UCSF Sustainability Action Plan:

Appendix V: UCSF Energy Targets and Strategies

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Proposed Targets

The existing buildings on the UCSF campus exhibit a wide range of energy intensities. Of the buildings reviewed, the range of reported energy intensity within each building category was sufficiently large to make the average energy intensity an unsuitable basis for setting energy reduction targets, particularly for new buildings. We would therefore recommend that targets be converted to absolute energy intensity values in kBtu/SF/Year that represent the initial goals. There are two main advantages to using absolute Energy Intensity values. The first is that the goals can readily be benchmarked against industry and peer institution performance, the second is that Energy Intensity is easily measured in completed buildings by evaluating actual energy consumption on an annual basis.

In lieu of the initial 30% improvement goal, we are therefore recommending an Energy Intensity that falls in the top quarter of comparable buildings. Broadly speaking, this goal represents an Energy Intensity that should readily be achievable with good design and construction practices, using conventional or well established systems, at little or no cost premium; in fact, some of the existing UCSF buildings are already meeting this target. In essence it represents good, but not exemplary performance.

In lieu of the 50% improvement goal, we are recommending an Energy Intensity that falls within the top ten percent of comparable buildings. Broadly speaking, this goal represents exemplary performance that will require innovative design, systems, and, to a large degree, building use.

The proposed targets are as follows:

	Current	**2014***	**2020***
Building Use	Current UCSF Range kBtu/SF/Yr	Top Quartile kBtu/SF/Yr	Top Decile kBtu/SF/Yr
Laboratories	248 – 370	170	120
Hospitals	308 – 504	*250	140
Offices	70 – 240	100	40
Classrooms	210 – 420	100	40

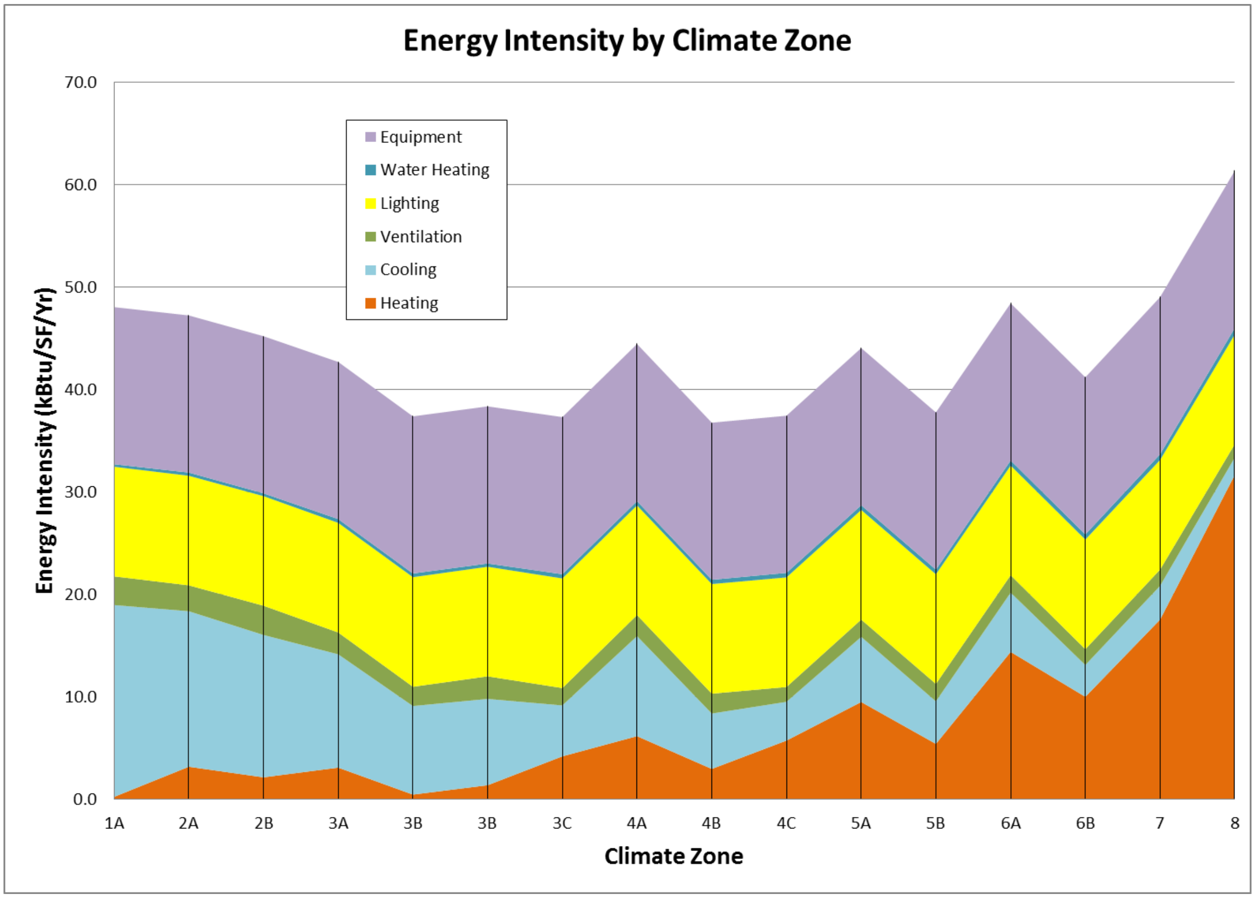
**Note that the numbers provided for 2014 and 2020 targets are reductions based on current building usage. Over time, the definition of top quartile and top decile will change.*

Energy Consumption Profiles

Energy use in a building can usefully be subdivided into five functional groupings, these being:

a. Lighting
b. Equipment and User Power
c. Heating and Cooling (Thermal)
d. Ventilation
e. Water Heating

The relative consumption varies greatly by region as can be seen in the following chart based on a Department of Energy (DOE) standard model. It should be noted that the model is based on a large office building that has a very low cladding to floor ratio, and the lighting and equipment values are standardized across all regions. This leads to very low overall Energy Intensity; nevertheless, it is indicative of the effect of climate on relative energy consumption. UCSF falls within climate zone 3C, one of the least demanding for heating and ventilation.



For laboratory buildings and hospitals, ventilation and cooling, and process equipment loads are significantly greater and so make up a far larger percentage of the total energy consumption.

Relative energy consumption varies not only between building types, but also within building groups depending on size and configuration.

Energy Efficiency Strategy Overview

Lighting

Lighting generally consumes between 8 and 15 kBtu/SF/Year. There is not a great variation between building types; laboratories and hospitals have only moderately higher lighting requirements than offices and classrooms.

Energy reduction strategies are relatively simple, being:

- Improve lighting fixture efficiency
- Reduce demand for lighting, particularly during daylight hours
- Improve controls to reduce unnecessary lighting consumption

Fixture efficiency: The baseline fixture in most designs is a T8 or T5 fluorescent fixture with high efficiency light distribution, with an installed lighting energy load of 0.75 to 1.00 W/SF. Reducing the load further requires using lower lighting levels, with increased task lighting, or using higher efficiency fixtures, such as LED. Reducing lighting levels lowers overall cast moderately. Adding LED fixtures currently is a significant increased cost, in the range of $25 to $30/SF, and is rarely done. As fixture quality improves and prices fall, LED uptake is likely to increase.

Reduce Demand: Reducing demand comprises both increasing daylight access and daylight penetration. For UCSF, most building footprints are set by site and program requirements leaving little opportunity for improving daylight access through building configuration. Good design, however, can appreciably improve the daylighting performance of buildings through appropriate glazing design, the use of light shelves and other shading and redirection strategies, and through the reduction of interior partitions. While maximizing daylighting, it is also necessary to avoid heat gain and glare. Generally good daylight design should be accomplished with little or no premium cost.

Improved Controls: Having ensured good daylight access and penetration, it is necessary to install control systems to limit unnecessary lighting. This typically includes both occupancy sensing and daylight dimming: often control of window blinds is incorporated into the control package. Control systems typically cost in the range of $2/SF for very basic systems to $8.00/SF for the more sophisticated systems.

Process Equipment and User Convenience Load

Equipment loads generally consume between 8 and 15 kBtu/SF/Year for offices, and as much as 30 to 40 kBtu/SF/Year for laboratories and hospitals.

As with lighting, energy reduction strategies are relatively simple, but can be harder to implement since they often involve greater impact on the users. The strategies are:

- Improve equipment efficiency
- Reduce equipment quantity
- Improve equipment controls

Improve Efficiency: Use high performance equipment, including Energy Star labeled equipment. While this can be readily incorporated for most standard office equipment, it can be challenging for laboratories and hospitals, where equipment is often selected for specific features or program requirements. Generally incorporating high performance equipment has little or no premium cost.

Efficiency can also be improved through building design, by provision of dedicated cooling loops or steam supplies for specific laboratory or hospital equipment. Dedicated cooling or steam loops add $3 to $5/SF.

Reduce Equipment Quantity: This is one of the most effective strategies, and one which reduces overall cost, but is one of the most difficult to implement, since it relies entirely on user implementation.

Improve Controls: As with lighting, equipment can be controlled through occupancy sensors to reduce standby loads. The cost of the sensors is relatively small, in the range of $1 - $2/SF

Heating and Cooling

Heating and Cooling is one of the most varied by region, as evidenced by the chart above. For UCSF, in region 3C, the cooling and heating load is relatively small, but there are still significant opportunities to improve the energy performance. For office and classroom buildings, the load can range from 15 – 30 kBtu/SF/Year. For laboratories and hospitals the load can range from 20 – 50 kBtu/SF/Year.

Energy reduction strategies are much more complex than for lighting and for equipment, although the basic principles are similar: reduce demand, improve efficiency and improve controls.

Demand Reduction: Demand reduction is primarily related to improving thermal performance of the envelope, including reducing solar gain through windows, and reducing the internally generated heat loads. For San Francisco, the climate is such that envelope thermal performance is not as critical as in more extreme climates such as Miami (Zone 1) and Anchorage (Zone 8); nevertheless there are appreciable gains to be made by optimizing the overall envelope and glazing performance.

Reducing internally generated heat load can include reducing lighting and equipment energy consumption, grouping heat-producing equipment, and providing dedicated equipment cooling systems. In addition, simply right-sizing equipment load can be a significant component, particularly for laboratories and hospitals.

Another example of load reduction is the elimination of heating and cooling, or the broadening of tolerance levels in selected spaces. This can be effectively incorporated into transitional spaces, lobbies and circulation areas, by using natural ventilation or passive convection systems. This not only reduces thermal energy, but also ventilation energy requirements.

Efficiency Improvement: There are many strategies related to improving efficiency of thermal energy delivery. These run from improving the heat or cool generation systems, to improving the efficiency of distribution and delivery to occupants.

Low cost, or conventional improvements include strategies such as:

- improved equipment efficiency in chillers, cooling towers, pumps, VFD controls and boilers,
- heat recovery, particularly for laboratory and hospital buildings
- low temperature reset
- commissioning

These should be accomplished within current budgets, and should be sufficient to deliver the initial target of top 25th percentile.

In order to reach the top decile it is necessary to incorporate innovative or non-conventional strategies. In some cases, particularly for offices and classrooms these can result in reduced cost as complexity and system dependence is reduced, but more commonly there are added costs. Strategies in this category can include:

- compressor free cooling: reduction or elimination of chillers through night time cooling with thermal energy storage (TESS), ground source heat rejection, etc.
- eliminating terminal reheat
- desiccant humidity control in lieu of cooling and reheat
- decoupling thermal energy and ventilation energy: using radiant heating and cooling independent of ventilation demand
- building thermal mass

These represent some of the more expensive strategies, which can add from $5 - $20/SF

Controls Improvement: Control systems should be such that thermal energy is only being delivered as needed. This can be accomplished by providing more demand load systems and smaller zones. Control improvements can add from $2 - $5/SF, recognizing that UCSF already uses sophisticated control systems on its buildings.

Ventilation

For offices and classrooms, ventilation energy is a relatively small component at 3 -5 kBtu/SF/Year. For laboratories and hospitals, however, the energy is appreciably higher, at as much as 35 – 70 kBtu/SF/Year. Reducing ventilation energy is therefore a significant target for laboratories and hospitals.

Energy reduction strategies are closely related to those for thermal energy reduction.

Demand Reduction: Reduce the overall air volume through off-hours ventilation set back, use of natural ventilation where possible, decoupling thermal and ventilation demand. For laboratories and hospitals, a major strategy is limiting areas of once-through air supply by separating laboratory and office zones, and isolating high air change areas. Most of these strategies will already be being incorporated into UCSF designs with no cost premium.

Efficiency Improvement: Improve equipment performance, right size fans for optimum power curve, use VFD. Most of these strategies will already be being incorporated into UCSF designs with no cost premium.

Controls Improvements: As with thermal energy, control improvement is focused on ensuring ventilation energy is used only as needed, through demand management and smaller zones. Again, most of these strategies are already in place at UCSF.

Water Heating

For UCSF buildings, water heating is almost inconsequential. Nevertheless, it is appropriate to economize in this area. Strategies include: point of use heaters for remote fixtures, low flow fixtures, use of high efficiency boilers, solar or reject heat heating, etc.

Cost Impact

Initial Target – Top Quartile

Meeting the initial target should not have a significant cost impact on the cost of new construction at UCSF. The California energy codes, and internal UC/UCSF policy already requires energy performance close to this target, with the exception of equipment load, which is regarded as 'un-regulated' under ASHRAE 90.1, and is not fully addressed in Title 24. Equipment load reductions can be sizeable, but they typically have more impact on equipment budgets and on user activity than on project cost.

Improved skin and glazing performance can typically be accommodated within existing envelope budgets through judicious design and attention to energy performance from the outset.

While incorporating the initial goals into current budgets should be achievable, it does require significant focus, and the use of integrated design processes to ensure that all systems and design elements are working together to deliver the higher performance demanded by the goal. Budgets need to be aligned with strategy from the concept phase, and design excellence/architectural character must be grounded in the demands of the envelope, glazing and daylighting efficiency requirements. We note that UCSF is already using Integrated Design principles, and that it is an industry and thought leader in this area. Continued commitment to this process, and to energy performance excellence should result in meeting the initial target within available budgets, or with very small increments.

Long Term Target – Top Decile

Meeting the long term target will be more challenging, and, with current technologies and construction practices, there will be additional cost. Over time, as the markets for high performance components and systems mature, costs should fall relative to conventional construction. Nevertheless, there is a cost associated with the higher performance. Again, however, it is worth noting that the new Mission Bay hospital is currently being designed to meet the top decile target, with little cost premium. Much of this is being accomplished through a high degree of integrated design and delivery.

The cost for the top decile goal can be broken down as follows:

Structural Frame

There should be no premium cost for the structural frame, recognizing that there are few, if any, opportunities to optimize building configuration and lease depth within the sites available to UCSF.

Cladding

Improve envelope thermal performance: Increase envelope insulation and air infiltration levels, improve glazing thermal and solar gain performance, optimize sunshading and light redirection, increase operability of windows (where appropriate)

For a typical UCSF building, the skin ratio to floor area is in the range of 0.6 SF of skin per SF of floor area. Glazing is in the range of 30% of skin area. An increase in skin cost of $10.00/SF for the opaque portion and $40.00/SF for the glazed portion (including sunshading/light shelves), would therefore result in an aggregate rounded increase in skin cost of $20.00, with an increase in cost per GSF of $12.00.

Roof

Improve roofing system: Incorporate high albedo roofing, increase insulation value.

For a typical UCSF building of four stories, the roof ratio is 0.25 to 0.30. Increasing the roofing cost by $5.00 leads to an increased cost per GSF of $1.00 to $1.50

Interior Construction

Increase transparency in interior partitions in office and laboratory buildings. Increasing transparency is not generally practical in hospitals or classroom buildings.

For a typical UCSF office building, the interior partition density is around 9 LF of partition per 100 GSF. For a laboratory, it is around 7 LF per 100 GSF. Current interior glazing is in the range of 2 – 3% of partitions being glazed. Increasing the ratio to 25% glazed, would lead to an increase in average partition cost from $20/SF of partition to $35/SF of partition, resulting in an increase in cost per GSF of $10.00 for laboratories and $12.00 for offices.

Mechanical Systems

For Office and classroom buildings, optimizing mechanical system performance, both for thermal and ventilation energy, will cost in the range of $3.00 to 8.00/GSF. For Laboratory and hospital buildings, the optimization can cost in the range of $5.00 to $15.00/GSF.

Electrical Systems

Optimizing lighting systems using current technology is largely within the current UCSF design baseline, and moving to technologies such as LED is not practical or economically feasible. It is likely, however, that within the next five to ten years the newer technologies will mature sufficiently to be incorporated into new buildings at UCSF. Clearly the cost is not knowable, but for them to be readily adopted into the broader marketplace, the cost premiums will have to fall within the range of $5.00 to $10.00/GSF.

Cumulatively, these premium costs could add $20 - $40/GSF to office and classroom buildings, and $30 to $50/GSF for laboratories and hospitals. These costs are likely to fall over the period of the goal as technologies and practices change, and as the strategies become more widely adopted. The costs may also be able to be offset to some degree by increasing use of Integrated Project Delivery, which is increasingly delivering higher performing buildings for lower cost.