NREL SITE OPERATIONS

SMART LABS DESIGN GUIDELINES

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1. Smart Labs - General

a. NREL is committed to the design, construction and management of Smart Laboratories that enhance safety as well as efficiently use resources such as energy and water.

b. These design guidelines shall be used in addition to NREL general design and safety documents listed below.
   - i. Ergonomic Management: Workstations, Materials Handling, and Back Safety PROC 600-4
   - ii. Local Exhaust Ventilation PROC 600-23
   - iii. Section 262713 of NREL's Electricity Metering
   - iv. NREL Mechanical Design Standards

2. Optimized Ventilation

a. VENTILATION REQUIREMENTS

i. NREL is committed to providing ventilation in laboratories that meets the highest standards of both safety and energy efficiency. All NREL laboratories shall use ANSI/ASSE/AIHA Z9.5-2012 and the ASHRAE Classification of Laboratory Ventilation Design Levels for optimized ventilation design.

ii. Designers shall use the following steps to determine the appropriate requirements for laboratory ventilation in collaboration with NREL safety and engineering professionals:
   1) Review user programming, occupancy classification and essential building functions and systems.
      a) Use environmental and safety requirements from the request for proposal (RFP) to determine unique ventilation needs in those spaces.
      b) Given the energy penalty associated with ventilation, equipment with larger-than-normal ventilation requirements should be isolated in smaller spaces whenever possible within laboratory design requirements. This avoids the energy consumption required to apply high ventilation rates to large spaces.
      c) Laboratory spaces should be built with as much flexibility as possible.
   2) Determine ventilation impact on safety performance, life-cycle costs of HVAC equipment and ongoing energy use requirements.
   3) Design for high ventilation effectiveness for laboratory spaces using industry best practices for diffuser type and location and exhaust location. Use computational fluid dynamics (CFD) to optimize ventilation system design and verify operations.

iii. Ventilation system controls shall conform with the general Sensors and Controls requirements specified in "4. Sensors and Controls" below.

iv. Control refinements for ventilation shall include:
   1) Ensure the capability to ventilate in occupied and unoccupied modes.
   2) Emergency override located near lab entrances or other high hazardous ventilation areas.

b. HVAC EQUIPMENT

i. Ventilation systems for laboratories spaces shall use variable air volume (VAV) equipment including, but not limited to:
   1) VAV exhaust fans

2) VAV supply air equipment
3) VAV fume hoods

ii. HVAC base equipment.
   1) The base design shall include the following equipment:
      a) VAV control: laboratory room control including Accutrol Accuvalve for supply and exhaust air control valves within labs.
      b) Energy recovery: Konvekta laboratory air energy recovery system including indirect evaporative cooling on the exhaust.
   2) Systems that improve upon this base equipment design can be considered.

iii. HVAC heating systems shall operate at full capacity with 95 °F source hot water and shall be compatible with source temperatures up to 180 °F.

iv. HVAC cooling systems shall operate at full capacity with 65 °F source chilled/cooling water and shall be compatible with source temperatures down to 47 °F.

v. Basic HVAC systems requirements shall be designed to use:
   1) Variable speed drives and controls on all motors over 1 HP and ECM motors where applicable
   2) Minimal fan energy using low pressure drop design using air handler design face velocity of 400 FPM or less and other low pressure drop best practices; see http://www.i2sl.org/documents/toolkit/bp_lowpressure_508.pdf.
   3) Minimize duct static pressure using static pressure reset based on air control valve position.
   4) Minimize exhaust fan energy by optimizing exhaust stack height and discharge velocity determine by wind tunnel modeling of exhaust dispersion for specifying acceptable exhaust/intake designs; see http://www.i2sl.org/documents/toolkit/bp_modeling_508.pdf
   5) Separate ventilation control from thermal control by using low energy design such as chilled beams; see http://www.i2sl.org/documents/toolkit/bp_reheat_508.pdf and http://www.i2sl.org/documents/toolkit/bp_chilled-beam_508.pdf

vi. HVAC system controls shall conform with the general Sensors and Controls requirements specified in “4. Sensors and Controls” below.

vii. In addition, the following should be considered for HVAC systems:
   1) Occupancy-based ventilation controls and
   2) Demand based ventilation controls.

c. EXPOSURE CONTROL DEVICES

i. Fume hoods shall be high performance VAV type. NREL preference is to use one of the following products or substantially equivalent equipment. Substituted equipment must be reviewed and approved by NREL mechanical teams.

1) Labconco Protector Xstream http://www.labconco.com/product/protector-xstream-laboratory-hoods/24
2) Kewaunee Supreme Air Venturi Fume Hood

ii. Multiple fume hoods should be manifolded together; individual exhaust for fume hoods shall be accepted only if required for safety.

iii. All fume hoods shall be ASHRAE 110 tested to verify containment per ANSI/ASSE/AIHA Z9.5-2012.

iv. Use exposure control devices (e.g. fume hoods, glove boxes) that are tailored to the specific tasks required.

v. Exposure control device controls shall conform with the general Sensors and Controls requirements specified in “4. Sensors and Controls” below.

3. Building Efficiency

a. Plug-load and Mechanical Equipment

i. ENERGY STAR and FEMP-designated products and equipment for applicable categories shall be purchased.

1) Product exceptions shall be considered only if no compliant product is available that meets financial and mission requirements.

ii. Products with heat or energy recovery features are preferred.

b. Energy Efficient Lighting

i. DAYLIGHTING

1) Unless precluded by laboratory activities, daylighting techniques shall be used throughout laboratory spaces as a first choice for lighting. Minimize glare in the laboratory by using low direct beam solar fenestration design.
2) Adjustable electrochromic windows, blinds or other opportunities for local control of daylight should be employed where feasible to allow researchers to adjust lighting needs and avoid issues with glare.

ii. ENERGY EFFICIENT LIGHTING PRODUCTS

1) LED lighting shall be used throughout the building.
   a) If LED lighting cannot be used (for instance no applicable product exists), the most energy efficient option for the space/fixture should be chosen.

iii. LIGHTING CONTROLS

1) Lighting control systems shall conform with the general Sensors and Controls requirements specified in “4. Sensors and Controls” below.
2) If occupancy/vacancy sensors are used the same system should control both lighting and ventilation to enhance safety
3) Daylight sensors shall be used as appropriate and tied into the lighting system.

c. Water Efficiency

i. Water efficient products that meet or exceed WaterSense certifications shall be used.

1) Product exceptions shall be considered only if no compliant product is available that meets financial and mission requirements.

ii. Water efficient laboratory equipment products should be used throughout the lab.

d. SOLAR PV

i. The design should include rooftop solar PV.

1) If rooftop solar PV is not installed with the building the building shall be solar PV ready ; see https://www.nrel.gov/technical-assistance/blog/posts/solar-ready-building-design-a-summary-of-technical-considerations.html

4. Sensors and Controls

a. Communication Requirements

i. All equipment and control systems shall integrate with NREL's existing Delta Controls BACnet system natively or via a gateway.

ii. All equipment and control systems shall integrate with NREL's existing energy management and information system (EMIS), the Intelligent Campus platform, using one of the following protocols (in descending order of preference):

1) Haystack[1]
2) BACnet (IP or Ethernet)
3) Modbus IP

iii. For the protocols identified in (ii) above, equipment and control systems shall support remote access from NREL's Intelligent Campus platform for real-time data collection of all relevant sensor and control points at a minimum time resolution of 1 minute.

iv. Exceptions must be individually justified by the design team and approved by NREL.

b. Implementation Guidelines

i. Except in cases of infeasibility or extreme cost, all control signals shall be accompanied by independent sensor feedback the confirms a proper response to the control signal. Exceptions must be individually justified by the design team and approved by NREL.

ii. All sensors and control signals supported by installed hardware shall be available for remote monitoring by the BAS and Intelligent Campus platform.

c. Commissioning and Analytics

i. Comprehensive documentation of sensor and control points shall be provided. This includes:

1) Cut sheets or specifications for all equipment and connected sensors
2) Sensor and control point labels with associated unique identifiers (Haystack), panel and point addresses (BACnet), or register maps (Modbus)
3) Description of measurement type, location, and units

ii. Verification of data collection in NREL's Intelligent Campus platform is required as part of control system commissioning. Verification shall include:

[1] http://project-haystack.org/

1) Confirmation that measured sensors and control points are properly labeled and attached to the correct equipment
2) Confirmation of correct units
3) Confirmation of successful data collection and valid sensor readings

iii. Functional commissioning of control sequences shall be confirmed by data collection and review via the Intelligent Campus platform.

iv. Control sequence descriptions shall be provided at a level of detail that enables creation of continuous commissioning rules within the Intelligent Campus platform.

d. Metering

1) Confirmation of correct integration of sensors and control points into the Intelligent Campus platform shall be required as part of the initial commissioning.
2) All energy shall be metered using electric, BTU and water meters per NREL's Electricity Metering construction specifications.
3) Functional commissioning shall include use of analytics to verify proper behavior during the commissioning period

ii. Submeters

1) Electrical sub meters by end use shall be provided on process/plug loads, HVAC and lighting.
2) Water sub meters shall be provided for cooling tower, evaporative cooling sections, MAU's, AHU's, clean rooms, irrigation and deionized water systems.

5. Other

a. BUILDING CERTIFICATION AND PERFORMANCE

i. Laboratory buildings must meet energy performance requirements and be verified one year after construction is completed including:

1) Agreed upon energy intensity requirements by end use
2) Agreed upon cfm/ft^2 requirements

b. RESEARCH STAFF ENGAGEMENT

i. Building occupants shall be part of a building tutorial upon opening which will include training on equipment use, safety and building specific technology.

ii. Training for building operators shall also be a part of the building opening and commissioning process.

c. ERGONOMICS

i. When developing places to sit in labs, the counter height for working, researcher comfort and health should be considered.

ii. Provide lab bench standing cutouts to provide adequate knee and foot clearance when completing standing tasks in front of the bench.

1) 4-inch-deep knee clearance
2) 4-inch-high and 4-inch-deep foot clearance

iii. Provide a foot rail or prop available (6 inches from floor) under lab bench in areas of prolonged standing
iv. Provide bench cutouts for seated workers
    1) Minimum 15-inch depth and a minimum 20-inch width
v. Provide height adjustable lab benches in appropriate locations