

Dartmouth

A photograph of the main building of Dartmouth College, featuring a prominent white clock tower with a green dome and a weather vane. The building is constructed of red brick with white window frames and a green roof. The scene is set against a blue sky with scattered white clouds, and green trees are visible in the foreground and background.

High Performance Building
Energy Policy



Purpose

The purpose of this guideline is to establish high, yet achievable energy performance targets for capital projects with a construction value of \$3 million or greater at Dartmouth College. The policy shall be used for projects involving new buildings as well as renovation of existing buildings.



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Introduction

Dartmouth College has been on the forefront when it comes to energy efficient design for a long time. There are many buildings on the campus that exemplify these efforts, however some efforts have been more successful than others. The common thread for all the capital projects in the last 20 years is, the approach taken on each has been to look for better ways to design and build these structures in order to serve Dartmouth for decades to come.

This document looks to establish a process where there is a benchmark for energy performance before the design consultants are on board. This is very similar to how projects establish budgets, funding and schedule requirements prior to the design team being hired. The intent of establishing the energy parameters early is so that the design team has a clear understanding of the endeavor they are about to embark on prior to providing a proposal.

Another intent is to foster a design process where all members are integrated and work together towards a common goal; a great project outcome that will serve the college well both in operational as well as occupational terms.

One particularly successful project in this regard is the Class of 1978, Life Science Center and many of the specifics in this document comes from that project. One of the most important lessons learned on this project is to establish an energy benchmark early that guides and motivates the design process. Preferably, this benchmark should be established before the design starts and preferably before the design process starts.

Class of 1978, Life Science Center



Academic and Laboratory Building

New Construction – completed 2011, 175,000 SF

The facility energy usage has almost achieved the levels modeled during the design phase. The model predicted 99,000 btu/sq ft-yr, including the greenhouse. Actual average yearly usage is 110,000 btu/sq ft-yr.

A reduction to 100,000 btu/sq ft-yr, would make it one of the most energy efficient laboratories in North America.



Benchmark Energy Targets

Benchmarking is the practice of comparing the measured performance of a single building over time, to similar-use buildings, or established norms such as an energy code. The goal of benchmarking is to provide the informed data required from which to establish performance improvement.

Typical factors that can be used to establish a benchmark for energy use:

- a) Establish a target that would be a percentage improvement over code minimum.
- b) Identify the proven performance of Non-Dartmouth buildings with similar use, size and climate and target a percentage better.
- c) Identify the proven performance of existing Dartmouth buildings with a similar use, size and climate and target a percentage better.
- d) Set an energy target utilizing a combination of all the above.

The most commonly used index today is the Energy Use Intensity (EUI), which adds up all of the building energy used in a year (including lighting, elevators, heat, cooling, auxiliary use, etc.) and divides it by the total of square feet in the building and provides you with the British Thermal Units that have been used per square foot, per year (Btu/sq ft-yr). Based on information provided and assembled by the Dartmouth FO&M Energy Management team, the chart below assembles existing Dartmouth buildings into broad categories, averages their actual energy use per category and provides an obtainable goal for improvement.

In cooperation with the design team, Dartmouth will establish energy performance goals early on in the design process, preferably before the SD phase so that the design professionals know what they need to accomplish before any design work starts. It is important that the team understands that the intent is to set aggressive, yet achievable energy targets that are in line with, or better than the best comparable projects done elsewhere.

Table 1: Annual Energy Use, on the following page, defines actual energy use for several Dartmouth buildings, separated out by higher performers and buildings with lower energy savings. The track record for the major construction projects during the last decade has been at least 35% better than required by code.



Table 1: Dartmouth College Site Energy Performance Targets by Building Type

Category Main Use	Good performers		Average Use/Category	
	Building	Btu/sqft-yr	Actual Btu/sqft-yr	Target Btu/sqft-yr
Science/ Labs	LSC	110,000	198,000	100,000
Dormitories without AC	19 East Wheelock	41,000	64,000	40,000
Dormitories with AC	Thomas	46,000	70,000	50,000
Dining	Collis	156,000	157,000	130,000
Class Room	Kemeny	68,000	86,000	70,000
Offices	37-50 Dewey Field Rd	97,000	62,000	50,000
Libraries	Baker- Berry	99,000	121,000	100,000
Athletic	Boss Tennis	50,000	90,000	70,000

Dartmouth EUI Calculations Based Upon:

Electric Energy: 3412 Btu/kWh

970 Btu/lb steam

3,000 Btu/ton-hr chilled water (assumes plant COP=4)



Energy Modeling

It is very important that energy modeling is done comprehensively and often during the design process to ensure that the design process is on the right track and that the energy model results are used to inform decisions about systems.

Energy modeling shall begin in the conceptual phase and shall continue through the construction document phase so it can inform design decisions. Energy modeling may be done by the design team or a hired third party. Dartmouth shall be informed of who will do the energy modeling. The energy modeler can use industry accepted packages such as eQuest, DOE-2, Energy Plus, Trane Trace or Carrier HAP. The files shall be made available to Dartmouth for their use.

The final energy model shall be based on the 100% construction documents. At a minimum, energy modeling shall be conducted during early design conceptual phase, schematic design phase, design development phase and for final design. All energy models shall summarize annual energy consumption and peak demand for:

- Heating energy
- Cooling energy
- Major HVAC units organized in logical categories
- Domestic hot water
- Interior lighting
- Exterior lighting
- Miscellaneous loads

Cost benefit analysis shall be conducted, starting in the SD phase, to assist the team in making informed design decisions. Cost benefit analysis shall also be done to inform the team in value engineering decisions effecting energy use and CO2 emissions associated with the project.

The cost benefit analysis shall calculate simple payback and net present value of relative design options and the analysis shall account for operating and maintenance costs for the life of the system.

Dartmouth College will provide information for energy costs and energy cost escalation rates.

After one year of operation for projects greater than \$10 million, the design team shall perform a calibrated energy model for the project where they use actual weather and usage data and compare it to what the real energy use is. If the discrepancies' are larger than 10%, the design team shall assist Dartmouth and the commissioning agent investigating what may be causing this.



LEED

US Green Building Council (USGBC) created a building rating system for new and renovation system that they called Leadership in Energy and Environmental Design (LEED) that is commonly used on new projects throughout the country and the world. Dartmouth has been using the LEED system for a number of projects with success, the biggest of them was the Life Science Center which got the highest possible ranking, platinum, and the maximum possible EAC-1 Energy Performance points

For projects between \$3 and \$10 million, LEED certification will be decided upon on a case by case basis.

For projects greater than \$10 million, LEED certification shall be required. This process shall be followed rigorously, including energy modeling.

Because Dartmouth prioritizes building energy performance, for all LEED projects Dartmouth targets a minimum of 36% energy use below code (LEED 2009 EAC1, 13 out of 19 energy credits).



Design Process

The design approach shall be a process where all project stakeholders such as the design team, the construction manager, and the specialty engineers have an opportunity to collaborate with the owner and end users on key decisions early on in the envisioning stage. This approach effectively maximizes resources to provide the essential input required for informed decision making in regard to design intent, programming, scheduling, and budget forecasting (both fixed and operating), as well as minimizing the need for value engineering or change orders in later phases of the process.

Most specifically, within the context of this document, this collaborative approach organically gathers the correct committee of experts that are required to discuss and decide upon building energy and comfort performance goals.

The design objectives of any Dartmouth capital project shall include provisions for obtaining high functioning, interactive spaces for building users; creating an energy-efficient, water-conserving, healthy, and comfortable environment for all occupants.

Therefore, a primary commitment of the design team shall be to implement an integrated design process that is focused on making the best architectural decisions from all viewpoints: sustainability, user requirements, user satisfaction expectations, and economic constraints.

The deliverable for each phase is defined in the Dartmouth College Project Delivery Process document which will be provided by the Dartmouth Campus Design and Construction Department.

Energy Saving Strategies

The design team is encouraged to think outside the box to evaluate suitable systems for the project. As a minimum, the design team shall:

- 1) Achieve the EUI as directed by the Dartmouth project team.
- 2) Minimize ventilation by using demand control ventilation (DCV) strategies and use of dedicated outside air (DOA) units.
- 3) Recover as much energy as possible by using the best energy recovery strategy for the project.
- 4) Reduce lighting power densities (LPD) and use lighting control systems that will further minimize the energy used by the lighting system
- 5) Reduce plug loads by specifying energy efficient equipment.
- 6) Reduce water use to 50% or less of what a conventional building uses.
- 7) Evaluate what renewable energy use systems can be used on the project
- 8) Use energy modeling extensively to evaluate different system types for the project.
- 9) Consider natural ventilation as energy efficiency strategy.



Equipment Sizing

It is Dartmouth's intent to minimize to manage both energy usage and capital cost. This must be done while considering future system expansions and system flexibility. To meet this intent, designers shall use proper and realistic load assumptions for both mechanical and electrical systems. Energy modeling of HVAC systems and an iterative analysis of design decisions and assumptions affecting loads, will enable this process. When applicable, actual measurements in similar facilities can be take and used to inform design decisions. Load assumptions shall be documented in the Basis of Design document.

The design team shall submit, for Dartmouth review, load and sizing calculations for major mechanical and electrical systems at each design submission. It is understood that the first such submissions will be preliminary in nature.

Value Engineering

It is Dartmouth's goal to account for long term goals and greenhouse gas emissions impact when considering Value Engineering options. Therefore, Value Engineering decisions during the design and construction phase that effect energy use and costs shall be subject to a cost/benefit analysis.

Project Specifics

Any design team for a Dartmouth project shall follow these guidelines. If they cannot meet the guidelines, the Dartmouth project management team need to be made aware of this as soon as possible.

Broad Goals

- 1) Create a structure that fits in on campus.
- 2) Create indoor conditions that provides comfort and ambiance that promotes a good work, research, learning and study environment.
- 3) Operation and maintenance needs shall focus on design measures that result in lower maintenance and substantially reduced energy costs.
- 4) Apply sustainable development principles in a practical, well planned and cost effective manner.



Outdoor Conditions:

Table 2: Outdoor Conditions by season (Based on ASHRAE 99.4% weather data and the Dartmouth College section 15010 of the Design Guidelines.)	
Site Location	Hanover, NH
Summer Dry Bulb Temperature	89°F dry bulb
Summer Wet Bulb Temperature	72°F wet bulb
Winter Dry Bulb Temperature	-20°F dry bulb

Building Enclosure

It is extremely important that the design team makes the building enclosure as airtight and well insulated as possible because it will result in smaller mechanical and electrical systems and it will always reduce the building energy use, no matter what the building will be used for its lifetime. The design team shall use the energy modeling process, described previously in this document, to make informed decisions about the building enclosure material and performance criteria.

The exterior shall be designed to endure for at least 75 years. Prevention of air and moisture intrusion is a high-priority goal applicable to all project team disciplines. Solar transmission shall be controlled and designed in accordance with ASHRAE Standard 90.1-2013 through high-performance, low-e glazing, overhangs and external shading, and other techniques to minimize solar heat gain and maximize light transmittance for daylighting where functionally practical.

Dartmouth College’s objectives for energy efficient building enclosures include, but are not limited to:

- The design team shall select materials that reduce energy use and minimize the heat island effect.
- The design team shall select and specify materials that are of high quality, capable of lasting 75 years and fit within the constraints of the budget.
- The wall design shall be designed for a continuous thermal and vapor barrier while keeping costs in-line with the available budget. Thermal resistance specifications shall be no less than:
 - R-30 wall insulation (Reference: 2012 IECC code requirement is U-0.064 or R-13 + R-7.5ci)
 - R-60 roof insulation (Reference: 2012 IECC code requirement is U-0.03 or R-25ci)
- Windows shall be selected based on assembly and glazing performance, including;
 - Infiltration
 - Solar gain and transmission
 - Thermal performance
- The enclosure design shall minimize external loads by reducing heat gain in the summer and minimizing heat loss in the winter. Vegetative roof with drought resistant, native species to be considered as appropriate.



Air Quality

The design shall meet rigorous comfort standards to ensure all occupants achieve the highest level of productivity and comfort. Elimination of volatile organic compounds (VOC), chlorine, and formaldehyde supports healthy, indoor environmental conditions.

The following key objectives shall inform the design of the project:

- 1) Manage the design and construction process to achieve good IAQ.
- 2) Control moisture in building assemblies.
- 3) Limit entry of outdoor contaminants.
- 4) Limit contaminants from indoor sources.
- 5) Capture and exhaust contaminants from building equipment and activities.
- 6) Reduce contaminant concentrations through ventilation, filtration, and air cleaning.

Temperature, Humidity, Ventilation, Filtration

Space temperature, humidity and ventilation levels are paramount to meeting the OPR for indoor environmental quality and energy efficiency. The following tables highlight the typical indoor thermal comfort and ventilation requirements for occupied conditions. Temperature setbacks will be utilized when feasible. Setpoints may be adjusted based upon specific space requirements.

Table 3: Space Temperature		
Space Type	Cooling °F DB max %Rh	Heating °F DB
Conference Rooms	75°F, 55%RH	69°F
Office Spaces	75°F, 55%RH	69°F
Corridors	75°F, 55%RH	69°F
Public spaces	75°F, 55%RH	69°F
Classrooms	75°F, 55%RH	69°F
Dormitory spaces	75°F, 55%RH	69°F
Laboratories	Program Defined	
Auditoriums	75°F, 55%RH	69°F



Acoustics

As a target, all MEP systems shall conform to ANSI standards, with maximum permissible background noise of 40 dBA in all spaces. The following NC levels shall be the basis for maximum total equipment noise permitted in the areas noted:

Space Type	NC
Public Areas (corridors, entries)	35 - 40
Lounges	35 - 40
Private Offices	30 - 35
Conference Rooms	30 - 35
Classrooms and Auditoriums	30 - 35
Dormitory bedrooms	30 - 35
Laboratories	40 - 45

Acoustic design requirements similar to those stated in ASHRAE Handbook—HVAC Applications, Chapter 47, Table 42, Design Guidelines for HVAC-Related Background Sound in Rooms shall also be used as a reference.