Priority: High priority should be given to energy efficiency and sustainability in all aspects of the design of NU facilities.

Energy Modeling: The contractor is to quantify energy performance as compared to a baseline building detailed in the latest edition of ASHRAE 90.1 Appendix G. Proposed building construction is to achieve a minimum 25% reduction in its Performance Cost Index (PCI) as compared to its Performance Cost Index target (PCIT) while major renovations are to achieve a minimum 20% reduction.

Life Cycle Cost: Each design decision that significantly affects long-term energy use shall be based on a life cycle cost (LCC) analysis incorporating construction, energy and operating and maintenance costs. The minimum life cycle term shall be no less than 20 years or the lifespan of the longest lasting piece of equipment (baseline and alternates compared), whichever is greater.

Energy Efficient Equipment: The use of *EPA ENERGY STAR* labeled equipment is encouraged where applicable. For categories of equipment not included in the *ENERGY STAR* program, selection of highly-energy efficient equipment is encouraged.

Central Utilities: Central utility systems typically operate with greater energy efficiency than do building level systems. Thus, HVAC systems should utilize central distributed chilled water, steam and electricity when these utilities are available.

Central HVAC Systems: Buildings should be served by a small number of larger central HVAC systems rather than numerous smaller systems (i.e. less than 5,000 CFM) or individual units such as fan coil units, window air conditioning units or "split systems". The installation of a smaller number of larger central systems provides more opportunity for the application of energy conserving features and control strategies.

Energy Management System: All new major HVAC equipment shall utilize UNL's Building Automation System (BAS) as the primary means of control unless otherwise directed by UNL. Secondary BTU meters shall be installed on all isolated hydronic loops at each point of heat generation (ie, standalone chillers, modular boilers, heat recovery chillers, etc.). Exceptions include stand-alone equipment and other specialized equipment.

Utility Metering: Automatic metering for electricity, chilled water, steam, natural gas, and water shall be installed in all new construction and renovations. See the *Utility Metering* narrative within these *Design Guidelines* for details. Secondary BTU meters shall be installed on all isolated hydronic loops at each point of heat generation (e.g., standalone chillers, modular boilers, heat recover chillers, etc.).

Outdoor Air: Conditioning ventilation air is the most significant energy load on campus, so exhaust and associated outdoor-air makeup airflow should be minimized. Fume hoods and other equipment that require large quantities of exhaust and makeup air should be installed with discretion and restraint. Outdoor air quantities for ventilation should meet but not exceed the requirements of *ASHRAE Standard 62* at all load conditions. Consideration should be given to system designs and control strategies that reduce outdoor air required for ventilation during periods of reduced occupancy without violating the requirements of *ASHRAE Standard 62*. Demand control ventilation, occupancy sensors, scheduling, temperature/humidity resets and similar strategies should be employed to conserve energy while satisfying space requirements. Dedicated outdoor air units in conjunction with dual-path AHUs should be used as appropriate to condition return air separately from outdoor air.

Exhaust Air Systems: Exhaust air systems shall meet or exceed *ASHRAE Standard 90.1* requirements for energy recovery. Where possible, a total energy (sensible plus latent) recovery system should be employed. Strategies that allow exhaust air systems to be operated at reduced capacity or turned off altogether during periods of non-use or reduced demand should be employed. Consideration should be given to variable volume fume exhaust systems and other variable flow exhaust systems. General exhaust (GEX) and hood exhaust (HEX) valves should be carefully sized to provide accurate flow control and feedback to the Building Automation System (BAS).

Fans / Ductwork: Fan energy consumption should be minimized by selecting the most efficient fan type(s) and size(s) for each application. Ductwork should be carefully designed to minimize pressure drop and system-effect losses. In many cases, arrays of smaller fans are preferred due to their smaller footprint, flexibility and ease of maintenance.

VAV Systems: In general, air distribution systems larger than 5,000 CFM shall be variable air volume (VAV) utilizing a variable frequency drive (VFD) to control fan motor speed. VAV systems reduce fan energy consumption while minimizing simultaneous cooling and heating of distributed air. Each room shall be considered a separate thermal zone, with individual thermostat connected to the BAS. Integration of occupancy sensors to allow VAV boxes to close during unoccupied periods is encouraged. VAV boxes should be properly sized to provide accurate flow control and feedback to the BAS.

Other Systems: Displacement ventilation systems should be considered. Appropriate applications include large lecture halls, sizable classrooms and atria.

Air Side Economizers: Air side economizers or dedicated outdoor air systems with energy recovery, should be provided.

Pumps / Hydronic Systems: Pump energy consumption should be minimized by careful selection of the most efficient pump type(s) and size(s) for each application. Piping and hydronic system components should be sized and configured to minimize the total pressure requirement at pump(s). Variable frequency drives (VFD) should be provided for pump motors of 5 HP or greater.

Variable Flow Hydronic Systems: Closed loop hydronic secondary/distribution systems, both heating and cooling, shall be variable flow systems with two-way control valves. A final three-way valve or bypass valve may be provided to prevent deadheading at low loads. Circuit setters should be considered to maintain system flow balance over varying pressure conditions. Reverse return systems should be considered where feasible.

Cooling Equipment: Cooling equipment shall be selected with efficiencies that meet or exceed minimum values listed in *ASHRAE Standard 90.1*.

Heating Equipment: Heating equipment shall be selected with efficiencies that meet or exceed minimum values listed in *ASHRAE Standard 90.1.*

Electric Heating: Electric-resistance heating should be avoided. Electric heat may be provided as an integral component within specialized packaged HVAC units (e.g. Liebert CRAC unit) when needed to provide tight humidity control.

Specialty Heating Systems: Sidewalk and/or entryway snow melting systems should not be installed. Similarly, roof, gutter and/or downspout ice melting systems are not allowed.

Humidification: Humidification should be limited to systems serving only humidity-sensitive spaces, and those spaces should be surrounded by a continuous, sealed vapor barrier.

Domestic Hot Water Systems: Opportunities to reduce energy usage for domestic hot water systems are encouraged. The use of heat pump water heaters or solar thermal heating should be considered. The use of steam condensate or other waste heat sources to preheat domestic hot water should also be considered. For small DHW loads, electric resistance heating may provide the lowest LCC.Point-source heaters should be considered for isolated loads.

Chilled Beams: Installation of chilled beam systems may be considered. Building envelope design should be optimized against heat and moisture infiltration in locations where chilled beams are considered. Design of chilled beam systems must consider that the building as a whole and/or individual spaces have a thermal mass lag and require a substantially longer warm up and cool down period, limiting night setback and duty-cycle opportunities. Energy models are to consider extended start-up and cool-down periods for cooling and dehumidification when comparing against alternative systems.

Interior & Exterior Lighting: Interior and exterior lighting energy consumption should be minimized while providing adequate light level and control. General strategies shall include the use of efficient fixtures and layouts to reduce the total lighting power density below the maximum requirements specified by *ASHRAE Standard 90.1*. Use of dimmable LED systems is encouraged. Rooms with multiple workspaces should be provided with occupancy sensors. Multi-level switching and daylighting techniques should also be utilized as appropriate. See the *Lighting* section within these *Design Guidelines* for additional information. In rooms that are used primarily for computer monitors, and even general offices, consider reducing the ambient lighting and providing task lights at workstations.

Natural Lighting: Full advantage should be taken of opportunities to provide natural lighting. However, full compliance with the *ASHRAE Standard 90.1* shall not be sacrificed in the process. Daylighting strategies should incorporate opportunities to reduce artificial lighting during periods of adequate natural lighting.

Transformers: Transformers shall be rated NEMA TP-1 for energy efficiency.

Motors: Electric motors shall be of the manufacturer's high-efficiency design with a minimum efficiency of 92%. Motors shall be sized to be loaded to at least 75% of rated horsepower when driving equipment at full load conditions and shall be inverter-rated.

Public Entrances: High-use public entrances should include vestibules or revolving doors. These improve occupant comfort and reduce infiltration.

Exterior Glazing: Large expanses of exterior glazing, particularly on building faces exposed to the most solar gain (e.g. south, east and west exposures) should be avoided to minimize summer heat gain and winter heat loss, except when justified by the LCC analysis. The use of multipane, "Low-E" exterior glazing is encouraged for energy conservation as well as occupant comfort. Fenestration U-value should be minimized within boundaries supported by LCC analysis, with requirements of *ASHRAE Standard 90.1* establishing the maximum allowable value. Treatments and architectural features that reduce solar heat gain, including awnings, blinds, and shades should be considered.

Envelope Insulation and Exfiltration: Envelope insulation shall meet or exceed requirements of *ASHRAE Standard 90.1* and those identified elsewhere within these Standards, whichever is more stringent. The judicious use of insulation can also reduce the size of mechanical equipment. Roofs should be vegetative or high-reflectance type. In general, UNL buildings should be designed to operate at a slight positive pressure relative to outdoor air. Design and implementation methods that tighten the building and reduce exfiltration are highly encouraged.

Water Conservation: Reduced-flow fixtures should be utilized to reduce water use while still meeting performance needs. However, waterless plumbing fixtures are not encouraged. Projects shall achieve a minimum 30% reduction from the baseline prescribed by *LEED 2009 for New Construction and Major Renovations*. Fixtures should meet or exceed *EPA WaterSense* program requirements.