University of Nebraska - Lincoln

Campus Energy Management Plan
2010

1 Executive Summary

This Campus Energy Management Plan sets forth a goal of reducing energy consumption in state funded buildings on city and east campuses by at least 15% by 2015. The existing campus energy infrastructure and current building energy use indices are presented to provide background and context.

Several concurrent energy conservation strategies are recommended to meet the stated reduction goal. These encompass the functional areas of: existing buildings, new construction and renovations, utility plants, energy data collection and analysis, communication, energy project processes, and energy information systems.

In addition to the main goal of energy reduction, this plan will achieve several other objectives including:

- Reduction of energy costs, peak electric / gas loads and greenhouse gas emissions
- Improved communication with the campus community regarding energy usage and ongoing conservation efforts

2 Introduction

The Board of Regents Strategic Planning Framework (2005-2008) lists six overarching goals and objectives to guide campus planning. The first five of these deal with excellence in education, research, outreach and service to the citizens of Nebraska. High-quality, appropriate facilities are required to support these goals. The sixth objective states that *The University of Nebraska will be cost effective and accountable to the citizens of the state*. It expands this goal, emphasizing that *efficiencies in design and operation are demanded in every building, design and renovation project*, and commits to *sustainable construction and operation methods that save building and energy cost.*

In support of this goal, we have developed this Campus Energy Management Plan so that we may continue to minimize the energy costs of operating UNL facilities through sustainable design, timely maintenance and efficient operation, while supporting the University's goals of excellence in education, research and outreach.

This plan will expand and build upon the verifiably successful track record of our past energy conservation efforts*: Between 2000 and 2009, total campus utility plant energy input has decreased by over 21% even though the total building area served by the utility plants has increased by over 840,000 square feet* (See Figure 1 in Section 3.1).

2.1 Campus Context

The University of Nebraska–Lincoln (UNL) is a land-grant research university originally chartered in 1869. Enrollment for the Fall 2010-2011 term was 24,610 students.

UNL has two primary campus facilities within the city of Lincoln: City Campus located immediately north of the downtown area, and East Campus located 1-1/2 miles east. Total City and East campus building area exceeds 12.6 million sq ft.

2.2 Scope

This plan focuses on strategies to reduce energy use in UNL's State-funded buildings and utility plants located on City and East Campuses. There are many other related stakeholders on campus (Landscaping, Custodial, Auxiliary Buildings, Transportation, Chancellor's Commission on Environmental Sustainability, Information Services, etc) and we recommend soliciting comments and support from all these groups when developing future revisions of this Plan.

2.3 The Energy Management Imperative

From 2002 to 2009, UNL's annual energy expenditures for state funded buildings have grown from $ 10.2M to $17.3M (non adjusted dollar amounts), an overall increase of 69%. During this same time span, total campus building area has only increased by 6%. UNL's energy costs are the second largest budget line item, exceeded only by salaries and benefits.

Energy costs will most certainly continue to add pressure to UNL's overall budget situation. However, there are also many global trends that suggest energy reduction efforts will become even more critical to the success of any large organization (1)(2)(3):

- Global demand for all energy sources is forecast to grow by 57% over the next 25 years.
- U.S. demand for all types of energy is expected to increase by 31% within 25 years.
- By 2030, 56% of the world's energy use will be in Asia.
- Electricity demand in the U.S. will grow by at least 40% by 2032.
- New power generation equal to nearly 300 (1,000MW) power plants will be needed to meet electricity demand by 2030.
- Currently, 50% of U.S. electrical generation relies on coal, a fossil fuel; while 85% of U.S. greenhouse gas emissions result from energy-consuming activities supported by fossil fuels.

We must control energy usage so that UNL can continue to focus on education, research and service to Nebraska.

2.4 Goals

Our goal is to reduce UNL's utility use by at least 3% per year for each of the next 5 years, with a minimum total reduction of 15% by 2015. (This will be calculated based on FY 2008-09 utility usage and corrected for normal weather conditions).

Concurrent objectives which will follow from the primary goal above, are

- Reduce energy cost (per square foot, constant dollars),
- Reduce peak electric and gas requirements,
- Reduce greenhouse gas emissions,
- Set an example of sustainability and green leadership, and
- Provide information to the campus community in order to help others reduce their energy use.

3 Existing Campus Energy Infrastructure

The following section discusses the existing campus energy infrastructure. This includes energy sources such as purchased utilities and generated utilities, distribution systems, and finally, energy end uses such as building lighting, equipment loads and HVAC systems. This infrastructure is monitored and controlled via several information technology components.

3.1 Purchased Utilities

Externally purchased electricity, natural gas and fuel oil are provided by NUCorp, a non-profit corporation created in 2001 between UNL and Lincoln Electric System (LES). The majority of these energy inputs are delivered to the utility plants (See Section 3.2) on city and east campus where they are either consumed to produce chilled water and steam or in the case of electricity, distributed to campus buildings.

There are some buildings located on the periphery of campus that are not served by either of UNL's two utility plants. Electricity and/or natural gas is delivered to these facilities directly using the local utility company's distribution system.

Figure 1 shows the past ten year usage pattern for the major energy inputs delivered to the campus utility plants (Note that 1 MMBtu = 1 Million Btu).

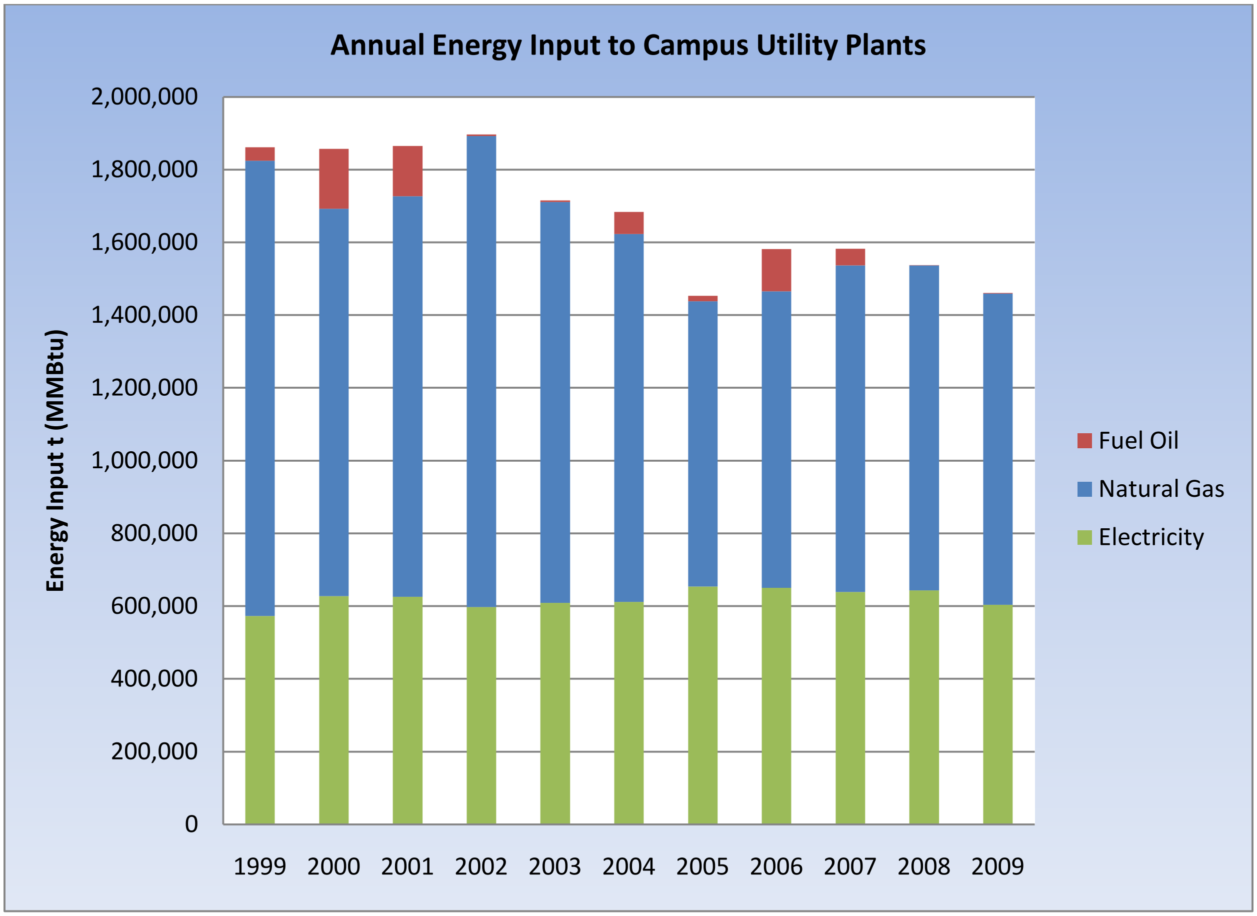

Figure 1: Annual Campus Utility Plant Energy Inputs

3.2 Generated Utilities and Distribution

City and East Campuses are each served by a dedicated utility plant that produces steam and chilled water for campus heating and cooling needs. Current plant capacities are listed in Table 1.

	City Campus Utility Plant	East Campus Utility Plant
Steam (Lbs / Hour)	360,000	220,000
Chilled Water (Tons)	20,000	7,000

Table 1: Campus Utility Plant Capacities

The total building area served by the utility plants is approximate 9.4 million gross square feet.

As a point of reference, the combined heating and cooling capacity of both plants is sufficient to heat and cool approximately 5000 single family homes of 2000 sq ft.

Steam, chilled water and electricity are fed to individual buildings via separate distribution systems for each utility.

3.3 Campus Buildings

UNL's existing building stock on City and East campuses is comprised of over 12.6 million gross sq ft spread over 239 buildings. Table 2 details how various campus functional uses are distributed among these buildings.

Usage	Number of Buildings	Total Sq Ft	%
Athletics	13	1,515,405	12%
Classroom / Office	59	3,396,802	27%
Federal	3	22,208	<1%
Housing	45	2,195,683	17%
Parking	3	1,352,484	11%
Public	18	1,255,334	10%
Research	32	1,923,651	15%
Service	21	848,006	7%
Miscellaneous	45	113,778	1%
Total	**239**	**12,623,352**	

Table 2: Campus Building Functional Usage Distribution

See Section 4.8 for current annual energy density and total energy use for major state funded buildings.

3.4 Energy Information System

The Energy Information System (EIS) represents the Information Technology (IT) component of the existing campus energy infrastructure. This section discusses the major components of the existing EIS currently deployed on campus.

3.4.1 Building Automation System

The first elements of UNL's Building Automation System (BAS) were deployed in the 1960's and it has been continually expanded and upgraded since that time. Expansion occurred to support new construction and as a result of replacing traditional pneumatic controls in existing buildings. There are some smaller campus buildings still served by pneumatic controls as well as some remaining pneumatic room temperature controls in larger buildings.

The BAS currently serves over 6.5 million square of building space and encompasses over 39,400 Input/Output devices and 19,000 control logic elements. It is one of the largest in Nebraska and its replacement cost has recently been estimated to be $26M-$40M (4).

Beginning in 1978, all major BAS hardware and software development has been accomplished primarily on an "in-house" basis. A small number of auxiliary buildings employ commercial systems and are maintained through service contracts with the manufacturers of those systems.

With regards to energy conservation, the relevant functions and responsibilities of the BAS include:

- Operating HVAC systems in a manner that minimizes energy usage while ensuring that building programmatic requirements are satisfied.
- Generating notifications and alarms if HVAC systems are not operating in an energy efficient manner or if the system is behaving in a way that places building systems at risk.
- Collection of hourly usage data associated with various types and numbers of utility meters (i.e., chilled water, steam, electricity, etc.).

3.4.2 Utility Meter Management and Reporting Framework

Utility meters are currently installed on campus to measure steam, chilled water, electricity, etc. These meters can be categorized by their data collection mechanisms:

- Meters that are connected directly to our BAS. These report usage on an hourly basis.
- Municipal Meters. These meters are located primarily on the periphery of the campus and are read monthly by the relevant utility company (e.g., Lincoln Electric System).
- Manually Read Meters. These are owned by UNL and are read monthly by UNL personnel.

The Utility Meter Management and Reporting Framework is comprised of application software and database elements whose major functions are as follows:

- A repository for monthly utility data.
- Engineering and maintenance related information for all meters.
- Relationship mappings of meters to campus buildings. This is not a trivial component since one building may be served by several meters of the same utility type whereas another building may "share" a utility meter with second building. There are many other special meter to building mapping circumstances that are also handled.
- Utility usage reporting and analysis. Preliminary work here includes a building usage website and energy analysis tools that have been added to the BAS.

A significant portion of software for this framework was developed during 2009-2010.

3.4.3 Utility Plant Control Systems

Both city and east campus utility plants use a control system that is comprised of Programmable Logic Controllers (PLC's) and a third party data aggregation / user interface software package provided by Wonderware (5).

There are currently 3500 input / output points connected to this system. Because of the nature of large utility plant operations, most plant equipment is currently controlled manually with software displays used for monitoring purposes only.

4 Recommended Energy Management Strategies

The following sections outline the strategies we will employ in order to achieve the goals set forth in Section 2.4. Our strategies fall into the following functional areas:

- Existing Buildings
- New Buildings and Major Remodels
- Utility Plants
- Energy Data Collection and Analysis
- Communication
- Energy Project Processes
- Energy Information Systems

It should be noted that we will not be starting from a zero baseline with no energy conservation whatsoever. We have completed many successful energy conservation projects, strategies and initiatives over the last 20-30 years, examples of which include:

- Room occupancy sensing in several buildings.
- Conversion of dual duct constant air volume to variable air volume systems.
- Heat recovery systems on 100% outdoor air handlers.
- Laboratory ventilation curtailment during unoccupied hours.
- Replacement of old, leaky dampers and actuators.
- Installation of individual electronic room thermostats.
- Implementation and deployment of optimized control algorithms.

Taking energy input data from Figure 1 (Section 3) and building construction data furnished by UNL's Office of Institutional Research and Planning, the following statement can be made: *Between 2000 and 2009, total campus utility plant energy input has decreased by over 21% even though the total building area served by the utility plants has increased by over 840,000 square feet*. We believe that this is a direct result of the success of our past energy conservation efforts.

4.1 Existing Buildings

In order to meet our energy conservation goals in our existing buildings, we must focus on those systems and buildings that yield maximum results for the minimum amount of time and capital resources expended. For example, Heating, Ventilating and Air Conditioning (HVAC) systems and lighting systems make up 83 - 90% of the energy consumed in a typical campus building. The remaining 10 - 17% is comprised of miscellaneous equipment and plug loads. We therefore recommend concentrating the majority of our energy reduction efforts on HVAC and lighting.

In order to provide further focus, we will indentify and rank the top 10-15 campus buildings which offer the greatest HVAC and lighting energy savings potential. Our rankings will be updated and refined as our other strategies are implemented.

The following sections discuss our recommended strategies for existing campus buildings to reduce HVAC and lighting energy use.

4.1.1 Reduce Building Operating Hours

Reducing building HVAC operating hours has the potential to provide significant reductions in energy use by shutting off equipment and letting space temperatures "float." We propose to document the reduced operating hour energy savings potential for all major classroom / office buildings. We will then partner with Registration and Records to reduce the number of buildings that need to be operated during evenings and weekends.

Another impediment to reducing HVAC operating hours is the local installation of server computers used by faculty. We will continue to identify these types of installations and work with Information Services and other campus units to remedy the situation. Typical solutions involve either relocating servers to a centralized location or installing a small, dedicated space conditioning unit.

4.1.2 Reduce Fume Hood Usage

A typical fume hood on campus has an annual energy cost of approximately $4000. This high energy / cost penalty is primarily due to heating and cooling the outside ambient air stream which is then exhausted after a single pass through the building. We therefore propose an aggressive strategy of reducing campus fume hood usage by:

- Educating and providing incentives for laboratory personnel to close fume hood sashes unless they are actively using the hood.
- Installing additional laboratory ventilation curtailment controls where appropriate.
- Finding and decommissioning hoods that are no longer needed to fulfill space programmatic requirements.

4.1.3 Commission High Energy Use Buildings

Commissioning of existing buildings (also known as "retro-commissioning") can be defined as:

"... a systematic process for investigating, analyzing, and optimizing the performance of building systems by improving their operation and maintenance to ensure their continued performance over time." (6)

Based on recent retro-commissioning case studies(7), expected energy savings range between $0.11 - $0.72 per square foot.

We will focus our retro-commissioning efforts on a subset of campus buildings. These buildings will be selected based on their current energy usage, square footage and energy savings potential.

Subsequent revisions of this master plan may involve expanding this strategy to additional buildings as well as establishing a frequency at which retro-commissioning should be performed.

4.1.4 Building Automation System Expansion

As funds become available, we will continue to expand our Building Automation System (BAS) in the following ways:

- Install new BAS equipment in those buildings that are now fully or partially served by old pneumatic controls. This will extend the breadth of our HVAC operation optimization strategies.
- Continue to install occupancy sensors in those offices already equipped with our electronic thermostats.
- Convert constant speed pumps and fans to variable speed operation.
- Develop a preventative maintenance program for BAS sensors and actuators to insure that the BAS is reading inputs and controlling outputs correctly.

4.1.5 Lighting

The majority of general interior lighting at UNL is fluorescent and most has been converted to T8 lamps with low-power electronic ballasts. In newer buildings, T5 lamps have been specified and installed. We propose to achieve additional lighting energy savings in the following ways:

- Continue upgrading fluorescents to more efficient technologies as older T12 lamps need service.
- Adjust lighting to improve quality while reducing the number of fixtures.
- Add controls to automatically turn off or dim fixtures to appropriate levels.
- Continue to educate users about the importance of turning off unneeded lighting.
- Continue to identify and take action on exterior lighting that is not necessary or is on at inappropriate times.

4.2 New Buildings and Major Remodeling

This section discusses our recommended strategies for reducing energy consumption in newly constructed buildings as well as major building remodels.

4.2.1 Start-up Commissioning On High Energy Usage Buildings

Commissioning of new buildings is an additional quality assurance mechanism that has seen widespread adoption in the last 8-10 years:

"Building commissioning provides documented confirmation that building systems function according to criteria set forth in the project documents to satisfy the owner's operational needs." (8).

Commissioning can uncover HVAC system issues and problems that create energy waste. Unfortunately, the cost of a rigorous and well documented commissioning process can be substantial. One common metric is 0.5% to 1.5% of total construction costs depending on the complexity of the facility(9). In order to strike a balance between commissioning costs and results achieved, we will champion the adoption of start-up commissioning for all new and remodeled laboratory and other high technology buildings.

4.2.2 Champion Energy Efficient Designs for Major Remodels and New Construction

We propose to intensify our efforts to champion building systems that minimize energy usage . The greatest impact can be achieved by having our energy engineers involved in the early design phases of any major project to verify that the design conforms to widely accepted guidelines for sustainability and energy conservation (10)(11). As part of this effort, we propose requiring A/E design teams perform and document energy simulations so that we may quantify all energy impacts of a major renovation or new construction. We will work closely with Facilities Planning and Construction to insure that design guidelines and processes are aligned with this strategy.

4.3 Utility Plants

The two campus utility plants are major consumers of electricity, natural gas and fuel oil. Our energy management efforts in the utility plants will concentrate on:

- Ensuring that that NUCorp continues to optimize gas, oil and electricity purchases.
- Continue existing efforts associated with equipment dispatch and performance.
- Continue efforts to obtain funding for previously identified capital construction projects that reduce plant energy consumption.

- Minimizing energy losses in the campus utility distribution systems including additional insulation and steam trap leak detection.
- Investigate alternative energy sources for steam and chilled water production.
- Explore new strategies to predict, detect and respond to electrical loads in order to minimize peak demand.

4.4 Energy Data Collection and Analysis

In order to provide historical context and baseline values for future analysis, we will continue to gather campus utility plant and building energy consumption data. Collected data will be used to generate various types of energy analysis and reports:

- Building and utility plant baselines
- Building benchmarking
- Utility distribution losses
- The ability to predict what a particular building or overall campus energy use should be at some time in the near future.

This effort will also allow us to develop a Statement of Energy Performance (SEP) metric for every state funded building as required for EPA's "Energy Star" program (discussed in Section 4.5).

4.5 Communication

We will develop a clear strategy to improve communications with university administration and the overall campus community. Specific areas of focus include:

- Quarterly reports which outline progress towards meeting the goals set forth in this plan. These reports will also include specific information regarding the costs, paybacks, energy savings and cost avoidance of all energy conservation initiatives implemented.
- We will join over 200 other institutes of higher education in the EPA's "Energy Star" Partner program. This will reinforce our commitment to energy conservation, provide additional benchmarking opportunities and provide EPA recognition for buildings that meet "Energy Star" ranking criteria.
- Develop web based resources and dashboards to increase energy usage and carbon footprint awareness and to communicate our diligence and success.
- Develop additional training and outreach for Deans, Directors and occupants concerning appropriate energy conservation behaviors.

4.6 Improved Energy Conservation Project Processes

We will work towards improving our internal processes related to energy conservation project scoping, prioritizing, funding and verification of savings.

For initial project scoping and prioritization purposes, we will maintain a database of energy conservation projects with estimated design/construction costs and energy savings. Energy projects will be prioritized based on several factors including: internal rates of return, building energy use metrics (see Figure 2 and Figure 3, Section 4.8), remaining building systems lifespan, etc. As periodic or one time funds become available, we will then be able to react quickly with a set of predefined projects.

Obtaining funding for energy conservation projects can often be a challenge even with an attractive internal rate of return. We propose setting up a revolving loan fund to pay for such projects. Once the fund is established with some seed money, balances would be replenished and increased over time using operating cost offsets achieved through energy conservation.

Our energy savings verification efforts will be aided by the Energy Information System strategies discussed in Section 4.7. Once the energy savings for a particular project have been sufficiently verified with real data, these savings will be entered into the project database previously discussed.

We will also look to expand our overall project delivery volume by working with Energy Service Contractors (ESCo's). ESCo's are private sector entities that offer energy project scoping, design and potential financing. A major differentiating factor between an ESCo and a traditional engineering design firm is that the ESCo will assume the risk associated with guaranteeing that a particular project meets the documented energy reduction target.

4.7 Energy Information Systems

This following section discusses specific Energy Information Systems (EIS) recommendations within the functional areas previously outlined in Section 3.4.

4.7.1 Building Automation System

- We will create a campus energy management and control operations center to be staffed by Building Automation System (BAS) operators and energy engineers. Multiple monitors will display separate information feeds: live and historical data from buildings, utility plants and campus distribution systems, BAS alarms, campus notices and alerts, weather data, etc. This operations center will benefit our energy reduction efforts through improved understanding of and reaction to energy flows as well as better communication between energy engineers, BAS operators and utility plant operations personnel.

- Investigate load shedding algorithms to lower peak electricity demand during hot summer weather.
- We will develop mechanisms by which real-time data from Utility Plants can be accessed by BAS operators.

Additional BAS capabilities and features will create positive outcomes for reducing energy usage. However, a continued hardware and software development effort must be sustained over the long term. Such development is critical to the success of our in-house BAS and our energy management efforts. Failure to continue in-house BAS development will ultimately result in a system that is obsolete, difficult to maintain and no longer meets the needs of the University. The economic impact of system obsolescence ($26-$40M) (4) is too great to ignore.

4.7.2 Utility Meter Management and Reporting Framework

Our utility meter management and reporting framework will be enhanced and expanded by:

- Developing and refining both long term trending and real time energy analysis tools. These tools will help us to identify energy deviations and help us to predict future energy usage.
- Working with the Accounting Department within Business and Finance, we will incorporate municipal meters into our framework including new data entry and data import mechanisms.
- Again working in concert with accounting personnel, we will develop additional utility usage reporting capabilities. The ability to identify usage by functional departments will provide further benchmarks and incentives for energy reduction.
- Additional sub-metering to major HVAC systems in high use buildings will be investigated and installed where appropriate.

4.7.3 Utility Plant Control Systems

- We will develop the necessary IT infrastructure so that both campus utility plant operational data (e.g., pressures, temperatures, run-times, etc.) can be gathered and archived for long term trending and analysis.
- We will add the necessary software components so that remote login to the utility plant control system becomes possible This will allow personnel to check on plant operations between city and east campus as well as from off-campus.
- Additional utility plant operational dashboards and user interfaces within the energy management control center discussed in Section 4.7.1 will be provided.

4.8 Existing Building Energy Usage Metrics

The current energy density (Kbtu / Gross Square Foot) and total energy usage (Kbtu) for major state funded campus buildings can be seen in Figure 2 and Figure 3 as follows.

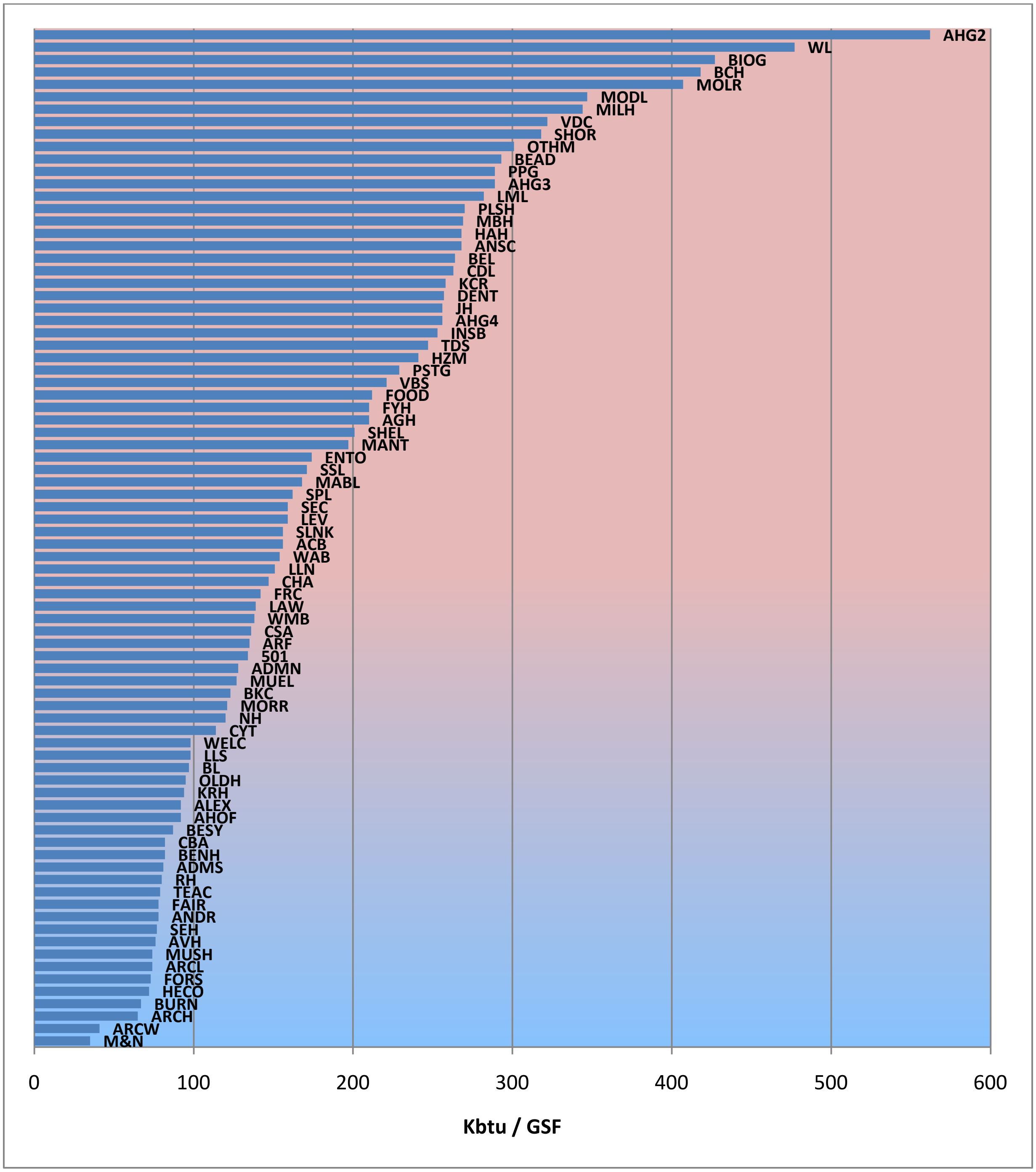

Figure 2: Existing Annual Energy Densities for Major State Funded Buildings

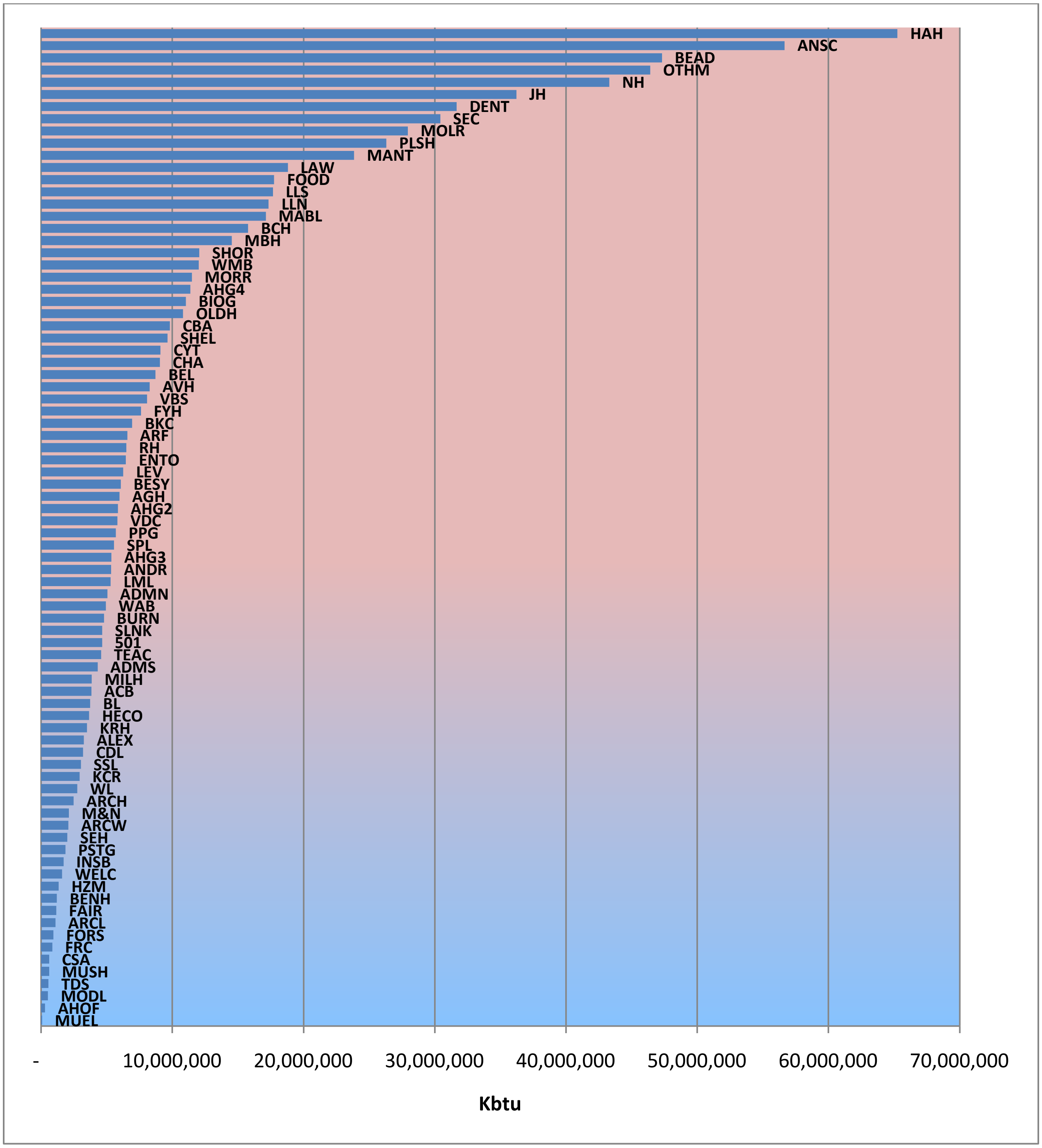

Figure 3: Existing Total Annual Energy Usage for Major State Funded Buildings

4.9 References

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