10/1/02
Dale Sartor

UC Merced Science + Engineering Building
Full Design Intent Document Report

Scope and Purpose

This report was prepared using the Lawrence Berkeley National Laboratory Design Intent Tool. A variety of reports can be generated from the Tool, depending on the intended use. More information and a downloadable version of the tool itself can be found at http://ateam.lbl.gov.

The central purpose for developing design intent documentation is to clearly record operational goals expected to be met by the facility. These goals also form criteria for commissioning the facility. Documenting a facility's design intent is based on an owner-driven process.

The complete Design Intent Document is a repository and archive of design and performance objectives, strategies, and metrics for this project. Each Objective represents a qualitative goal of importance to the owner. Each has one or more Strategies, which are the means of achieving the goal. Each Objective also has one or more Metrics, which provide a quantitative measure of whether or not the Objective has been met. Assessment Records associated with the Metrics record measurement methods and actual measurements made at different points in a project's lifecycle.

If successful, design intent documentation will initiate and maintain a constructive and iterative dialog between the design team and the owner, thereby improving the quality of information flow regarding work the design team is responsible to complete, while minimizing the likelihood of misunderstandings.

Project Information

Project Name: UC Merced Science + Engineering Building
Project Address 1: University of California Merced
City: Merced State: CA Zip:
Phase Design Intent Document Was Started: Design Development
Home Page URL:
Year Project Initiated: 2001 Floor Area: 166000
Building Stories: 3 Number of Buildings: 1
Building Use Type: General
Lab Type: Teaching and Research
Code Occupancy Group: Mixed
Percent of Floor Area in Labs:

Team Contact Information

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Contact Notes: Much of the design intent information was obtained from the Mechanical Basis of Design provided by Matt on July 26, 2002. Information first entered by Dale Sartor.

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Owner's Goals

The proposed facility should be designed to use 20% less energy than a baseline building, without sacrificing the habitability or the comfort and health of the occupants. A LEED rating of Silver should be attained.

Design Team Selection

Not applicable (team selected)

Design Areas, Objectives, Strategies, &Metrics

Design Area: General

Description: This area includes whole-building information or information pertaining to multiple design areas.

Objective: Achieve high overall energy efficiency

Description: Energy efficiency is low energy consumption to accomplish a given task. High overall efficiency is low whole-building energy use (electric energy, peak electric power demand, natural gas, and any other fuels) to provide a laboratory building of a certain size.

Strategy: 20% energy savings from UC system wide benchmarks for existing labs

Comments: UCM central plant infrastructure is being planned around meeting this energy performance strategy

Description: UC has developed energy consumption benchmarks that account for building location and type (e.g. lab use)

Strategy: Achieve LEED Silver rating

Description: The Leadership in Energy and Environmental Design (LEED) system was created by the U.S. Green Building Council to comprehensively rate buildings for their environmental impact and sustainability.

Strategy: Exceed Title 24 requirement by 20%

Description: Energy code requirements can typically be easily outperformed. Such requirements make a convenient baseline against which simulated performance can be compared. Title 24 is California's State Energy Code. Buildings can comply with the Code either by the prescriptive or performance method. The prescriptive method means meeting specific requirements for different end-uses (e.g. lighting and ventilation) and construction details (e.g. level of insulation). The performance method means running a computer simulation of the building and showing that its simulated annual energy use is lower than the maximum level allowed in the Code

Strategy: Commission
Comments: What are the University guidelines referenced in the BOD?
Description: Commissioning is the process of ensuring that building elements and systems are designed, installed, programmed, and adjusted to operate as intended. Ideally, the commissioning begins early in the design process, and continues throughout the life of the building. 3rd party commissioning will be done in accordance with University guidelines and LEED requirements.

Strategy: Minimize life-cycle cost
Description: The life-cycle cost of a building is its total cost over its entire life, including design, construction, operation, maintenance, renovation, and decommissioning; future costs are discounted to present value for comparison. Minimizing life-cycle costs usually results in higher first costs and lower operating costs than are common for typical buildings.

Strategy: Utilize most likely maximum (MLM) to estimate actual loads
Comments: Karl Brown should review this description
Description: Equipment, especially in labs, is often oversized based on very high estimates of load to allow for worst-case conditions plus safety margins. The oversized equipment often performs poorly at part (actual) loads. Oversizing central plant equipment also wastes first cost. Estimating most likely maximum (vs. design peak plus safety) allows decision makers to evaluate tradeoffs between cost and risk (of undersizing) and to consider optimum sizing and efficiencies under the most likely conditions. Allowances can be made in the design to provide additional capacity should higher than anticipated (MLM) loads materialize (or to accommodate changes in the future).

Metric: Total annual kWh/sf
Description: Whole-building electric energy use per gross square foot of building. From building electric meter (plus allowance for central plant cooling).
Target: 33 KWh/sf

Metric: Annual source BTU/sf (combined gas and electric)
Description: Whole-building total energy use per gross square foot of building. Source BTU/sf is calculated using 10,280 BTU/kWh of electricity, a multiplier of 1.024 for natural gas, and 1.38 for steam to account for generation, transmission and distribution losses.
Target: ??? BTU/sf

Metric: Annual peak W/sf
Description: Highest annual whole-building peak power in Watts per gross square foot of building. From building electric meter plus allowance for central plant cooling (pumps only, given thermal storage)

Target: 5.3 W/sf

Metric: Annual $/sf energy cost
Description: Whole-building energy cost for electricity and all fuels for the year, per gross square foot of building.
Target: ??? $/sf

Metric: Energy Effectiveness: 100 x idealized BTU/actual BTU (source)
Description: Actual source BTU/sf (determined as above) normalized to an ideal case and expressed as a percent (scale is 0 to 100).
Target: ??? unitless

Metric: Annual peak Heating BTU/hr/sf
Description: Whole building space and water heating peak BTUs per hour per gross square foot (steam generators plus allocation from central plant)
Target: 34 BTU/hr/sf

Metric: Total annual heat Th/sf
Description: Whole-building heat (gas) energy use (therms) per gross square foot of building. Gas steam generators plus allocation from central plant.
Target: 1.5 th/sf

Metric: Annual peak cooling tons/Ksf
Description: Maximum cooling load draw on central plant in tons per gross square foot
Target: 2.9 tons/Ksf

Design Area: Architectural: Loads

Description: The Architectural Loads area includes elements of the building and its surroundings (envelope, furnishings, landscaping, etc.) that create or affect the loads put on the building's mechanical and electrical systems.

Objective: Minimize Ventilation Loads
Description: Apply architectural solutions to minimize the amount of ventilation air while meeting all fresh air, exhaust, heating, and cooling requirements.

Strategy: Install minimum number and size of fume hoods
Description: Fume hood airflow requirements often dominate the ventilation load. Review research requirements to minimize the need for fume hoods.

Strategy: Allow duct sizing and duct fittings to easily add and remove hoods
Comments: Confirm this will be done
Description: Sizing ducts for some increase in the number of hoods further reduces the pressure drop in the interim and ensures that adequate future capacity will be available without creating noise and pressure drop problems. Providing duct fittings with blank-offs make future connections easy.

Strategy: Use the smallest hood practical
Description: Hoods should only be used for activities that require them. Review research requirements to minimize the size of hoods. Smaller hoods have lower first and operating costs and take up less space.

Strategy: Use glove boxes
Comments: Were glove boxes considered?
Description: Glove boxes, since they have no open sash, have significantly lower airflow requirements than fume hoods.

Strategy: Use high-performance hoods (Berkeley hood, etc.)
Comments: 100 fpm w/ 20" sash opening was specified. Design assumes 90% diversity in teaching labs and 80% diversity in research labs (seems high and should be refined as UCM gets experience). The high performance "Berkeley" hood will be evaluated for commercial readiness as the design progresses.
Description: High-performance hoods use less exhaust air than standard hoods yet provide equal or better containment.

Strategy: Minimize cooling air requirements (use water cooling, e.g.)
Comments: Cold rooms and other large refrigerators will be water-cooled using tower cooling (water side economizer).
Description: It is usually more efficient to cool process loads with a cooling water system than by rejecting the heat to the air in the lab room. Another option is rejecting the heat directly into the exhaust so it does not appear as a cooling load in the space.

Strategy: Provide mechanical space for efficient air distribution
Description: Efficient air distribution requires the system to be designed with low-pressure drops. To reduce pressure drops in air-handling units and ductwork, larger cross-sections and straight-as-possible duct runs are called for, so adequate space allocation and careful coordination is needed.

Strategy: Natural ventilation in offices
Description: Operable windows will be available for natural ventilation in offices. Switches will close off the mechanical ventilation when windows are open. Operable windows should not be utilized in labs with fume hoods.

Metric: Peak lab-only exhaust cfm/NSF
Description: This is the lab exhaust airflow under peak conditions, expressed in cfm per net square foot of lab area. (target provided by Dale Sartor)
Target: 1 cfm/Nsf

Objective: Minimize Heating and Cooling Loads
Description: Architectural elements, area layouts, building programming, and construction details all impact the need for heating and cooling.

Strategy: Reduce airflows
Comments: see "Minimize Ventilation Loads" Objective
Description: The amount of air flowing through the building drives heating and cooling energy use, since the air must be tempered from outside conditions.

Strategy: Insulation
Description: Thermal insulation in the floor, walls, and ceiling or roof reduces conductive heat transfer. Minimum R-values shall be 30 for roof, and 13 for walls and floors. A 20% or more reduction in heat transfer from Title 24 requirements is expected.

Strategy: Fenestration
Description: Fenestration (windows, skylight, light-transmitting areas of doors, etc.) can dominate the envelope load. High performance glazings and assemblies can minimize undesirable heat gains and losses while providing natural light and ventilation. Glass shall be Solarban 60(2) or better with the following specifications: 69% visible light transmission, .29 U value, .37 relative heat gain (SHGC), and a maximum 33% of the wall area.

Strategy: 3. Infiltration and internal air sealing
Comments: Is this being addressed?
Description: A tight shell and tight internal partitions (walls, doors, and floors) allow desired pressure differentials to be achieved with less differential airflow.

Strategy: 4. Vapor barrier
Comments: Is this being addressed
Description: Good vapor barriers are needed to keep insulation dry and to minimize vapor migration to and from humidity controlled spaces.

Strategy: 5. Solar reflectivity
Comments: Is this being addressed?
Description: Increasing the solar reflectivity of the exterior surfaces of the building (or "albedo") reduces the cooling load.

Strategy: Reduce heat island effect on the site
Comments: Is this being addressed?
Description: Reducing the localized heating due to unshaded surfaces that absorb sunlight can take the form of shading, the use of reflective materials, reducing above-ground parking, or an open-grid (less than 50% impervious to water) pavement system.

Strategy: Wide temperature and humidity deadband
Description: HVAC loads can be reduced by increasing the deadbands for temperature and humidity (allowable range). For most areas of the building the

allowable temperature range is 68 to 77 degrees F with no humidity control.

Strategy: Good orientation and window shading
Comments: Was orientation considered in the design (including fenestration details)?
Description: Unwanted heat gain can be reduced by good orientation and shading of windows. Exterior shading will be utilized.

Metric: Peak tons/sf
Description: Peak tons per gross square foot
Target: 2.9 tons/sf

Objective: Minimize Lighting Load
Description: Access to natural light and effective use of natural and artificial light can greatly reduce lighting load and energy use.

Strategy: Daylighting (skylights, light shelves, etc.)
Description: Fenestration and associated reflective surfaces designed to bring in natural light reduces the amount of artificial light required. High-performance glazing has a high visible transmission while minimizing unwanted heat transfer.

Strategy: Surface reflectivity (paint)
Comments: confirm this strategy being used.
Description: Highly reflective architectural coatings make most effective use of the available light, natural or artificial.

Design Area: Mechanical: Ventilation System
Description: The mechanical ventilation system consists of air-handling units (fans, filters, heating and/or cooling coils, etc.), supply ductwork, terminal devices for controlling temperature and/or pressure in the zones, exhaust and return-air ductwork, exhaust fans and exhaust stacks.

Objective: Maximize average efficiency
Comments: See Objectives "Maximize Full-Load Efficiency" and "Maximize Part-Load Efficiency". Need to calculate metric. This objective (and metric) will relate to Most Likely Maximum (MLM) and average diversity assumptions.
Description: A high average ventilation efficiency (i.e. a low ventilation energy per square foot of building) is achieved by maximizing both the full and part-load ventilation efficiencies.

Metric: Total annual ventilation kWh/sf
Description: The sum of the electrical energy (kWh) used for all ventilation systems (supply, exhaust, return, lavatory, etc.) divided by the gross building area (gsf).
Target: ??? Kwh/sf

Objective: Maximize full-load efficiency

Description: Maximizing full-load efficiency involves minimizing the power requirements imposed by the system components and maximizing the efficiency of the equipment providing the ventilation. Ventilation efficiency should be at least 20% better than Title 24.

Strategy: Efficient Fans

Comments: How efficient are the plug fans specified?

Description: Efficient fans (typically airfoil or vane axial) convert more of the input shaft power to flow and pressure in the air stream. In addition to the fan itself, the inlet and discharge conditions are critical to good fan performance.

Strategy: Efficient Motors

Comments: Note that loads on equipment and equipment efficiency should be addressed prior to motor selection.

Description: Although motors are relatively efficient converters of electrical to mechanical energy, choosing the most-efficient motor for the application is typically very cost-effective. DOE maintains the "MotorMaster" database of motor efficiency, which is valuable for making motor selections. Premium efficiency motors will be utilized.

Strategy: Efficient Mechanical Drives

Comments: Confirm direct drive use.

Description: Mechanical drives include belts, couplings, shafts, and gearboxes. Cogged or synchronous belts are more efficient than standard V-belts. With variable-speed inverters, many applications can be driven directly, eliminating belt energy losses and maintenance altogether.

Strategy: Low pressure-drop system

Comments: Size for flexibility of future load.

Description: The power required to move air through a system is proportional to the product of the airflow and the pressure drop. Once the airflow requirements are minimized (see sections on load reduction), there are major opportunities to improve efficiency by reducing pressure drops throughout the ventilation system. A low velocity, low pressure-drop system will be designed.

Strategy: Low pressure-drop filters

Description: Filter pressure drop can be reduced through reduced face velocity and careful selection of the number of filters and their filtration efficiency. The maximum face velocity will be 400 fpm.

Strategy: Low pressure-drop coils and heat-recovery devices

Comments: Confirm bypass damper still in.

Description: Coil face area will be increased to allow a maximum 400 fpm face velocity. In addition to increasing coil face area, low-pressure drops may be achieved by using fewer rows and wider fin spacing, as well as bypasses around coils not in use. A bypass damper will be used on the pre-cool coil . Separate fan coils or radiators (including radiant panels) can be used in the zones to eliminate coils from the ventilation air stream.

Strategy: Low pressure-drop ducts
Description: Low duct pressure drops can be achieved by increased duct area, straighter and shorter duct runs, and low-loss fittings. See also "Manifolded exhaust system" strategy under "Maximize part-load efficiency". Maximum pressure drops of .1"/100' for low cfm ducts and 1750 fpm for high cfm is specified.

Strategy: Low pressure-drop pressure or volume control devices
Comments: This is a concern.
Description: Throttling devices (dampers or air valves) to regulate the supply and exhaust from lab rooms should be selected to minimize pressure drop while still providing effective control.

Strategy: Increase exhaust stack height
Description: Minimize required exhaust stack velocity by increasing stack height for equivalent dispersion. Stack heights are well above minimum.

Strategy: Reduce duct leakage
Description: Construct ducts to minimize leakage to maximum 1%.

Metric: Peak total (all fans) W/cfm
Description: The sum of the electrical power (W) used for all ventilation fans at design conditions divided by their total design air flow (cfm).
Target: ??? W/cfm

Objective: Maximize part-load efficiency
Description: Optimizing part-load efficiency (when system is running below design conditions, which is nearly always) involves loads and equipment that can vary flows and do so efficiently.

Strategy: Variable-volume fume hoods
Description: Variable-volume hoods intentionally vary the exhaust airflow to maintain constant face velocity at any sash position. Lowered sashes thus result in reduced airflows.

Strategy: Demand- controlled ventilation

Description: Using carbon dioxide (CO_2) sensors as a proxy for air quality allows the airflow to be reduced when occupancy is below design levels. This strategy is appropriate in offices and conference rooms, but not in labs with 100% outside air.

Strategy: Occupied/unoccupied ventilation control
Description: When rooms including labs are unoccupied, ventilation rates can be reduced. The ratio of occupied to unoccupied air change rates are as follows: 6/4 for labs, 15/4 for animal holding, 10/4 for animal procedures, 4/0 for cage washing, and 4/0 for offices. Occupancy sensors and manual switches will be utilized.

Strategy: Variable-volume temperature control
Comments: Increasing air supply to satisfy internal cooling loads is particularly problematic with 100% outside air, as the outside air also must be cooled (significantly increasing the peak cooling load).
Description: Variable-volume temperature control reduces airflow when the cooling load is below design and saves ventilation energy compared to a constant-volume design. Controls should be set up to reset the supply fan speed to just satisfy the most-demanding zone. Trade-offs between air supply temperature and air volume need to be considered. High cooling load zones should be required to add fan coil units to reduce the required air volume. Provisions to add fan coils (e.g. valved tees, etc.) should be made.

Strategy: Variable-speed fans with VFDs
Comments: See "Efficient Fans" strategy for fan information.
Description: With variable-volume systems, the most efficient way to vary fan capacity is by varying the fan speed, rather than using variable inlet vanes or discharge dampers. Variable frequency drives will be used on all major fans.

Strategy: Manifolded exhaust system
Description: Manifolded exhaust systems combine the exhaust from multiple hoods or lab areas into a common exhaust system with fewer exhaust fans. This scheme takes advantage of diversity, reducing the average duct pressure drop.

Strategy: Multi-stack exhaust system
Comments: Two fans used, more would be better
Description: On VAV exhaust, multi-stack exhaust systems use two or more staged exhaust fans to maintain required discharge stack velocities without the need to introduce large amounts of bypass air.

Strategy: Ventilated animal holding racks

Description: By individually supplying and exhausting animal holding racks, and controlling air flow based on load (animals present) average air flow requirements will be reduced.

Metric: Average total cfm/peak cfm
Description: The average flows of the total of all the fans (supply, exhaust, and return) divided by the total design flow of all the fans.
Target: ??? fraction

Design Area: Mechanical: Chiller Plant
Description: The chiller plant consists of all of the components that supply chilled water to the building, including chiller(s), chilled water and condensing water pump(s), cooling tower or evaporative condenser, and piping, controls, and accessories.

Objective: Maximize cooling efficiency
Comments: Chilled water is provided by a central plant. The design intent of the central plant is not addressed in this document.
Description: Maximizing cooling efficiency means getting the most net cooling for the input energy and power. Central Plant efficiency is not addressed in this design intent document.

Metric: Total annual cooling kWh/sf
Description: Total electrical energy specifically for cooling (chiller plant, any evaporative cooling, run-around coil pumps in cooling mode, etc.) divided by the gsf of the building. Include allocation from central plant.
Target: ??? kWh/sf

Objective: Meet Peak Load Efficiently
Description: Efficiently meeting peak load means designing a cooling system (chiller plant, evaporative cooling, heat recovery, etc.) with low plant kW/ton at design conditions.

Strategy: Evaporative cooling
Description: Evaporative cooling is that supplied by evaporating water. The most common types are indirect, direct, and combined. In indirect evaporative cooling, air is cooled by water evaporated on the other side of a heat exchanger (or e.g. tower water is used in a cooling coil). In direct evaporative cooling, water is evaporated directly into the air, cooling and humidifying it at the same time. UCM will utilize an indirect tower cooled pre-cool coil to temper the outside air supply.

Strategy: Thermal energy storage
Description: Thermal energy storage makes use of chilled water cooled during off-peak times to provide cooling during on-peak periods. This reduces the peak load to only pump power (and the precool tower).

Strategy: Efficient cooling tower
Description: An efficient cooling tower uses the minimum amount of fan and pump energy required to achieve the design tower water supply temperature. This means draw-through airflow, relatively large fill and low height.

Strategy: Efficient piping, pumps, and motors
Description: Efficiently moving water through the chiller plant means minimizing the power required per gpm of water flow, both on the demand side (piping) and the supply side (pumps and motors).

Strategy: Efficient piping
Description: Efficient piping reduces pressure drops by increasing pipe diameter, making the shortest, straightest runs possible, and eliminating unnecessary components (e.g. balancing valves at coils with 2-way control valves). Lay out the piping first and let that dictate the equipment locations rather than the reverse. Piping will be designed for a maximum 4'/100' pressure drop.

Strategy: Efficient pumps and motors
Description: Efficient pumps meet the design operating point (flow and pressure or "head") at low shaft power (bhp) requirements. Carefully selecting between size, speed and manufacturer options can pay dividends. Also look for pumps with a relatively large efficiency "bulls-eye". Premium efficiency motors will be utilized, and pumps will be controlled by variable frequency drives to optimize system efficiency.

Strategy: Multi-temperature cooling plant
Description: For buildings that have chilled water requirements at different temperatures, generating the minimum amount of colder water with one or more separate chillers will increase overall plant efficiency. This project will utilize water solely cooled by a closed circuit cooling tower for much of the space cooling loads as well as process cooling (e.g. compressor cooling of cold rooms).

Metric: Peak cooling W/sf
Description: Electrical power (W) for the entire cooling system at design conditions divided by the building gsf.
Target: ??? W/sf

Metric: Peak cooling kW/ton
Description: Electrical power for the entire cooling system divided by the number peak cooling tons delivered to the building
Target: ??? kW/ton

Metric: Peak cooling tons/Ksf

Description: Peak-cooling tons delivered to the building divided by the gross square feet (in thousands)
Target: 2.9 tons/Ksf

Objective: Meet Partial Load Efficiently
Description: Efficient part-load operation requires that the system reduces cooling demand efficiently and that the plant meets the reduced demand efficiently.

Strategy: Water-side economizer
Description: A closed circuit cooling tower will provide evaporatively cooled water to a pre-cool coil and process loads.

Strategy: Variable-speed fans for cooling tower
Comments: confirm VFD control on tower.
Description: As cooling load or outdoor wet bulb temperature decreases, the cooling tower fans can slow down while still meeting the tower water supply temperature requirements. Fan speed control, with all fans controlled together, is more efficient than two-speed control or fan staging.

Strategy: Variable-flow water pumping with variable-speed pumps
Description: Using a variable-flow chilled water system with two-way valves and variable flow through the chiller (with local bypass if needed) is a much more efficient distribution scheme than a constant-flow chilled water system with three-way control valves. The pump speed will be controlled by a VFD to just satisfy the most-demanding zone.

Strategy: Air side economizer
Description: "Free cooling" using an airside economizer will be used in zones with air recirculation (offices and administrative areas).

Strategy: Control optimization
Comments: More details on the control sequences are needed
Description: Controls will be utilized to minimize cooling loads (e.g. reset temperatures in unoccupied zones)

Metric: Average kW/ton
Description: Total annual kWh required to provide cooling divided by the total cooling provided in ton-hours. This is primarily a central plant issue.
Target: ??? kW/ton

Objective: Minimize Simultaneous heating & cooling
Description: The loads here are those created by the system fighting itself (i.e. simultaneous heating and cooling). See objective "Minimize Heating and Cooling Loads" for other load reduction strategies.

Strategy: Minimize simultaneous heating and cooling

Comments: See objective "Minimize Heating and Cooling Loads" for other load reduction strategies.
Description: Simultaneous heating and cooling typically occurs when there is a central cooling coil in the air-handler and reheat coils at the zones. Since lab buildings use large amounts of outside air, reducing this situation is key to reducing cooling loads.

Strategy: System configuration (terminal cooling, e.g.)
Description: The most effective way to minimize simultaneous heating and cooling is to eliminate it by using cooling coils at the zones. The air-handler has a preheat coil only or (in hot climates) may have a cooling coil for tempering. Heating and cooling coils will be used in all laboratory zones to eliminate the need for re-heat.

Strategy: Controls
Description: Controls can greatly decrease simultaneous heating and cooling by (e.g.) resetting the supply air temperature from the air-handler up until the most-demanding (cooling) zone is just satisfied. Controls will optimize the use of tower pre-cooling at the air handler with cooling and heating coils in the zones. Controls will also optimize the tradeoffs between increasing airflow and decreasing air temperature where VAV is used for temperature control.

Strategy: High load zones
Description: Provisions will be made to add cooling capacity (fan coil units) to high load zones (initially and in the future as conditions change). This will reduce the need to supply excessive air quantities, or overcool the supply air using the pre-cool coil (resulting in the need to re-heat in other less demanding zones).

Design Area: Mechanical: Heating Plant
Description: The heating plant consists of all of the components that supply hot water to the building, including boiler(s), hot water pump(s), and piping, controls, and accessories.

Objective: Maximize Heating Efficiency
Comments: See Heating Plant Objectives "Minimize Heating Load", "Meet Peak Load Efficiently", and "Meet Part-load Efficiently".
Description: Efficiency of the central plant will not be addressed in this document, however, an overall objective minimizing heating energy has been established.

Metric: Annual heating BTU/sf
Description: BTU per year of site energy consumed for heating, divided by the building gsf. Steam generator plus allocation from central plant.
Target: 150,000 BTU/sf

Metric: Peak heating BTU/hr/sf
Description: peak BTU (input to the heating plant) per hour per gross square foot (allocation from central plant).
Target: 34 btu/hr/sf

Objective: Minimize Heating Load
Comments: see "Architectural/Minimize Heating and Cooling Loads" and "Mechanical: Chiller Plant, Minimize simultaneous heating and cooling" for other load-reduction strategies
Description: Reduce the need for heat for the building spaces, as well as domestic and industrial hot water

Strategy: Minimize outside air requirement
Description: See ventilation strategies

Strategy: Minimize simultaneous heating and cooling
Description: See ventilation strategies

Strategy: Optimize controls
Description: Reduce zone temperature set points and airflow when unoccupied. Reset supply air temperature to minimize unnecessary heating of unoccupied zones, or zones requiring cooling.

Strategy: Minimize domestic and industrial hot water use (fixtures, etc.)
Description: The use of low water use fixtures and automatic fixture controls will reduce hot water consumption.

Objective: Meet Peak Load Efficiently
Description: Use the least amount of energy per hour to meet the design heating load.

Strategy: Return heating water at low temperature
Description: Low return hot water temperature can increase boiler efficiency (and save pump energy). System will be designed for 210 degree F supply and 120 degree F return.

Strategy: High efficiency hot water distribution
Description: Utilize high efficiency pumps, and premium efficiency motors. Size pipes for low pressure drop - maximum 4'/100.'

Strategy: Humidify with gas heat, not electric
Description: In areas that require humidity control, humidifiers that are gas-fired greatly reduce electric peak and energy consumption relative to electric steam generators. Gas humidification will be used for the animal areas. Humidification will not be provided in other areas.

Objective: Meet Partial Load Efficiently

Comments: See also "Variable-flow water pumping with variable-speed pumps" under chiller plant/meet partial load efficiently
Description: Efficient part-load operation requires that the system reduces heating demand efficiently and that the plant meets the reduced demand efficiently.

Strategy: Variable flow hot water
Description: Utilize two-way control valves. Vary flow using VFDs on pump.

Design Area: Electrical: Lighting System
Description: The lighting system consists of natural and artificial light sources and distribution as well as automatic and manual controls.

Objective: Maximize Lighting Efficiency
Comments: See also strategies under "Architectural/Minimize Lighting Load" objective.
Description: Provide adequate lighting for all activities while using the minimum electricity. Reducing the need for artificial lighting and efficiently meeting peak and off-peak lighting needs are all included.

Metric: Annual Lighting kWh/sf
Description: Total electrical energy used for indoor and outdoor lighting, divided by the building gsf.
Target: ??? kWh/sf

Objective: Minimize Need for Artificial Lighting
Description: Reduce the need to illuminate areas with artificial light sources. See "Minimize Lighting Load" objective and strategies under "Architectural"

Strategy: Task Lighting
Description: ???

Objective: Meet Peak Lighting Needs Efficiently
Description: Provide design-condition lighting with the minimum electrical input power.

Strategy: Efficient sources
Description: Efficient source of artificial light generate and deliver light with a minimum of input power. T-5 and other efficient lighting sources will be utilized.

Strategy: Electronic ballasts
Description: Electronic ballasts, which themselves have low losses, drive fluorescent lamps at high frequency, increasing their efficiency.

Strategy: Efficient luminaires
Description: Efficient luminaires have highly reflective surfaces, good optics, and appropriate lenses to effectively deliver the light generated by the lamps to where it can be effectively used.

Strategy: Controls
Comments: See dimmable ballasts and daylight harvesting
Description: Controls for utilizing natural light automatically dim or switch off artificial light sources when there is adequate daylight available. Outdoor lighting controls should be combined with motion sensors or time switches.

Metric: Peak lighting W/sf
Description: Total design-hour load (W) for lighting, divided by the building gsf.
Target: 1.1 W/sf

Objective: Meet Off-Peak Lighting Needs Efficiently
Description: Provide a lighting system that can efficiently meet lighting needs when demand is less than design light levels.

Strategy: Automatic controls
Description: Automatically switch off lighting in areas that are unoccupied.

Strategy: Manual controls (multiple switching)
Comments: confirm
Description: Provide manual switching to allow bi-level or tri-level control, manual daylight harvesting (perimeter fixtures switch separately, and local area control to give occupants the maximum flexibility to tailor lighting levels to their needs.

Strategy: Dimming controls
Comments: confirm
Description: Provide manual dimming controls to allow occupants to adjust their light levels to suit the individual and task.

Design Area: Electrical: Distribution System
Description: The electrical distribution system includes high voltage switchgear, transformers, metering, motor control centers, wiring, and power conditioning

Objective: Minimize Losses

Strategy: Efficient transformers
Comments: confirm

Strategy: Highest practical voltage (277 V lights, etc.)
Comments: confirm

Strategy: Upsize wiring
Comments: confirm

Strategy: Metering
Comments: need details

Design Area: Process: Process/Plug Loads
Description: Laboratory process equipment and plug loads are a major energy consumer and contributor to infrastructure sizing

Objective: Meet process loads efficiently
Description: Utilize efficient lab and office equipment and control for minimum use.

Metric: Annual Process kWh/sf
Description: Total annual process and plug load (kWh) divided by the gross square feet
Target: ??? kWh/sf

Objective: Meet peak loads efficiently

Strategy: Energy Star equipment
Comments: Is/will any energy star equipment be specified in the design?
Description: Utilize Energy Star labeled equipment

Strategy: Efficient process equipment
Comments: Was any consideration to energy efficiency given to the selection of process equipment?
Description: Utilize energy efficient process equipment

Strategy: Water-cooled
Description: Refrigeration equipment (e.g. freezers) often dump heat into the room, increasing the cooling load. Ideally this equipment should transfer heat to a closed water cooling system. Use of tap water for cooling should not be done. Tower water and (in extreme cases) chilled water will be available to cool equipment including cold rooms and large refrigeration units.

Strategy: Reject heat at highest possible temperature
Comments: Reject to tower water or the equivalent. Specify equipment with large heat exchangers to avoid unnecessarily low cooling water temperatures.
Description: Select equipment that can be cooled with tower water - not requiring low temperature cooling.

Strategy: Reject air-cooled heat directly to exhaust
Comments: confirm.
Description: Ideally "cascade" airflow so that it can be used first for ventilation and personnel comfort and then passed over or through high heat producing equipment. Heat producing equipment should be placed near the exhaust rather than the supply.

Strategy: Use outdoor condenser
Comments: confirm use?
Description: Where "split" systems are available, use refrigeration equipment with outdoor condensers to avoid heat rejection in the space.

Metric: Process Peak W/sf
Description: Most likely maximum (MLM) total watts for process and plug load divided by the gross square feet
Target: ??? W/sf

Objective: Meet part loads efficiently
Description: Select equipment that can be turned off or put into a sleep mode when not in use.

Strategy: Enable power-management features
Comments: confirm
Description: Many products (e.g. computers and copy machines) come with power management features that put the equipment to sleep after a set period of inactivity. In some cases these products are shipped from the manufacturer with the power management features turned off. Power management features will be enabled.

Strategy: Workstation occupancy sensors
Comments: is anything like this being deployed? How will the need and opportunities to minimize equipment energy use be transmitted to the occupants?
Description: Workstation controls can include occupancy sensors to turn off monitors, lights, fans, and other appliances left on after the user leaves.

Strategy: Automatic process controls
Comments: confirm
Description: Select equipment that automatically reduces power consumption and utility use (e.g. cooling water) when not in use, or when not operating at peak capacity.

Strategy: Manual process controls
Comments: confirm
Description: Select equipment that can be turned on and off or otherwise controlled to reduce energy consumption when not in use. Avoid equipment that has long startup procedures such as calibration that would prevent good control.

Strategy: Size systems properly accounting for real loads and load diversity
Description: Utilize actual steady state equipment power draw rather than nameplate data when estimating thermal loads from equipment. Utilize realistic estimates of diversity, ideally based on measured data of similar buildings/equipment leading to an estimate of the most likely maximum

conditions. Design system to minimize peak energy consumption at these conditions. Also design system for optimum performance at the much lower average conditions. Additional loads to account for growth, changes, and safety factors, will be carefully considered. Capacity in the distribution systems, e.g. wires, pipes, and ducts will be amply sized. These are the most difficult to change later. Provisions to add capacity such as fan coil units in lab spaces will be utilized.

Design Area: Operations and Maintenance

Description: Although operations and maintenance is rarely part of the design, it is important for the design team to document its intent relative to O&M

Objective: Ensure proper operation

Description: Proper O&M has a profound effect on the performance of a laboratory building. The designer and owner must match the O&M Resources to the O&M needs, and provide tools to ensure optimum operation.

Strategy: Test, adjust, and balance

Comments: see questions asked

Description: Describe what testing, adjusting, and balancing may be expected in the operation and maintenance of the lab to optimize performance. What tools are the designers specifying to facilitate O&M?

Strategy: Measure and verify performance

Comments: The International Performance Measurement and Verification Protocol specifies how to perform and record measurements of loads, equipment efficiencies, and other performance parameters.

Description: The building will have a powerful monitoring system that will assist the user in measuring and verifying performance.

Strategy: EMCS Coordinator

Comments: see question asked.

Description: Many sophisticated energy monitoring and control systems (EMCS) are installed and underutilized or even bypassed because of the lack of operator training, time, or motivation. The qualifications of the operator and level of effort expected to meet the design intent should be described.

Objective: Control peak loads

Description: The peak load will be controlled through the capabilities of the design combined with the capabilities and motivation of the operator.

Strategy: Load management controls

Comments: see question asked

Description: Passive control systems such as optimum control of the TES, occupancy sensors, and daylight controls will yield reductions in peak demand. What additional controls will the operator have to manage the load during peaks? This will most likely relate to the EMCS design.

Design Area: Energy Monitoring and Controls
Description: An energy monitoring and control system (EMCS) monitors performance and provides HVAC and lighting controls. Controls can be integrated or stand-alone.

Objective: Monitoring of building and system performance
Description: Extensive monitoring will facilitate performance tracking, diagnostics, and optimization

Strategy: Metric tracking
Comments: confirm
Description: The monitoring system will be capable of tracking and benchmarking the metrics identified in this design intent document

Strategy: Web Benchmarking
Description: The metric tracking will be linked to a web based benchmarking tool (report) that will allow students, faculty, and practitioners to view key performance indicators over time.

Strategy: User feedback
Comments: confirm
Description: The relative energy consumption (or proxy) of various labs and the building as a whole will be reported to the occupants via the web. Specific attention will be paid to fume hood exhaust air and the energy and safety benefits of lowering the sash.

Objective: Optimize building/system controls
Description: The building will be controlled by a distributed DDC building management system (BMS) that will have powerful control and graphic capabilities

Strategy: VAV Fume hood control
Description: Fume hoods will be controlled to a constant face velocity. As the sash is closed the exhaust volume will reduce.

Strategy: Occupancy sensor control of lighting and HVAC
Description: Occupancy sensors will be utilize to automatically turn off lighting, increase the temperature deadband, and reduce airflow when the room/zone has been unoccupied for a set period of time.

Strategy: Window switches
Description: Switches on operable windows in offices will turn off ventilation and temperature control when the window is opened.

Strategy: pre-cool optimization

Comments: see questions

Description: The tower fan and pump will be controlled to optimally provide set point (of what?). Tradeoffs between pre-cooling, re-heating, and chilled water cooling (in the zone) will be optimized (how?).

Strategy: Other

Description: Other control strategies should be described

Summary of Performance Metrics

		Target		
Design Area:	General			
Metric:	Total annual kWh/sf	33 KWh/sf		
Metric:	Annual source BTU/sf (combined gas and electric)	??? BTU/sf		
Metric:	Annual peak W/sf	5.3 W/sf		
Metric:	Annual $/sf energy cost	??? $/sf		
Metric:	Energy Effectiveness: 100 x idealized BTU/actual BTU (source)	??? Unitless		
Metric:	Annual peak Heating BTU/hr/sf	34 BTU/hr/sf		
Metric:	Total annual heat Th/sf	1.5 th/sf		
Metric:	Annual peak cooling tons/Ksf	2.9 tons/Ksf		
Design Area:	Architectural: Loads			
Metric:	Peak lab-only exhaust cfm/NSF	1 cfm/Nsf		
Metric:	Peak tons/sf	2.9 tons/sf		
Design Area:	Mechanical: Ventilation System			
Metric:	Total annual ventilation kWh/sf	??? Kwh/sf		
Metric:	Peak total (all fans) W/cfm	??? W/cfm		

Metric:	Average total cfm/peak cfm	??? Fraction		
Design Area:	Mechanical: Chiller Plant			
Metric:	Total annual cooling kWh/sf	??? kWh/sf		
Metric:	Peak cooling W/sf	??? W/sf		
Metric:	Peak cooling kW/ton	??? kW/ton		
Metric:	Average kW/ton	??? kW/ton		
Metric:	Peak cooling tons/Ksf	2.9 tons/Ksf		
Design Area:	Mechanical: Heating Plant			
Metric:	Annual heating BTU/sf	150,000 BTU/sf		
Metric:	Peak heating BTU/hr/sf	34 btu/hr/sf		
Design Area:	Electrical: Lighting System			
Metric:	Annual Lighting kWh/sf	??? kWh/sf		
Metric:	Peak lighting W/sf	1.1 W/sf		
Design Area:	Electrical: Distribution System			
Design Area:	Process: Process/Plug Loads			
Metric:	Annual Process kWh/sf	??? kWh/sf		
Metric:	Process Peak W/sf	??? W/sf		
Design Area:	Operations and Maintenance			
Design Area:	Energy Monitoring and Controls			