

# Opening Duke University's Energy Data

by

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## Abstract

Duke University stores and maintains a variety of data regarding energy and water consumption on its campuses. These data have traditionally been known to and accessible only by Duke's Facilities Management Department (FMD), and a limited set of other personnel. As interest in sustainability increases at the University, students and faculty undertaking energy and water analyses, efficiency, and conservation projects will need access to these data. Similarly, the Facilities Management Department, which is actively working to help Duke achieve its carbon neutrality goal of 2024, stands to benefit from collaboration with students and faculty to analyze data and find opportunities for conservation.

This master's project sought to build stronger relationships between the academic and Facilities communities. The project included writing several online resources to improve FMD's communications with the rest of the University regarding energy use and energy data. Among those resources is a short form students and faculty can use to request energy data access, which is backed by a simple new approval process proposed to FMD. An energy data visualization was created to demonstrate an original use for energy data. The project also identified and assisted the growth of several discrete collaborations between FMD and Duke's academics, as a means to induce broader academic research on the University's utility data.



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## 1. Introduction

In 2007, Duke University signed the American College & University Presidents Climate Commitment (ACUPCC), "committing the university to develop an institutional plan to achieve climate neutrality." (Sustainable Duke, 2009) To meet its obligation to the ACUPCC, Duke has established a Climate Action Plan, which lays out a plan for a long-term decrease in GHG emissions.

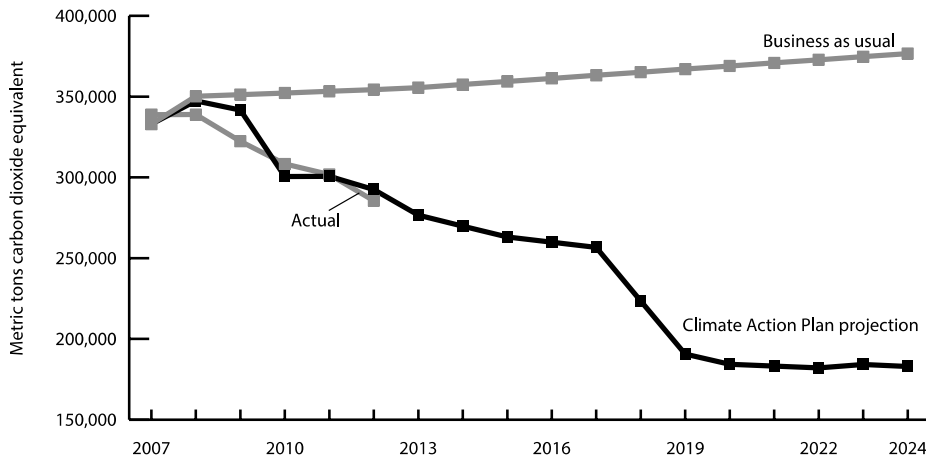


Figure 1 Duke's Climate Action Plan GHG reduction projections

Figure 1 shows that Duke's Climate Action Plan calls for a 45% reduction in emissions by 2024. As of 2012, the University is on target to meet this goal. The reduction to date is primarily from Duke University's discontinuation of coal as an energy source, and from Duke Energy reducing the GHG intensity of its energy mix (Sustainable Duke, 2012a).

As with any large-scale institutional reduction in emissions, contributions will need to come from all members of the Duke community. During a public engagement on



October 4, 2012, President Richard Brodhead spoke on GHG reduction:

*"It takes acts by the administration, it takes choices at a high level. But it can't be solved by administration entirely either, it actually has to be solved by the behavior of everybody all day long." –President Brodhead (Duke Human Resources, 2012)*

Figure 2 President Brodhead discusses climate neutrality on October 4, 2012

Importantly, President Brodhead pointed out Duke's unique position to go beyond making simple operational changes, as might happen in a traditional commercial setting. He said:

*"We want our researchers to produce the new answers for the future that will enable the world not to use energy as wastefully as it currently does." –  
President Brodhead (ibid)*

On the broadest scale, this project is designed to help Duke University on the road to turning that vision into a reality.

Duke's Durham campus is home to 175 buildings, which are actively managed by the University's Facilities Management Department (FMD). Because FMD is responsible for handling energy issues, this group has borne the brunt of the work in pushing Duke to reach its carbon neutrality target.

Duke is also home to one of the leading interdisciplinary energy studies programs in the country, in the Nicholas School of the Environment. The University also offers world-class educations in undergraduate and graduate science, engineering, technology, and math.

There is substantial potential for collaboration between FMD and the academic departments at Duke University. Generally, "facilities managers at colleges and universities often pride themselves on being nearly invisible to the students, faculty, and staff at their universities." (Devoy, 2012, p. 40) Facilities managers at Duke have started breaking with this trend, and are already making efforts to bridge the gap between the academic and operational worlds. Those efforts include through co-teaching a course in the Nicholas School, and working with a few individual students on real-world facilities projects. Nonetheless, substantial potential for collaboration remains.

Collaborative projects can potentially reveal new insights into how campus energy use can be managed and reduced, help prioritize abatement actions, model and forecast building energy consumption, and optimize on-site generation strategies, among other ideas.

These collaborations will not occur spontaneously, however. Researchers (used in this document to refer to students and faculty) must first be interested in exploring local questions about energy, and FMD must be willing and interested to work with them.

One potentially powerful technique to spur these collaborations is to simply make information about the possibilities more available. Although Duke is a friendly community, with 3,262 faculty and 14,591 students (Duke Office of News &

Communications, 2012), it can be difficult for an interested researcher and an appropriate facilities expert to meet and form a team.

This master's project has sought to move a considerable amount of information about energy use at Duke on to the web, to help pave the road for more extensive collaboration between the academic community and FMD. It has also sought to substantially lower the barriers for an academic researcher to get data about campus energy consumption, under the hypothesis that easy access to a rich data set will draw inquisitive minds.

In conducting interviews and meetings for this project, substantial anecdotal evidence emerged that there is interest in campus sustainability across a broad array of disciplines. The University as a whole, individual researchers, and the Facilities Management Department stand to gain considerably from closer collaboration and information sharing in the future.

## 2. Background

### 2.1 Origin of the project

Duke University's Energy Initiative ([energy.duke.edu](http://energy.duke.edu)), which launched in 2011, is a University-wide organization that seeks to engender "new research collaborations that span academic disciplines and institutional boundaries" on energy issues (Duke University Energy Initiative). Building collaborations that address energy use at the University is a natural undertaking for the Initiative. When the Initiative started looking into campus-focused projects in 2011, it quickly became clear that data about energy use were difficult to obtain. This master's project emerged as a result.

### 2.2 Climate Action Plan

Duke has designated 2024 as its target for net zero greenhouse gas emissions, in part because 2024 will be the 100<sup>th</sup> anniversary of the founding of Duke. Duke has maintained in its Climate Action Plan that it will eliminate 45% of its GHG emissions, and purchase offsets for the balance. From 2007 through 2012, Duke has successfully stayed on its projected path of emissions reduction.

Moving forward, it is likely that keeping up with carbon reduction goals will require a mix of strategies that call for both centralized abatement actions and contributions from community members. The 2012 Greenhouse Gas Inventory Update cited "commuting, energy conservation, and air travel" as the source for the next tier of reductions. (Sustainable Duke, 2012a)

While getting Duke community members to participate in helping the University achieve its climate neutrality goal seems a viable prospect, quantification of efforts will play an important role. Conservation measures will need to be prioritized by cost versus benefit, progress will need to be measured, feedback will need to be given to those taking action, quantitative experiments will need to be designed, et cetera. Access to data – in this case energy and water consumption data – is a prerequisite to quantification of results.

### 2.3 Energy data at Duke

Broadly, the following building utility data is available at Duke.

Group	Steam	Chilled Water	Electricity	Water
Students & faculty	Monthly	Monthly	Monthly	Monthly
FMD employees	15 minute	15 minute	Monthly, some 15 minute	Monthly

**Table 1 Duke utility data**

(Strictly speaking, "energy data" refers to steam, chilled water, and electricity data, whereas "utility data" includes water as well. Most of the data issues facing these utilities are similar, and the terms are usually interchangeable.)

Steam is used primarily for heating, as well as some processes in laboratories, such as equipment sterilization. Chilled water is used for cooling. Water refers to potable water, which is used in faucets, drinking fountains, and other standard plumbing fixtures.

Rows distinguish groups with different levels of access. Columns distinguish utilities. "Monthly" and "15 minute" refer to the periodicity at which consumption figures are recorded.

Steam and chilled water are produced at central plants on Duke's campus, which are managed by FMD. Natural gas and electricity are the fuel sources, respectively. Electricity is brought in from Duke Energy at high voltage, and stepped down for campus use. Potable water is delivered from the City of Durham.

Monthly consumption data for these utilities is available in a web-based software package called EnergyWitness. EnergyWitness is a Microsoft SharePoint-based data storage, retrieval, and visualization system created by IDS Systems.



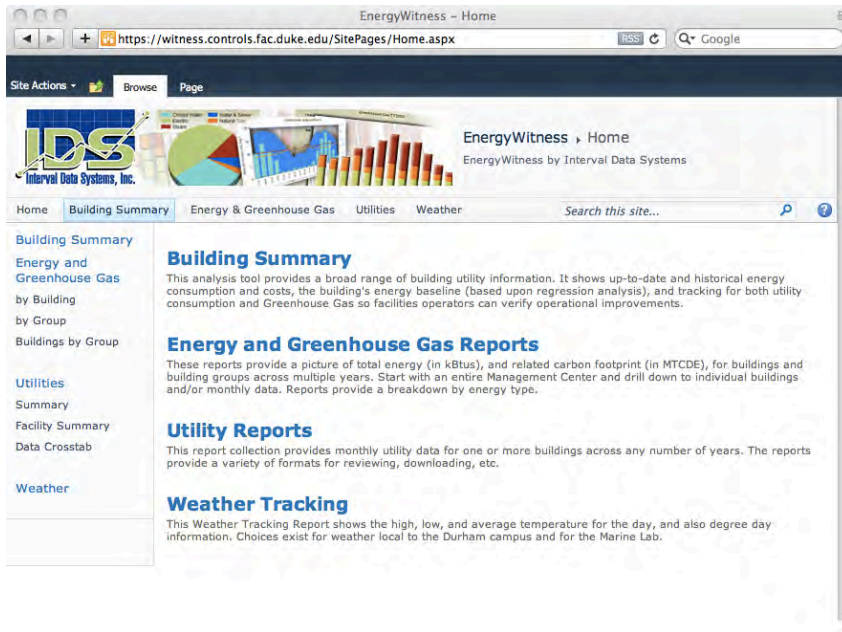


Figure 3 EnergyWitness homepage

Students and faculty can ask FMD for access to EnergyWitness on an individual basis. The student or faculty's NetID is added to a special list of authorized users if his or her request is approved.

Some FMD employees also have access to the building automation system (BAS) at Duke. A BAS is a computer system which controls electromechanical equipment in a building, such as HVAC, fire suppression, security controls, and lighting. Not all of a building's electromechanical equipment is necessarily connected to a BAS, as some buildings use old equipment which does not offer a digital interface.

The BAS is used by FMD in its daily operations. Because accidental misuse of the BAS could result in jeopardizing building occupant safety, FMD cannot offer direct access to the system to non-employees. However, data from the BAS, which can be both more frequent and more granular than what is available through EnergyWitness, can be exported from the system by Facilities personnel.

The information listed in Table 1 is only a summary. Many buildings at Duke are not metered individually, or are metered for some utilities but not all. Individuals interested in more detailed information should contact FMD's [Energy Manager](#).

## 2.4 Facilities' Strategic Initiatives

The Facilities Management Department is responsible for the operation, planning, and construction of campus facilities. In Duke's fiscal year ending 2012, FMD managed \$82 million worth of construction projects (Facilities Management Department, 2012), in addition to managing the 175 buildings on campus,

maintaining the grounds and roads, and operating the campus energy plants (FMD). FMD is primarily housed in [Smith Warehouse](#), on the border of East Campus.

The Facilities Management Department has a substantial charge to keep all Duke buildings operating safely and as designed throughout the year. Their mission is to "provide excellence in planning, design, construction, operations and maintenance for Duke University's facilities, grounds, and utilities in a safe, customer-focused, efficient and sustainable manner." (FMD, 2008) This mission does not encompass engagement with building occupants about energy use, nor is that topic among their strategic initiatives (ibid).

As New Buildings Institute and others have documented, occupant behavior can play a major role in building efficiency, particularly in cooling climates such as North Carolina. (Heller, 2011) However, as Duke's Climate Action Plan begins to necessitate changes in building occupant behavior, other organizations, such as Sustainable Duke, the Duke University Greening Initiative (DUGI), and similar groups will need to address the issue, absent a change in FMD's strategic initiatives.

## 2.5 Open Data

While no official definition exists, "open data" can be described as data that are provided by a researcher or organization under terms that explicitly allow for interested parties to use those data without obtaining individual permission, signing contracts, requiring sharing of results, or surmounting any other encumbering factors.

In recent years, many kinds of organizations, including private companies, universities, and government agencies, have decided to open data for use from outsiders. Purposes vary, but most organizations cite advancement of their own goals as the primary rationale for opening data.

## 2.6 Related work

### 2.6.1 Peer work at other universities

#### *Arizona State University*

Arizona State University's Campus Metabolism is custom software that shows electricity, heating, and cooling demand on a per-building basis for ASU's campus. The software allows users to look at both historical and current data in clear visual graphs, as well as to download data for their own analysis. (Arizona State University)



Figure 4 ASU Campus Metabolism

### Campus Conservation Nationals

In 2013, roughly 150 higher education institutions are participating in USGBC's Campus Conservation Nationals, a nationwide competition among resident halls at American colleges and universities to reduce per capita energy use. The participating institutions include UNC, Brown, Princeton, and other top-tier universities. (Lucid Design Group, 2013a)

The competition is run using Lucid Design Group's Building Dashboard software, a web-based tool that visualizes energy and water use. The tool can show real-time usage if those data are available, and allows each school to configure data download options for members of that school. (Users outside a school can never download raw data for that school). (Lucid Design Group, 2013b)

The event homepage is <http://www.competetoreduce.org>.



Figure 5 Lucid Building Dashboard



Figure 6 Lucid Building Dashboard detail

Figure: Previews of Lucid Design Group's energy visualization tool in use at St. Lawrence (<http://www.buildingdashboard.com/clients/stlawrence/>) and Brown (<http://buildingdashboard.net/brown/keeney/#/brown/keeney/>).

### Energy monitoring at Ivy Plus universities

Of the twelve Ivy Plus schools other than Duke (Yale Office of Sustainability), most have an operational web-based energy dashboard for at least one building.



University	Data	Address
<b>Brown</b>	Public	<a href="http://buildingdashboard.net/brown/">http://buildingdashboard.net/brown/</a>
<b>Columbia</b>	Private	<a href="http://environment.columbia.edu/initiatives">http://environment.columbia.edu/initiatives</a>
<b>Cornell</b>	Public	<a href="http://portal.emcs.cornell.edu">http://portal.emcs.cornell.edu</a>
<b>Dartmouth</b>	Testing	<a href="http://www.dartmouth.edu/~neukom/projects/green_lite_dartmouth.html">http://www.dartmouth.edu/~neukom/projects/green_lite_dartmouth.html</a>
<b>Duke</b>	None	
<b>Georgetown</b>	Private	<a href="http://sustainability.georgetown.edu/getinvolved/switchoff/">http://sustainability.georgetown.edu/getinvolved/switchoff/</a>
<b>Harvard</b>	Testing	<a href="http://sustainability.hres.harvard.edu/icb/icb.do?keyword=k59241&amp;pageid=icb.page252412">http://sustainability.hres.harvard.edu/icb/icb.do?keyword=k59241&amp;pageid=icb.page252412</a>
<b>Johns Hopkins</b>	Testing	<a href="http://buildingdashboard.net/jhu/">http://buildingdashboard.net/jhu/</a>
<b>MIT</b>	Public	<a href="http://energymap.mit.edu">http://energymap.mit.edu</a> (offline)
<b>Princeton</b>	Testing	<a href="http://buildingdashboard.net/princeton/">http://buildingdashboard.net/princeton/</a>
<b>Stanford</b>	Public	<a href="http://buildingdashboard.net/stanford/">http://buildingdashboard.net/stanford/</a>
<b>U. Chicago</b>	Testing	<a href="http://buildingdashboard.com/clients/uchicago">http://buildingdashboard.com/clients/uchicago</a>
<b>U. Penn</b>	Testing	<a href="http://buildingdashboard.net/penn/">http://buildingdashboard.net/penn/</a>

Table 2 Energy Monitoring at Ivy Plus Universities

## 2.6.2 Related work in the federal government

### *Green Button Initiative*

The White House and the US Chief Information Officer have announced the Green Button Initiative to bring energy consumption data to residential electricity customers nationwide (EnerNex). The initiative, announced in 2011, seeks to push the utility industry to rally around making energy consumption data easily downloadable via a distinctive green button on utilities' websites.



Figure 7 The Green Button (Data.gov)

The initiative has support from dozens of companies, and the White House announced in March 2012 that 15 million households would soon be able to download their consumption figures down to 15-minute intervals. (White House, 2012)

### *Data.gov*

Beyond the world of energy, the Federal government has put serious effort into building a government data clearinghouse at [data.gov](http://data.gov). The site, launched in 2009, has influenced federal data sites in several countries, including the UK, Canada, France, and Italy. (Open Knowledge Foundation) Data sets commonly include information on safety and public health, federal spending, geography, telecommunications and transportation.

The Department of Energy has participated in the federal movement towards open data by launching [energy.gov/data](http://energy.gov/data), and hosting an Energy Datapalooza in Washington, DC in 2012. The event promised to "demonstrate how private-sector entrepreneurs are creating jobs and helping Americans save money, using open data as their fuel." (Department of Energy, 2012)



Figure 8 DOE Open Energy Data

### *Sharing of scientific results*

A 2013 memo by Dr. John Holdren, Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy, requests all government agencies "with more than \$100 million in research and development expenditures to develop plans to make the results of federally-funded research publicly available free of charge within 12 months after original publication."

Explaining the rationale for this memorandum, Dr. Holdren elaborates: "For example, open weather data underpins the forecasting industry and provides great public benefits, and making human genome sequences publicly available has spawned many biomedical innovations—not to mention many companies generating billions of dollars in revenues and the jobs that go with them. Going forward, wider availability of scientific data will create innovative economic markets for services related to data curation, preservation, analysis, and visualization, among others." (Holdren, 2013) Although addressing a much smaller market, a similar rationale can be applied to Duke's utility data.

## Machine to machine communication: EnergyIQ & EnergyIQ API

EnergyIQ "is an action-oriented benchmarking tool for non-residential buildings" produced by Lawrence Berkeley National Laboratory, a part of the US Federal Government. (Lawrence Berkeley National Laboratory) The tool offers a machine interface (also called an application programming interface, or API), which allows software developers to create programs that leverage EnergyIQ's computational abilities without showing users the EnergyIQ application directly. The creation of this machine interface represents LBNL's understanding that there is potential to derive value from machine to machine communication, in addition to traditional human-machine communication. More on this topic, as it relates to Duke's energy data, appears below, in "API access."

### 2.6.3 Related work at the municipal and state levels

#### NYC Open Data

New York City has built a site for sharing called NYC Open Data. The site lets users download data about city affairs, such as crime and energy use. It also has basic visualization tools to assist users with rapidly understanding the available data. The site is built on Socrata, a commercial platform for open government data.

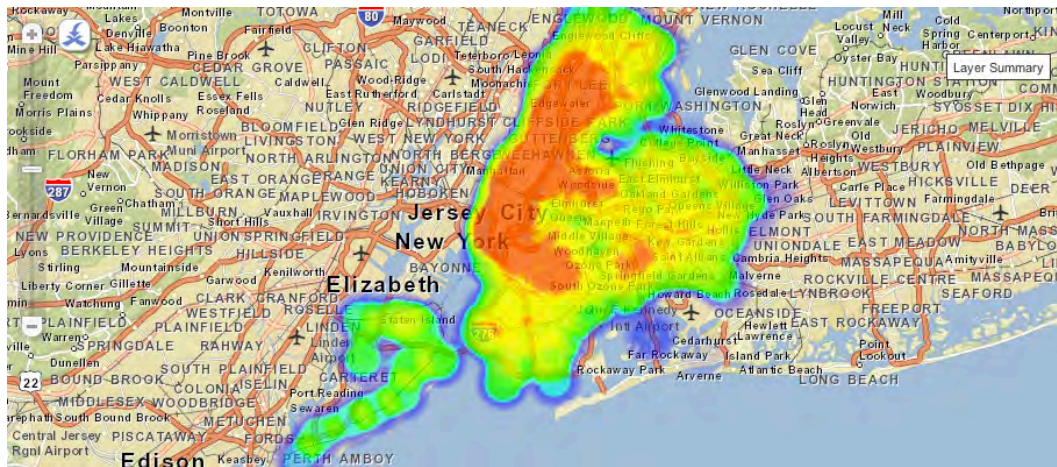


Figure 9 NYC Open Data

The heat map in Figure 9 shows 2010 energy consumption in New York City. The author produced this map in under one minute from the NYC Open Data homepage ([nycopendata.socrata.com](http://nycopendata.socrata.com)). The gradient shows high average building use (red) to low average building use (blue) by zip code. Exact data are available at <https://nycopendata.socrata.com/Environmental-Sustainability/Electric-Consumption-by-ZIP-Code-2010/74cu-ncm4> (City of New York, 2013).

Socrata is also used by Seattle, Chicago, and other states and municipalities. In February 2013, the company released an "Open Data Field Guide" to help institutions with open data campaigns. (Rabah, 2013)

#### **2.6.4 Related work at Duke**

##### ***Campus Sustainability Competitions***

For several years, Sustainable Duke has operated a competition called Green Devil Smackdown. The competition pits students and departments against each other to complete sustainability-related tasks throughout the year. The 2013 competition attracted 583 participants as of February 23, 2013. (Sustainable Duke, 2013)

The Smackdown is driven by actions and pledges such as producing promotional videos or pledging to turn off computers at night. It has the potential to be enhanced by data-driven performance feedback to participants.

##### ***Fall 2011 NSOE Program Management group***

A group of three Nicholas School Master of Environmental Management students looked at the interaction of Facilities, Sustainable Duke, and the Energy Initiative as part of the Nicholas School's Program Management (ENV 802) course. Among other findings, they identified a need for Facilities to create a web page that "provides details on what types of assistance can and cannot be provided" to students and researchers looking to enact on-campus energy-related projects. The impetus for this page is two-fold: to allow researchers to easily find out what data are available to work with, and to reduce the burden on Facilities of answering individual inquiries. (Quinlan, Neal, & Lai, 2011)

##### ***2012 Master's Project analysis of sustainability strategic plan***

A group of three Nicholas School MEM students completed an analysis of Duke's strategic plan for sustainability. While they found Duke has a strong plan, in their recommendations, they said Duke should "integrate sustainability into the curriculum," and "increase student involvement." The team notes that students represent a "vast intellectual resource" available to work on sustainability issues.

The group also suggested that Duke "streamline the reporting process" for collecting sustainability data across the University, pointing out that a lack of coordinated data collection and sharing has hampered sustainability progress at Duke. (Hildenbrand, Jones, & Willie, 2012)



### *Building Energy On Campus (ENV 830)*

A new course in the Nicholas School for the Spring 2013 semester, Building Energy On Campus (ENV 830), examined the use of energy in buildings on Duke's Durham campus. The course filled to capacity (15 of 15 seats), implying an interest among students in studying local energy issues.

## **3. Objectives**

The broad objective of this master's project was to make Duke University's utility data more accessible to the Duke community, as a catalyst for interdisciplinary sustainability projects.

That objective manifested in several specific goals:

1. Document available energy data on the web
2. Simplify the procedure for students and faculty to request access to energy data
3. Produce an example work product using energy data
4. Integrate energy data into coursework and ongoing research
5. Understand the University's disposition towards opening energy data for collaborative academic work

### **3.1 Document available energy data on the web**

This project sought to make the web a viable source of information for understanding the basics of energy management and energy data management at Duke. With 18,000 academics (Duke Office of News & Communications, 2012), it is difficult to predict which ones will be interested in local energy issues, but surely some who are interested will not have the time or network to pursue information through individual referrals, as has traditionally been done. Although peer-to-peer communication is rightly a precious and prized means of information exchange on University campuses, it cannot scale effectively to deliver basic information to a wide audience.

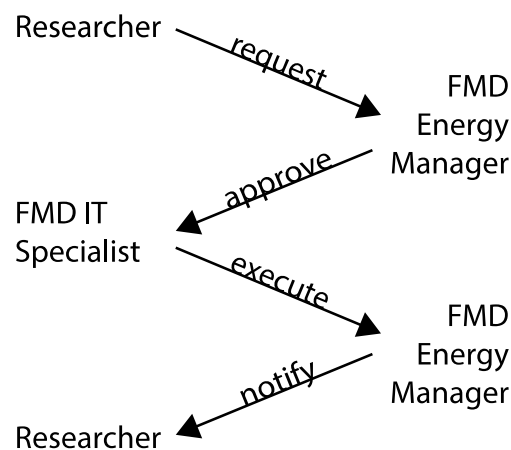
Making the web a viable source of information entailed producing several new and revised pages for FMD's web site, which explain energy management and energy data management. Those assets were turned over to FMD for use at their discretion.

[\(Jump to results\)](#)

### 3.2 Simplify procedure for requesting access to energy data

Prior to this project, a researcher interested in Duke's energy data may have had a difficult time finding those data. The first step was simply to understand that the Facilities Management Department was the department responsible for housing such data. That role was not clearly documented on their web site – i.e. as of April 1, 2012, searching for "energy data" on [fmd.duke.edu](http://fmd.duke.edu) yielded no results.

Once a researcher found and contacted FMD, the researcher would be directed to the Energy Manager, in FMD's Utilities & Engineering group. After discussing his or her research interest with the Energy Manager, the researcher's request for data would go through the following process:



**Figure 10** Current EnergyWitness authorization process

This process was not automated or centrally managed; each step required at least one email or similar communication. In the author's initial phase of this project, 56 business days transpired between the initial expression of interest in energy data and receiving access to any data. In helping to get three other researchers data, requests were processed in one business day, four business days, and 33 business days.

An important consideration for many researchers, particularly students, when deciding on a line of inquiry (e.g. for a course project) is the ease with which that student believes he or she will be able to obtain data. Students do not, as an extreme example, look into questions for which they are certain there will be no data available, simply because they know they will not be able to complete their assignment.

Similarly, students are more likely to pursue a research question when data are easily available. Typical courses at Duke University last 13 weeks (in the college and most graduate schools), with course projects running for a portion of that time. For a student needing to answer a research question for a course project, there is rarely a benefit to successfully acquiring a dataset that was hard to obtain. Course projects grade on depth and accuracy of analysis, so any time spent acquiring data is simply a cost with no benefit to the student.

Anecdotally, a professor from Trinity's Statistics department shared that the most popular data set for coursework in her department is Duke Basketball data (Cetinkaya-Rundel, 2012), because it is:

- Easy to obtain
- Relevant to students' lives
- Analytically interesting

[\(Jump to results\)](#)

### 3.3 Produce an example work product using energy consumption data

An inevitable question that arises around any effort to open data is, “will anybody use it?” This is a particularly salient question for organizations with limited resources available to prepare data for broad consumption.

To illustrate that there are indeed uses for Duke's energy data beyond those already in place at FMD, this project created an example work product that used energy data in an original way.

[\(Jump to results\)](#)

### 3.4 Integrate energy data into coursework and ongoing research

While some members of the Duke community may be interested in examining energy data simply out of curiosity, most Duke students and faculty have abundant obligations and limited free time. Incorporating energy data into course work allows students to understand local energy use in detail while not taking time away from for-credit studies.

Incorporating energy data into course work also offers benefits to faculty and FMD:

- Structured, graded analyses give students incentives to produce high quality work with accurate results
- Data can be used both for projects that are neutral to the type of data being analyzed (e.g. in a statistics course) and projects specifically about building energy consumption (e.g. in a building science or behavior change course)

- FMD can challenge students to answer pre-defined questions that assist in real-world operations
- Faculty can help coordinate stable, long-term arrangements wherein successive years of students assist FMD with pertinent operational questions

This project sought to establish at least one partnership between an ongoing research effort or course and FMD.

[\(Jump to results\)](#)

### 3.5 Assess the disposition of the University towards open energy data

An important driver behind the success of any interdepartmental effort is the level of interest from management in the success of that initiative. Duke University has a relatively strong data collection apparatus for utility information, but the extent to which the Facilities Management Department wants to expose those data for others to analyze has been unclear. This project sought to hear directly from the Vice President of Facilities on his position towards making utility data, and contextual information explaining those data, more available to others within the University.

[\(Jump to results\)](#)

## 4. Methods

### 4.1 Communications

This project primarily focused on changing management practices. To that end, in-person meetings were the main tool of execution. A total of 40 formal meetings were held over a 15-month period, as well as several casual conversations.

Meetings were held with a variety of stakeholders, including: FMD; Duke's Energy Initiative; Sustainable Duke; professors in the Nicholas School of the Environment, the Pratt School of Engineering, and Trinity College; and students in the same schools.

### 4.2 Microsite

A small website, dubbed a 'microsite,' served as a source of information on the project. The microsite contained six pages:

- About
- Opportunity
- What is Open Data?
- Duke's Data

- Data Samples
- Contact

The microsite was temporary and was taken offline at the conclusion of the project. Content was staged on sites.duke.edu, a Wordpress host operated by the University. sites.duke.edu allows for public and NetID-protected areas, the latter of which was leveraged to offer protected exports of sample data from EnergyWitness. Pages only used simple HTML and CSS to convey information; they used no JavaScript, Flash, or other dynamic technology.



Figure 11 Microsite

### 4.3 Benchmarking

Simple web searches were used to determine how peer (Ivy Plus) institutions expose energy data. The resulting table (see Energy monitoring at Ivy Plus universities) revealed that a majority use Lucid Design Group's Building Dashboard, which can optionally be set to allow download of raw data to members of each client university. Other schools had built one-off systems to disseminate energy data.

### 4.4 Creating an EUI map

Refer to 5.3 for a description of this work product.

Energy consumption data was exported from EnergyWitness. Data included building ID numbers, assigned by University Plant Accounting, as a key.

GIS data was exported from Duke's ArcGIS server. Special permission was obtained to use Duke's ArcGIS server for this project.

The GIS and energy consumption data were merged in Excel on the building ID key. EUI calculations were completed in Excel, and joined to the GIS data in ArcMap. The ArcMap symbology was altered to show conditional color gradients based on building type, and substantial tweaking to labels was performed to produce the final map.

## 5. Results

### 5.1 Document available energy data on the web

Four web pages were written and revised in coordination with the Facilities Management Department. The pages are:

1. Explanation of energy and water flow on Duke's Durham campus
2. Explanation of data available for academic use
3. Form to request access to energy and water data
4. Sample utility data

Page 1 explains the chilled water loop and steam tunnels, how electricity arrives at campus, and how potable water is distributed. Page 2 explains utility data, IDS EnergyWitness, and Duke's BAS. The form on page 3 provides researchers a structured method to request access to EnergyWitness, and requires they explicitly acknowledge some bounds on the use of Duke's energy data. Page 4 is a simple list of four links to data sets exported from EnergyWitness, which have been cleared for ad hoc use by members of the University community.

Copies of these pages, as they were tendered to FMD, are presented in the appendices. Content live on the web will naturally evolve and may not reflect the content in the appendices. If it is posted, the content will appear on [fmd.duke.edu](http://fmd.duke.edu).

### 5.2 Simplify procedure for requesting access to energy data

A new process was proposed for researchers to request access to utility data.

In this process, all requests are by default approved, as long as they provide a reasonable explanation of interest in the data. Importantly, the preliminary approval rests with the IT specialist who handles the mechanics of authorizing the individual researcher to access the energy data management system. If the individual in the IT specialist role sees no explanation, an explanation that feels amiss, or otherwise has a concern, he can defer to the judgment of the Energy Manager.

This new process can be completed in a single business day, potentially even offering researchers same-day access to energy consumption data.

This new process is less secure than the prior process, but strives for a more beneficial balance of convenience and security for the University. Requests for access to the energy data management system will still require an explanation of the work being done, and will still be limited to individuals within the Duke community. Repercussions to anyone considering abusing the system can be severe.

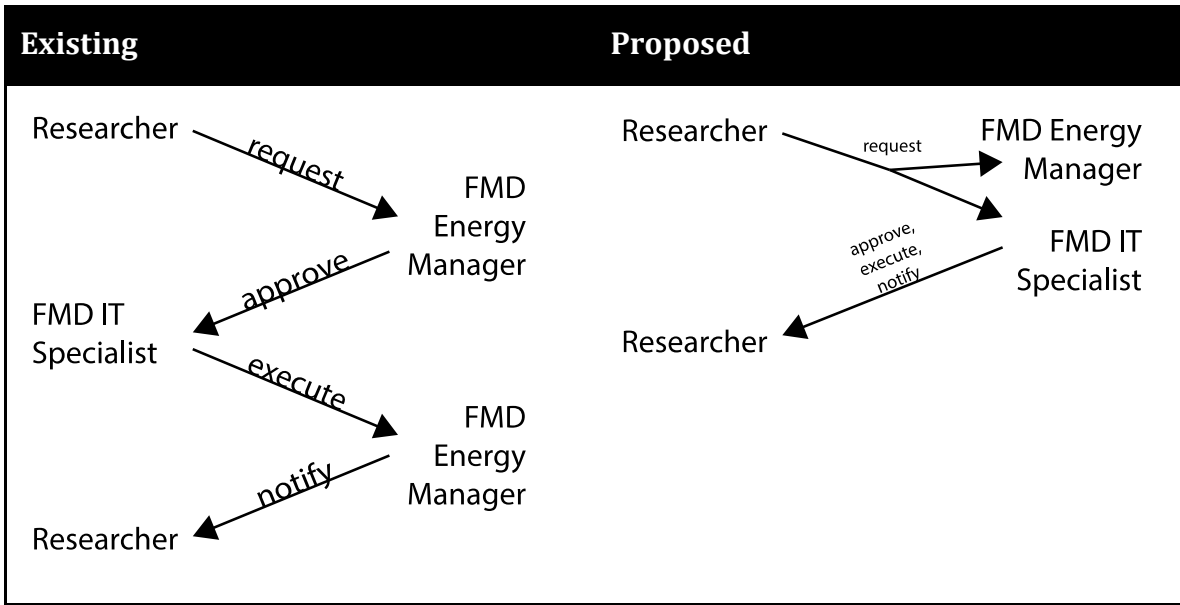


Figure 12 Proposed EnergyWitness authorization process

As the Energy Manager is copied on all requests, he or she can intervene in any request the he sees as unsuitable, and either block or revoke access to the energy data management system. A suggested form is shown in the appendices.

### 5.3 Produce an example work product using energy consumption data

The work product produced to demonstrate an original use of energy data is a map of the energy use intensity (EUI) of Duke’s West Campus in Durham. This map serves multiple purposes, chiefly to show there is a dramatic difference in the EUI of Duke’s buildings. The map can also act as a conversation starter for Duke community members curious about the energy use of the buildings they regularly occupy, and can spur creative thinking for other uses of energy data.

The map is shown in the appendices.

### 5.4 Integrate energy data into coursework and ongoing research

In conversation with the author, several students and professors expressed interest in working with utility data in the future.

This table presents certain venues where energy data may be used in the future:

<b>Name</b>	<b>Possible use</b>	<b>Timeframe</b>
<b>Dr. Daniel Egger, Pratt, Data Mining</b>	Course assignments	Fall 2013
<b>Building Energy On Campus, course, ENV 830</b>	Sample energy analyses	Spring 2014
<b>Duke Energy Initiative</b>	Various projects & research	Spring 2013, ongoing
<b>Page Gravely, DEL-MEM</b>	Master's project	Spring & Fall 2013
<b>Andrew Myers, MEM</b>	Central chiller plant optimization modeling	Spring 2013

**Table 3 Forthcoming coursework involving energy data**

Note that no uses listed here are guaranteed to occur. These are forward-looking statements which reflect the author's understanding at the time this report was written. As courses and projects evolve, the information listed here may prove to be materially incorrect.

As these projects are developed, a corpus of experiences will emerge which FMD can later draw on to create more standardized processes for researchers to access energy data.

### 5.5 Assess the disposition of the University towards open energy data

On Monday, March 11, 2013, the author met with John Noonan, Duke University's Vice President of Facilities, to discuss his department's position towards increasing access to energy data for members of the University community. Also in attendance were: Russell Thompson, Director, Utilities & Engineering Services; Steve Palumbo, Energy Manager; and Casey Collins, Energy Engineer. What follows is a subjective review of the content from the meeting. (Direct quotes were not permitted).

Broadly, the Facilities Management Department is interested in working with academics on research projects regarding campus energy and water use. They have a history of collaborating with individual professors and students, which they say few organizations of Duke's size can rival.

The Department does not formally count collaboration with academics among its strategic goals. Facilities' priorities are primarily focused on the safe operation of campus. Their Strategic Initiatives do include Sustainability, which can include "working with the Duke community to raise awareness and foster the development of environmental policies and procedures." (FMD)

The Vice President clarified that facilities personnel are allowed to spend time on collaborative activities, but those activities are not considered part of their job responsibilities, and time for collaborative activities must give way to operational needs.

Regarding lowering the barriers to accessing utility data in particular, the Vice President was generally tolerant of the idea, but had a number of concerns.



1. **Concern regarding financial data.** Overwhelmingly the largest concern is that EnergyWitness, the energy data system that FMD uses for billing, contains detailed financial information about utility costs. Giving a student or faculty member access to EnergyWitness inherently gives them access to utility cost data. Using cost data per building, a user might be able to extrapolate what various academic departments are paying for energy, since departments pay based on the percentage of square feet they occupy in a building. Budgeting at the University is a sensitive process, and departments, which FMD considers its clients, may not want other departments knowing what they pay for energy use. FMD does not feel at liberty to share this information without consulting its clients.
2. **Concern regarding access in perpetuity.** The Vice President expressed a preference that anyone granted access to EnergyWitness be automatically de-authorized after a pre-determined period had lapsed (e.g. one year). Users would always be able to manually renew their request for access. Such a mechanism would give FMD a greater understanding of whom exactly might be accessing its energy data.
3. **Concern over demands on FMD staff.** The Vice President expressed some concern that lower barriers to energy data may result in a drain on his staff's time. The Energy Manager said 20 requests for data a year would be "high," a number low enough to seemingly assuage some of the Vice President's concern. The Vice President requested web pages regarding utility data make it clear that Facilities has its own questions students and faculty can work to answer, as a way of balancing the cost and benefit of making utility data more available.

## 5.6 Future work

There are numerous opportunities to expand on the work in this project; a discussion of a few select topics follows.

### 5.6.1 Interval data collection

At present, utility data available in EnergyWitness is spaced at monthly intervals. Many emerging applications of energy data make use of "interval" data, which typically refers to recording an energy consumption value for a building every 15 minutes.

FMD does have the capacity to capture some 15-minute data, but only for steam and chilled water, and only with some buildings. To improve on this situation, FMD is in the process of putting in place additional data storage systems, and has instituted a

policy of logging all utility data (electricity, chilled water, and steam) at 15-minute intervals wherever possible (Palumbo, 2013).

The following figure illustrates the data collection tools FMD has and is putting in place as part of this improvement.

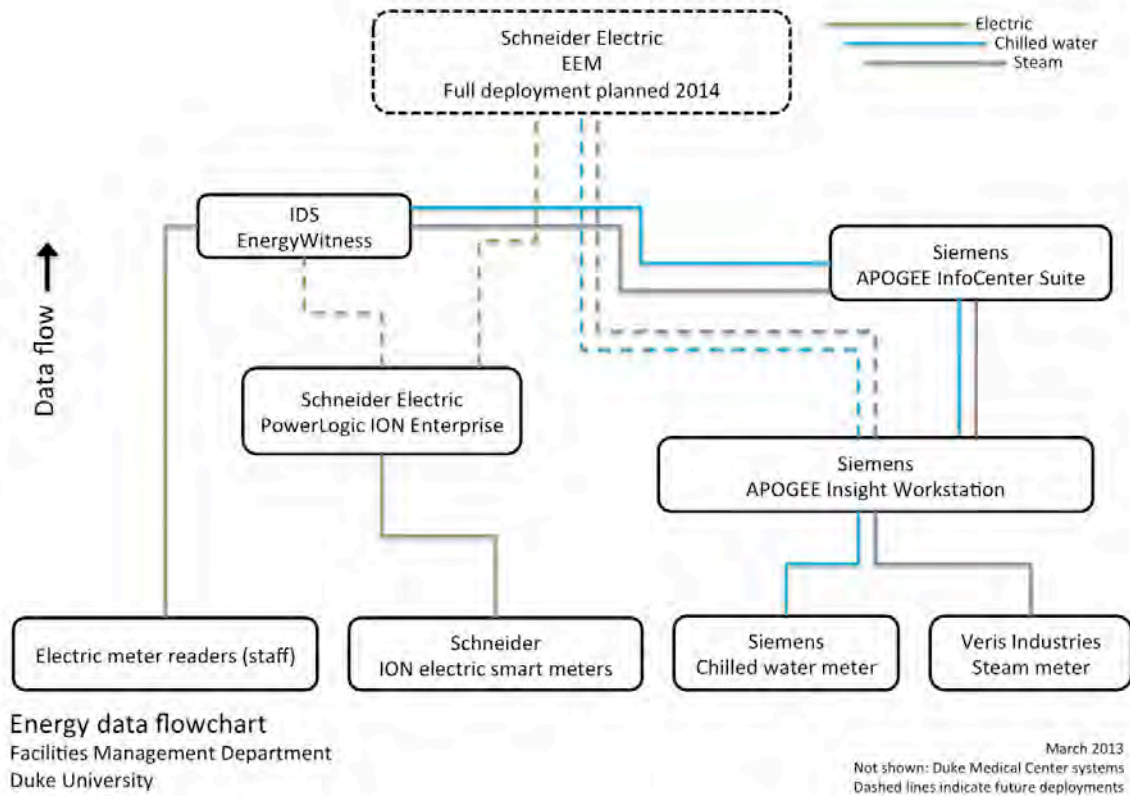


Figure 13 Energy data capture process

Duke has started to deploy smart electricity meters, which can record electricity consumption in 15 minute intervals, in the 2012-2013 academic year. As of the March 27, 2013 Campus Sustainability Committee Energy & Water Subcommittee meeting, 91 smart meters had been installed (Campus Sustainability Committee, 2013). As a result of this effort, 15-minute electricity data should become available for the first time in the 2013-2014 academic year.

### 5.6.2 API access

Energy dashboards, such as those deployed at many of the Ivy Plus schools (see Peer work at other universities), offer campus users the ability to see basic charts and graphs about energy consumption. Some, such as Lucid Design Group's Building Dashboard, also offer the ability for users to download data. This is a powerful additional feature, as it lets users import data to an analysis program of their

choosing (e.g. Excel, Stata) and derive insights not presented to them in the pre-configured displays.

Beyond offering downloadable data, an energy management system can offer API access (application programming interface). API access allows machine to machine communication, such that software on one computer can process and react to data on another. If API access was available to Duke's utility data, students could build custom visualization or feedback tools, optimization algorithms, conduct experiments based on real-time energy data, or pursue a variety of other ideas. Related work on this front is taking place at a national level through Green Button Connect (<http://www.greenbuttonconnect.com>).

API access is currently not a common feature in most energy management suites, and the value proposition of maintaining it is often difficult to explain. Securing API access to Duke's energy data gave way to more preliminary needs in this project, such as the ability to easily find and download static energy data.

### 5.6.3 Environment Hall

The Facilities Management Department is constructing a new building to house the Nicholas School, starting in 2014. The building is slated to be LEED Platinum, and energy use is of concern to the School.

A Building Committee from the Nicholas School has taken responsibility for communicating the preferences of the School to FMD and the building architect. As of February 20, 2013, no decisions about the nature or feature set for an energy monitoring system had been made by the Building Committee.

## 6. Discussion

Duke's relatively new Energy Initiative has created a natural champion within the University to foster further partnerships. All parties involved in this project, including FMD, the Energy Initiative, Sustainable Duke, and others have stated support for the concepts of data sharing and are in agreement with the core ideas of this project.

### 6.1 Cultural differences

Although the potential for collaboration is large, it is important to acknowledge the different operational contexts and cultural realities between academia and Facilities Management. The Facilities Management Department is, at present, tasked both to think about long-term facilities issues, and handle short-term events and emergencies. Culturally, the department operates from a relatively risk-averse

philosophy. Projects are planned and specified; budgets and execution are closely monitored. Improvements are made iteratively, with small changes to practices and habits accumulating slowly over time.

Academia typically operates from a risk-tolerant or risk-seeking position. New ideas and experiments are lauded for their creativity and distinction from the status quo. Often, academic theories are tested purely in a computer simulation, a laboratory, or on an inert set of data. Running experiments rarely means impeding the everyday goings-on of a community.

Acknowledging these differences is important to setting expectations for the pace of collaboration between the Facilities Management Department and the rest of the University.

## 6.2 Data interoperability

While the White House has launched the Green Button initiative to give residential electricity customers access to their consumption data, no such initiative exists for commercial data. Commercial electricity use is inherently more complex than residential use, since a single institution often operates multiple buildings, frequently with several billed tenants per building (as is the case for Duke).

As of 2012, technology companies were coming to consensus that Green Button could be adopted directly for commercial buildings (St. John, 2012). Once consensus around a single format is finalized, FMD may want to adopt a product or practice that automatically makes energy consumption data available for its buildings in that format. Doing so will allow third party tools, such as those produced by DOE's Apps for Energy contest, to be used with Duke's energy data. (Challenge.gov)

## 6.3 Other Duke institutional data

In the course of this project, various parties raised broad questions about how Duke University manages institutional data. The scope of this project expressly did not include answering these questions. In the long-term, however, the University may benefit from considering a more coordinated approach to sharing data between schools and departments. An institution-wide facilitator could help form relationships more quickly, manage concerns about data quality and privacy, and promulgate best practices for data sharing.

Work at various levels of government (e.g. [data.gov](http://data.gov), [data.seattle.gov](http://data.seattle.gov), [data.cityofchicago.gov](http://data.cityofchicago.gov), and others) may provide guidance on how to set up a successful program.

## 6.4 Covariate data

This project primarily centered on opening utility consumption data at the University, but these data alone cannot answer many important research questions. Energy and water consumption data here refers specifically to consumption per utility per building per month. In most analyses, researchers will be interested in how energy consumption changes with respect to some other variable or set of variables, for example:

- Building size
- Seasonality
- Weather
- Building purpose (e.g. lab, offices)
- Building construction year
- Building occupancy level
- Heating and cooling set points

Aggregating these data was outside the scope of this project, but may provide a worthwhile follow on project. Data about building size and weather is already recorded in EnergyWitness. Construction year and building purpose are available from FMD, but not publicly. Building occupancy is intentionally not tracked institutionally, and is difficult to measure. Heating and cooling set point information is available, but requires FMD cooperation to relay data from Duke's building automation system. Departmental space usage (e.g. for buildings that house multiple departments), which is used to calculate utility invoices, is recorded institutionally, but is considered privileged information that is only available to a limited set of staff.

These are just some examples of potential variables a researcher may want, but serve to illustrate the variety of challenges that need to be overcome to obtain the relevant data.

### 6.4.1 Tech Ratings

The Facilities Management Department classifies each campus building with a Tech Rating. The Tech Rating is a figure on a 1 to 5 scale that conflates a building's age, year of last renovation, and operational sophistication into a single number. There is no public list of buildings and their Tech Ratings.

### 6.4.2 3D models

In 2011, the Facilities Management Department worked with Colorado-based Concept 3D to develop 3D models of many buildings on Duke's Durham campus.

These buildings are available in Google Earth's 3D buildings layer, and are listed in Trimble's 3D Warehouse. (Green, 2011)

The 3D models may be useful to researchers wishing to create visualizations of energy consumption, to understand how energy consumption correlates with cubic volume, or for other uses. The models are not available for direct download off of the web. An email address, [mapsteam@duke.edu](mailto:mapsteam@duke.edu), is listed at <http://about.duke.edu/maps>, for more information about the models.

## 7. Acknowledgements

This project was entirely dependent on contributions of time and attention from other members of the Duke community.

In particular, I would like to thank Steve Palumbo, Duke FMD's Energy Manager, and Casey Collins, Duke FMD's Energy Engineer, for their contributions. No material progress on this project could have been made without Mr. Palumbo's support, and his continued advocacy for the issues presented here are sincerely appreciated. Mr. Collins, in addition to supporting the principles behind this project, spent countless hours providing educating on the details of energy use and energy data at the University, which added significantly to the depth of this project.

I would like to thank Dr. Richard Newell, Director of Duke's Energy Initiative and my master's project adviser, for his mentorship and guidance throughout this effort. I additionally want to express thanks to Katie Moore, former Energy Initiative staff, and Dr. Dalia Patiño-Echeverri, my academic adviser, for helping form the idea for this project and helping get it under way.

I appreciate the assistance of Duke's [Statistical Consulting](#) group with developing the list of covariate data in section 6.4.

Lastly I would like to thank the too-numerous-to-name students, faculty, and staff who contributed ideas, data, referrals, proof-reading, and feedback on this project through its duration.

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## 9. Appendices

Appendices I-IV show web content developed in coordination with and for use by Duke's Facilities Management Department. The decision to publish or not publish this content on [fmd.duke.edu](http://fmd.duke.edu) rests with FMD. The content combines existing material from [duke.edu](http://duke.edu) with original writing and graphics.

Appendix V shows the EUI map discussed in sections 3.3, 4.4, and 5.3.

<b>Appendix</b>	<b>Content</b>
<b>Appendix I</b>	Utilities background
<b>Appendix II</b>	Utility data background
<b>Appendix III</b>	Utility data samples
<b>Appendix IV</b>	Form to request EnergyWitness access
<b>Appendix V</b>	West Campus EUI map

# Appendix I - Utilities background

Building Maintenance

Grounds

Housekeeping

Waste Reduction & Recycling

Projects, Planning, Design,  
Construction

> Utilities & Engineering  
Excavation Program  
Utilities Services  
Engineering

Energy & Environment

Safety

Emergency Planning

Maps & Records

News & Alerts

## ■ Utilities Services

### Overview

Energy needs at Duke are met by three major utilities:

- Electricity
- Steam
- Chilled water

Duke is organized as a [district](#) heating and cooling system. Buildings at Duke are heated by steam and cooled with chilled water, both of which are generated on-campus at central plants. Electricity from Duke Energy provides power to the campus.

The University also manages water and sewer on its campuses. The Durham campus is connected to Durham's municipal water supply.

All utilities are managed by the Duke Utilities & Engineering Services group within the Facilities Management Department. Content on this page refers to Duke's Durham campus, but the Facilities Management Department manages Duke's Beaufort campus as well.

### Chilled Water

From 2004-2012, Duke University developed the majority of a Central Chilled Water System that consists of two central plants (28,000 ton cooling capacity) and 14 miles of distribution piping. These plants are both on West Campus. After leaving each plant, chilled water runs to each building on campus, and then through various pipes and air handling equipment to cool those buildings. After leaving a building, the previously chilled water returns via closed loop to a chilled water plant for reuse.



The University's Utility Master Plan confirmed that the central production and distribution of chilled water is the most efficient and economical method to provide the cooling needs for Duke University's campus including the School of Medicine and Medical Center. The system provides chilled water for process equipment cooling and building air conditioning in a reliable and cost effective manner.

Services include utility billing/administrative services and operation, maintenance, and expansion of the University's central chilled water plant and distribution infrastructure from the point of generation to the point of delivery (building interface).

### Electrical System

Electricity enters Duke's campus through a ring of five distribution substations, which are supplied with power from Duke Energy.

Duke Utility & Engineering Services High Voltage Shop is responsible for the installation, operation, maintenance and distribution of high voltage (12kV and 4kV) electric power on campus. The group supports the University, Hospital and Medical Center to maintain the integrity of the electric system on campus, which consists of the five distribution substations, over 15 miles of duct banks and 62 miles of electrical cables.

Services include:

- Preventative maintenance
- Installation, repair and replacement
- Dispatching, monitoring and operations
- Planning for new and increased loads
- Electric energy meter reading, repair and installations
- Street light repair, maintenance and installations

Building secondary service and interior electrical systems are handled by the Maintenance Services [Electrical Shop](#).

### **Municipal Systems**

Duke's civil infrastructure consists of a vast array of water, drainage, and sewer systems, as well as paved roads, walks and parking lots, all serving the academic, research, and residential buildings and lands of Duke.

#### Roads, Sidewalks and Paths

DUES maintains over 18 miles of private roads and 24 miles of sidewalks, along with associated paths throughout its academic and residential areas.

#### Water, Sewer, & Storm Drainage

Duke maintains approximately 34 miles of City Water and Sewer Lines. Duke's storm water runoff is collected in its storm drainage system. The storm drainage system consists of an extensive system of nearly 32 miles of storm pipes and drainage ditches.

### **Steam System**

Steam is the main heat source for buildings on campus. Steam is produced at two central plants, one on East Campus and one on West Campus.

The steam system provides high-pressure steam to the entire Duke University, Hospital and Medical Center community. The steam plants run on natural gas (from PSNC), fuel oil, and recycled oil. Prior to April 2011, coal was used as an energy source.



Steam is distributed through 35 miles of distribution piping and is used for space heating, hot water heating, hospital medical equipment sterilizing, dining services, pool heating, dishwashing and other process uses.

The steam system group provides engineering, capital project management, operations, maintenance and renewal of the underground steam distribution and condensate return system. The steamfitters maintain and operate approximately 35 miles of steam and condensate piping and associated manholes on campus which contain the valves for the system operation. Inside the building mechanical rooms, the steamfitters provide O&M on the steam metering stations, pressure reducing stations, and condensate return systems.

#### West Campus Steam Plant

Duke's West Campus Steam Plant was built in 1929 and is located near Research Drive. In February 2009, the plant ended an 80-year tradition of coal delivery by rail car and began its step toward reducing Duke's use of coal. Until then, it was the primary plant for heating East and West Campus in addition to the de-humidification of structures and sterilization of machinery for the Duke Health System.

With the opening of the renovated East Campus Steam Plant, the West Campus Steam Plant will be a peak shaving plant with the capacity to burn oil, recycled oil and natural gas when demand is high during the winter. Boilers at the West Campus Steam Plant use natural gas as a primary fuel and #2 fuel oil as a backup.

#### East Campus Steam Plant

Duke's East Campus Steam Plant was built in 1929 and

is located on the eastern end of Campus Drive, near Smith Warehouse. The 6,600-square-foot plant was used to heat Duke's buildings from 1929 to 1978. In May 2008 the Duke Board of Trustees approved funding to renovate the plant to add capacity to the steam system, provide for future growth and burn natural gas, which produces lower emissions and greenhouse gases than coal. Renovations were completed in August 2010.



The renovated plant features 15 natural-gas Miura boilers, which require less water and time to produce steam and will also utilize propane as a backup fuel.

# Appendix II - Utility data background

Building Maintenance

Grounds

Housekeeping

Waste Reduction & Recycling

Projects, Planning, Design, Construction

Utilities & Engineering

> Energy & Environment

Energy Management

LEED Buildings

Water Conservation

Energy Data

Data Request

Data Samples

Safety

Emergency Planning

Maps & Records

News & Alerts

## # Building Utilities

Duke tracks data for these utilities:

- Electricity
- Steam
- Chilled water
- Water & sewer
- Storm water

Generally data are recorded each month for each campus building. Data is available for 5-10 historical years, depending on the building and utility. Electricity, steam, and chilled water, while measured separately, are also compiled together via energy conversion factors to provide like-to-like comparisons of total energy usage (expressed in kBtu) and green house gas (GHG) emissions. [Learn more about Duke's utilities.](#)

Data is recorded in a software package called [EnergyWitness](#) made by [Interval Data Systems](#). EnergyWitness uses a Microsoft Sharepoint front end and Microsoft SQL Server back end. This system is protected by an authentication process that requires individual Duke NetIDs to be activated for use.

### Availability

Duke's energy data is available to students, faculty, and staff who would like to work with it. Interested parties should [contact Duke Facilities](#) for authorization to use EnergyWitness.

### Interface

EnergyWitness provides a graphical, browser-based interface, and a method to export data.



Within EnergyWitness, commonly used reports include:

#### Building Summary

This analysis tool provides a broad range of building utility information. It shows historical energy consumption and costs, the building's energy baseline (based upon regression analysis), and tracking for both utility consumption and GHG emissions.

#### Energy and Greenhouse Gas Reports

These reports provide a picture of total energy (in kBtus), and related carbon footprint (in MTCDE), for buildings and building groups across multiple years.

#### Utility Reports

This report collection provides monthly utility data for one or more buildings across any number of years.

## Data Formats

Data exports can be in CSV, Excel, XHTML, and other formats. Several [data samples](#) are available. There is currently no machine interface or API to EnergyWitness.

## # Building Internals

Duke University uses Siemens' building automation software (BAS) to operate buildings. BAS applications control heating and cooling, lighting, fire response, and other systems within buildings. FMD has the capacity to log data about each of these systems, including air handling, power consumption, and chilled water circulation. Data can be logged at a wide range of intervals, from once a second to once every few hours.

The Facilities Management Department selectively logs data about specific building systems and features to meet their day-to-day needs, but these data are not shared publicly. Individuals with research projects can [work with Facilities](#) to log and review data about building systems of interest to them.



# Appendix III - Utility data samples



Building Maintenance

Grounds

Housekeeping

Waste Reduction & Recycling

Projects, Planning, Design, Construction

Utilities & Engineering

> Energy & Environment

Energy Management

LEED Buildings

Water Conservation

Energy Data

Data Request

Data Samples

Safety

Emergency Planning

Maps & Records

News & Alerts

### # Energy Data Samples

You must have a valid Duke NetID to download these files, as this content is for use only within the Duke community. Do not distribute elsewhere.

These data samples have been downloaded directly from EnergyWitness and are designed to give a sense for the data available in that system. The descriptions listed here represent the exact steps in EnergyWitness one needs to follow to reproduce the downloads.

#### Sample 1

Energy / Greenhouse Gas by Group by Building  
University-A&S, University-University, All Buildings  
Chilled Water, Electric, Steam  
FY2006-FY2012

Download (123KB) (download links disabled for mockup)

#### Sample 2

Facility Utility Summary  
Engineering-All Buildings  
All utilities  
FY2007-FY2012

Download (545 KB) (download links disabled for mockup)

#### Sample 3

Energy / Greenhouse Gas by Building  
University-Engineering  
Chilled Water, Electric, Steam  
FY2012

Click Fitzpatrick to go into the By Building subreport, then Fitzpatrick again to go to the Monthly data report.

Download (download links disabled for mockup)

#### Sample 4

Data Crosstab  
University A&S, All Buildings  
Chilled Water, Electric, Steam, Storm Water  
FY 2008-FY2012

Download (156KB) (download links disabled for mockup)

**Download all samples (373 KB) (download links disabled for mockup)**

## Appendix IV - Form to request EnergyWitness access



### Facilities Management Utility Data Request

The Facilities Management Department (FMD) welcomes the opportunity to work with students and faculty members who would like to analyze Duke's energy usage. In addition to providing data to support work by Duke community members, FMD can help students and faculty identify real, practical research projects that can both accomplish academic research goals and improve FMD's operation of campus.

For a list of projects FMD would like help with, visit [Sustainable Duke's Living Laboratory page](#).

Access provided through this form will include consumption figures for Duke's campuses, broken down by building, utility, and month.

Name

NetID

Affiliation

- Student
- Faculty
- Staff

School

- Trinity
- Fuqua
- Nicholas
- Pratt
- Law
- Graduate School
- Divinity
- Other

Explanation of interest in energy data

Describe with whom you may share raw data

What is the last date you will need access to utility data? If no date is given, access will expire after one year. (mm/dd/yyyy)

### Acceptable uses

Data provided by FMD may be used for general purposes within Duke University. **Raw data may not be transferred outside of the University without explicit consent of the Duke Energy Manager.** FMD does not guarantee the accuracy of the available data. Researches are individually responsible for managing concerns about data quality.

I understand

Submit

# Appendix V – Duke West Campus EUI map

