sprinkler	9,822
						Subtotal [gal]		**23,474**
			July Rainwater and Graywater Harvest [gal]					(4,200)
						Net GPWA [gal]		**19,274**

WEc4.1 and WEc4.2

Cooling Tower Water Management

WEc4.1-4.2 – Cooling Tower Water Management



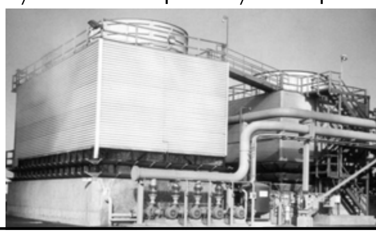
WEc4.1-4.2 – Cooling Tower Water Management

- Use 3 /per minute / per ton of refrigeration
- Average facility uses 500 tons of cooling
- 1,500 gallons of water per minute

WEc4.1-4.2 – Cooling Tower Water Management

Intent

- Reduce potable water consumption for cooling tower equipment through effective water management and/or use of non-potable/ makeup water



WEc4.1-4.2 – Cooling Tower Water Management

Requirements-

- WEc4.1- Chemical Management Plan- address chemical treatment, bleed-off, biological control, staff training; and improve water efficiency

Points-1- Exemplary Performance - NOT Eligible

WEc4.1-4.2 – Cooling Tower Water Management

Requirements-

- WEc4.2- Non potable water source use- use makeup water of at least 50% non potable water to supplement potable water; have a measurement program in place to verify makeup water

Points- 1; Exemplary Performance Eligible (95%)

WEc4.1-4.2 – Cooling Tower Water Management

- Develop a cooling tower plan
- Install conductivity meters
- Use make-up water that consists of non-potable water

Sample in Massachusetts

- Re-adjust setpoint on bleed-off controller
- Increase concentration ration from 4 to 12
- Saving 600,000 gallons per year
- Cost savings = $3,900/year

WEc4.1-4.2 – Cooling Tower Water Management

Documentation Guidance-

- **WEc4.1:** provide number of operating cooling towers; provide water management plan for all towers; provide design plan, photos, documentation for each cooling tower; provide narrative of conductivity meter, automatic controls, and set points for each cooling tower

WEc4.1-4.2 – Cooling Tower Water Management

Documentation Guidance-

- **WEc4.2:** provide narrative of all non potable/makeup water, delivery system, and volume, **AND**
  - Option 1: (streamlined) verify that 50% of makeup water in performance period came from non potable/non natural sources
  - Option 2: provide metered data for each water supply demonstrating that 50% of makeup water used during performance period was from non potable/non natural sources

Reading – June 23

Session Four	Topic	Required Reading
June 23, 2009 – Tuesday 8:00 – 11:00 AM	Materials - Purchasing Materials - Waste Management Indoor Environmental Quality	LEED EB O&M Reference Guide – Materials & Resources; LEED EB O&M Reference Guide – Indoor Environmental Quality;

Questions