SECTION 01301C – DESIGN GUIDELINES FOR ENERGY & ENVIRONMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Brown invests considerable resources each year in upgrading and updating existing facilities. This document is intended to assist those involved with the process to verify that newly renovated or constructed facilities include consideration of long-term energy costs, and outlines Brown's energy use and design guidelines as they relate to building design.

B. Generally speaking, this Guideline includes energy conservation requirements for a minimum of 25% and up to 50% better than Rhode Island Energy Codes (currently based on AHRAE 90.1-2004). This Guideline is based upon Standards, utility company incentives, and/or "Collective" Best Practices and a least-operating-cost focus.

C. Specific design or system data is mentioned herein as well as within the other specific sections of the Brown Design Standards, i.e. pipe insulation or motor efficiencies, etc. As these guidelines are intended to complement the existing Design and Engineering process, those sections also need to be referenced as necessary in conjunction with this Standard.

D. This Guideline should be further supported with on-going investigation, pilot studies and projects, and feedback from A/E Firms and Project Participants. As such, it is the intent that this document be updated on a regular basis.

1.02 BACKGROUND & OBJECTIVES:

A. Brown University is facing ever-increasing costs and environmental impacts due to campus expansion, aging infrastructure and increasing energy rates. This design guideline provides an overview of steps to be taken or actions to consider to achieve the following in new building construction or existing building renovations:

1. Reduced life-cycle cost
2. Reduced environmental impact
3. Improved employee environment
4. Improved profitability and operations for all stakeholders

B. Energy and Environmental Mission: In order to develop sustainable and equitable patterns of local and global resource use, Brown University will minimize its energy use, reduce negative environmental impacts and promote environmental stewardship. Brown will use the opportunities created by these actions

1.03 DESIGN ANALYSIS BASIS

A. Minimum Standard: 25% minimum is required, and up to 50% more efficient than ASHRAE 90.1 when lifecycle analysis thresholds are met as indicated in section 1.04 (Applicable to all designs for retrofit and new construction, standard based on the most current version of ASHRAE 90.1, which is presently 90.1 2004). Exemptions to the above Design Analysis basis must be obtained by the Project Manager through the Brown Energy and Environmental Director by documenting that achieving the higher standard is not life cycle cost effective. Such exemptions must be sought and received during the design phase. Efficiency is defined for new construction and major renovations on a facility based on overall energy density (BTU/Sqft) and on nominal efficiency when evaluating equipment only. If appropriate, Carbon Intensity can be substituted for either of the above, when alternative energy sources are available.

B. If ASHRAE 90.1 is not applicable, life cycle cost analysis will be performed to determine the preferred option within performance guideline requirements, based on Life Cycle costing.

1.04 LIFE CYCLE COST ANALYSIS

A. Life cycle cost analysis shall be based on the following:

1. 8.5 percent or greater internal rate of return (this discount rate takes into consideration future price escalation and relatively low risk of energy efficiency in the design process)

2. All factors included in the analysis should be documented (although not all of the following factors are required to be included in the analysis):

   a. Energy rates and price escalation

   b. Water costs, chemical costs, and other maintenance/operating costs

   c. Replacement and disposal costs

B. Access to the web-based Life Cycle Cost analysis tool, Brown Energy Efficiency (BEE), may be requested from the Energy and Environmental Programs Coordinator.

C. For Life Cycle Cost Analyses, the following Base Utility Rates are applicable for FY09:

1. Steam/HTHW (CHP): $13 Per MMBTU

2. Chilled Water (From District plant): $0.08 Per Ton-hour

3. Electricity with demand:$0.13 Per KWH

4. Electricity without demand: $0.10 Per KWH

5. Natural Gas: $13 Per MMBTU (Mid-Large Buildings)

6. Natural Gas: $16 Per MMBTU (Small Buildings)

7. Water (including sewer related charges): $7.50 Per 1,000 gal

8. #2 Fuel Oil (non CHP): $15 Per MMBTU

9. #6 Fuel Oil (non CHP: $11 Per MMBTU

D. Example Rate of Return: The following chart compares rate of return and simple payback.

Rates of Return Based on Simple Payback and Expected Equipment Life

ASHRAE Expected Equipment Life	Simple Payback (Years) 1	2	3	4	5	6	7	8	9
5-yr	97%	41%	20%	8%	0%	-6%	-10%	-14%	-17%
10-yr	100%	49%	31%	21%	15%	11%	7%	4%	2%
15-yr	100%	50%	33%	24%	18%	14%	11%	9.1%	7%
20-yr	100%	50%	33%	25%	19%	16%	13%	11%	9.2%

exemption due to lack of cost effectiveness or inapplicability of ASHRAE 90.1. Green highlighted cells identify range of years of simple payback associated with 8.5 percent or greater rate of return. Yellow highlighted cells indicate return of less than 8.5 percent. Green indicates required implementation for New Construction and availability of additional funding for Renovations or replacement of energy consuming equipment

1) Example One:

- Expected Equipment Life = 15 years
- Estimated Simple Payback = 5 years
- The table indicates the rate of return is 18 percent. 18 percent is greater than the threshold of 8.5 percent so efficiency improvements should be adopted.

2) Example Two:

- Expected Equipment Life = 10 years
- Estimated Simple Payback = 8 years
- The table indicates the rate of return is 4 percent. 4 percent is less than the threshold of 8.5 percent. Non-monetary benefits or other positive aspects of feature should be reviewed and an exemption can be sought, if applicable.

E. Simple Payback Based on Rates of Return and Expected equipment life: The following chart denotes the system payback in years, based on annual rates of return and expected equipment life:

Simple Payback (Years) Based on Rates of Return and Expected Equipment Life

ASHRAE Expected Equipment Life	Rate of Return 5%	6%	7%	8%	8.5%	10%	12%	24%	32%
5-yr	4.3	4.2	4.1	4.0	3.9	3.8	3.6	2.7	2.3
10-yr	7.7	7.4	7.0	6.7	6.6	6.1	5.7	3.7	2.9
15-yr	10.4	9.7	9.1	8.6	8.3	7.6	6.8	4.0	3.1
20-yr	12.5	11.5	10.6	9.8	9.5	8.5	7.5	4.1	3.1

Note: Highlighted cells show maximum simple payback equivalent to 8.5% minimum rate of return (aka internal rate of return, discount rate, hurdle rate, etc)

Part- 2 – Execution

2.01 Design Guideline Principles

A. The following general design guidelines and principles are to be incorporated into all building projects:

1. Minimize External Loads – Improve Envelope.
2. Minimize Internal Loads (Major Equipment) – Power Systems, Computer Systems, Switching Equipment, System Support Equipment.
3. Minimize Internal Loads (Supplemental Equipment/Systems) – Lighting, Kitchen, Office Equipment, Plug Loads, Water/Sewer.
4. Optimize Air Conditioning Equipment and Systems – Air Handling Units, Unitary Equipment, Computer Room Equipment, and Controls.

5. Minimize System Losses – Optimize Ductwork, Optimize Piping.

6. Maximize Efficiency of Central Plant Equipment – Boilers, Chillers, Pumps, and Controls.

7. Optimize Infrastructure Improvement Process – Cogeneration, Thermal Energy Storage, Redundancy Requirements.

8. Ensure Continued Performance Through Requirements for Metering, Training, O&M Manuals, Test/Adjust/Balance (TAB), and Commissioning.

2.02 Universal Project Requirements:

A. The following universal project requirements are to be incorporated into all building projects:

1. Operating and Maintenance (O&M) Manuals: O&M manuals are required for every project, unless declined by PD&C during project scoping. Manuals to include:

   a. Final "No Exception Taken" Submittal Data

   b. As-built documentation and record drawings

   c. HVAC Manuals, including the following:

      i. General

      ii. Installation

      iii. Servicing

      iv. Parts

   d. Control Information, including as appropriate:

      i. Drawings

      ii. Sequence of Operations

      iii. Schematics

      iv. Design setpoints

   e. Sequence of Operations Narrative

2. Balancing: Balancing is required for HVAC and mechanical systems according to accepted engineering standards.

3. Air Balancing:

    a. Air balance report required for all HVAC systems.

    b. Utilize and adjust VFDs to provide load response flexibility and to simplify balancing requirements.

    c. Balancing is not considered complete until temperature standards are met consistently.

    d. The project engineer is to determine what level of air balance is required in conjunction with Brown FM personnel. For general office space, air flow balanced for each diffuser is typically acceptable (unless detailed information is available for the space). For equipment rooms, the design should specify air flow rates to meet peak loads for each major piece of equipment in the space. Equal air flow per diffuser is not an acceptable design unless specific equipment data is unavailable.

4. Hydronic Balancing (if applicable)

    a. Hydronic balance report required and verified.

    b. Utilize and adjust VFDs to provide load response flexibility and to simplify balancing requirements.

    c. Balancing is not considered complete until temperature standards are met consistently.

    d. The project engineer to determine location of gauges and sensors to enable for system testing and monitoring in conjunction with Brown FM personnel. Pump gauges are to be provided, at a minimum, to allow for the analysis of flow rates in the Hydronic system.

5. Commissioning:

    a. Full project commissioning is required for all new construction, remodeling, and retrofit projects involving energy consuming equipment. Control points and programming logic feeding to and from project system should be verified and calibrated as part of project design and implementation.

    b. Commissioning should generally be performed by third-party provider but Project Manager can elect to pursue alternative approach if more appropriate to project scope and requirements. For guidance on third-party commissioning, see the energy conservation website used by several of the larger California Utilities at:

http://www.energydesignresources.com/resource/37/ . Commissioning agent should generally be involved throughout the planning, design, and construction process including the following phases:

i. Commissioning Team Development

ii. Predesign

iii. Design Phase - Submittal/Progress Review

iv. Construction Phase

v. Acceptance Phase - Verification of Performance

vi. Warranty Phase

vii. Continuous Commissioning

2.03 Air Handling Unit (AHU) Design:

A. Building AHU design and system performance to be enhanced via the following:

1. Minimizing hp at design conditions. Note Minimum AHU component efficiency Per ASHRAE 90.1 2004:

AHU Sizing	Constant Volume	Variable Volume
<20,000 cfm	1.2 hp/1000 cfm	1.7 hp/1000 cfm
>=20,000 cfm	1.1 hp/1000 cfm	1.5 hp/1000 cfm

2. Installing VFDs in all AHU systems.

3. Providing VAV boxes to meet present zoning requirements and adaptability for future equipment / space utilization needs.

4. Matching control setpoints with equipment requirements, standards and occupancy requirements including use of dual setpoints occupied/unoccupied) and/or separate areas for personnel conditioning.

5. Minimizing maintenance requirements and maximizing service accessibility. Include policy-compliant filter configuration.

6. Sizing AHU coils and air flow ability to allow for higher Supply Air temperatures and still provide acceptable conditions – allowing greater use of air-side or water-side economizer operation.

7. Provide for full economizer capability in conjunction with an adequately sized/controlled relief fan (exceptions for systems served by water-side economizer).

8. Provide low leakage dampers.

9. Provide ventilation control guidance.

2.04 Motors and Electrical Systems

A. Motors shall be specified to be premium efficiency. Motors for use with VFDs shall be inverter-duty premium efficiency type.

B. VFDs shall be required for all of the following applications:

1. Secondary Pumps.

2. Cooling Towers.

3. AHUs.

4. Relief Fans Tied to AHUs for Economizer Operation.

5. Booster Pumps.

6. HW Circulating Pumps.

7. Large Exhaust Fans.

C. VFDs should also be considered as options to improve overall system efficiency subject to life cycle cost analysis for the following:

1. Chillers.

2. Primary Pumps.

3. Air Cooled Condenser Fans – Grouped.

4. Computer Room Air Conditioning Units.

D. Additional Motor/Electrical Considerations and Opportunities

1. Utilize electrical filters/line protection as necessary to protect VFDs and other distribution system components.

2. Verify all new motors are premium efficiency VFD compatible.

3. Consider over sizing electrical distribution where practical, to reduce line losses (maximum voltage drop 2% at design load – feeders, 3% branch)

4. Utilize high efficiency transformers (NEMA TP-S).

5. Utilize power factor correction equipment locally and/or at service entrance to reduce distribution system losses and utility costs.

6. Metering to be provided and tied-into campus metering system where applicable.

2.05 Chiller Systems

A. Overview

1. Select most efficient chiller type for each project (life cycle costing). Note minimum chiller component efficiency, Per ASHRAE 90.1 2004:

Sizing	IPLV
<150 tons	0.67 kW/ton
>=150 tons, <300 tons	0.60 kW/ton
>=300 tons	0.55 kW/ton

2. Consider over-sizing chiller condenser and cooling tower to improve efficiency/reduce peak hp requirements.

3. Compare chiller selections based on the estimated load profile for the facility. This provides an indication how the design performance compares with expected operating conditions.

4. Provide the load profiles for chillers in design package.

5. Note minimum chiller water distribution loop insulation thickness, per ASHRAE 90.1 2004:

If insulation Conductivity = 0.22-0.28 Btu*in/(h*ft2*deg F) and Mean Temp Rating = 100 deg F, then

Nominal Pipe (in):	<1	1-<1 ½	1 ½ - <4	4 - <8	>=8
Minimum Insulation Thickness (in):	0.5	1.0	1.0	1.0	1.5

B. Chiller Plant Design

1. Provide summary tables of code specifications for each piece of equipment and the actual equipment selections.

2. For multiple chiller installations, provide model of energy efficiency calculations and provide specific operating sequences to maximize energy savings to control contractor, including:

   a. Cooling tower operating specifications and curve (Example, per ASHRAE 90.1 2004, minimum of 38.2 gpm /hp at 95 deg F entering, 85 deg F leaving and 75 deg F wb Outdoor Air).

   b. CW and CHW flows.

   c. Chiller loading and control sequences.

   d. Economizer operation and control sequences. Select optimal chilled water setpoint possible for system (include consideration of economizer capability). Include waterside economizer for all chiller plant designs unless not life cycle cost effective (analysis should include consideration of factors such as facilities with minimal air-side economizer potential and year-round cooling requirements).

2.06 Controls

A. General Guidance:

1. System graphics to be provided.

2. Programming software and access to all control functions to be included with operating station.

3. Metering software, where available and applicable to the facility, to be provided.

4. Major facility renovations should include facility energy metering and tracking capability

B. Controls should be designed to Facilitate “Continuous Commissioning”.

1. Controls documentation shall include all initial set points and sequence of operation for all systems. Provision of process flow is diagrams encouraged.

2. System should include long-term logging capability to provide simplified system performance evaluations and trending of data.

3. Alarms required as sequences change, equipment fails, etc.

4. System to be designed to facilitate ongoing verification and calibration of sensors.

C. Ventilation Systems: (Minimum control algorithms to include the following):

1. Ventilation Demand Control with CO2 Sensors during occupied and unoccupied hours.

2. Mixed Air Temperature Reset.

3. Cold Deck Temperature Reset with Humidity Override. Select the zone with the greatest cooling requirements to establish the minimum cold deck temperature differential which will satisfy requirements.

4. Enthalpy Economizer.

5. Night Setback.

6. Optimum Start-Stop.

D. Chilled Water Systems: (Minimum control algorithms to include the following):

1. Chiller Optimization- The program will select the chiller or chillers required to meet the load with the minimum energy requirements.

2. Chilled Water Temperature Reset- During non-peak design operating hours (Chilled Water leaving Temperature based on Outdoor Air Temperature).

3. Condenser Water Temperature Reset.

2.07 Temperature Standards for conditioned building spaces:

Space	Temperature (S/W)	RH (S/W)
Power Room	80/60	NA
Computer Room	75/68	50/40
Emergency Generator Room	Outdoor Ambient +15 and winter 65	NA
Mech. & Elect. Equip. Room	Outdoor Ambient +15 and winter 65	NA
Vacant space	90/50	60/NA
Power Room (w/out batteries)	85/50	55/15
Power Room (with batteries and/or Battery areas)	77/50	55/15
PBX and LAN Rooms	78/60	55/15
Fitness Center	78/68	NA
Data Center	75/68	40 (+/- 10)

Administrative Office Space	78/68	NA
Work Center	78/68	NA

2.08 Lighting Systems

A. Provide for automatic lighting control for all areas, as follows:

1. Schedule Based

2. Occupancy Sensor

3. Daylighting Sensor

4. Other Control Signal

B. Provide 2-lamp fixtures in all general and individual offices where task lighting is provided

C. Select light-colored ceilings and walls to encourage reflection and distribution of light throughout space.

D. Optimize ballast and lamp efficiency.

E. Minimum light levels by space type per IES guidelines.

2.09 Building Envelope

A. Analysis shall be based on site-specific requirements and the overall ability to minimize heating/cooling loads. Applicable design considerations to include:

1. Optimized roofing insulation and/or reflective coating (note: Reflective roofing is required for facilities in climate zones 1, 2, and 3 and reflective roofing should be evaluated for other climate zones based on building use and expected economic benefit).

2. Optimization of glazing as a percentage of building exterior.

3. Glazing and window treatment configuration appropriate to climate and site-specific conditions.

4. Provide vestibules on buildings higher than four stories.

5. Optimize use of solar energy.

2.10 Comfort Heating Systems

A. Each facility should be evaluated to determine the degree to which comfort heating, comfort humidification, and process humidification is required.

1. Comfort heating should be designed to minimize potential for simultaneous heating/cooling.

2. Utilize heat recovery whenever possible.

3. Optimize comfort heating system based on location and expected usage requirements:

   a. Minimum overall efficiency for boilers should be at least 80 percent for facilities where space heating is required.

   b. Heat recovery from the condenser side of water-cooled systems should be evaluated if a building is expected to have concurrent boiler and chiller operation. Although ASHRAE 90.1 2004 primarily addresses the minimum requirement for service water heating, the following guideline may be applicable for preliminary design screening purposes of facilities as well. Condenser heat recovery is required if the system meets the following requirements: facility is expected to operate 24 hours per day, heat rejection capacity of water cooled system exceeds 500 tons and design service heating loads exceed 1,000,000 Btu/h.

2.11 Plumbing Equipment and Systems

A. Where local utilities allow for sewer credits, meter make-up water and blow-down water for cooling towers or irrigation water.

B. Utilize low flow devices in faucets and shower heads.

C. Utilize low water use toilets and urinals.

D. Utilize grey water for irrigation and plumbing, where possible.

E. Evaluate waterless urinals where possible.

F. Evaluate rainwater harvesting and reuse.

G. Evaluate instantaneous point of use water heaters versus distributed hot water options.

H. Evaluate the use of automatic sensor-based faucets.

I. Evaluate the use of other reduced-water consumption and sustainable technologies.

2.12 Project Incentive Analysis

A. Project incentives are an important component to the completion of energy efficiency projects.

B. Review utility, local, state, and federal sources for potential incentives and report incentives to energy and environmental office.

C. Incentives can provide funding for:

1. Energy Analysis
2. Design
3. Equipment
4. Construction
5. Commissioning

D. Some incentives may be found in analyzing the tax implications of the project.

E. In addition, by evaluating incentive programs, the design team may make changes to the proposed design to take advantage of funding options. These changes may result in an overall improved design.

End of Section