Energy-Smart Buildings

Microsoft is using less electricity and saving money by analyzing data from its buldings.

Here's how.

Buildings use 40% of energy globally—when buildings run more efficiently, the energy and cost savings have a significant impact. And although building codes and certification standards are improving how new buildings are designed, we can achieve significant energy savings by re-examining our existing building stock.

At Microsoft, we started the Energy-Smart Buildings (ESB) initiative to reduce our energy costs. Specifically, we are deploying software that pulls data from the buildings' existing heating, cooling, and power systems, and analyzes it to detect when buildings are not running as designed—a valve that got stuck open, a fan that was left on. The building engineers can use that data to quickly find and fix problems, prioritizing by the highest savings or by business impact. We can save energy, save money, and extend the life of our building systems when they run as designed.

Before ESB, the only ways to evaluate how well things were running were to scan through menus on building management systems, or to drive to a building and start manually checking systems. Both options were time-consuming and it was hard to see the big picture. Now, we track operations of our Redmond campus online, and we can see and triage errors as they occur.

We expect our full deployment will have a payback of 2.5 years. The software is changing how we manage our portfolio. We are now in the planning stage of rolling this software out at other Microsoft sites globally.

We think other building owners—businesses, school districts, universities, cities, governments—can see the same benefits. This document provides an overview of the solution we are using to reduce our energy consumption, and the questions we considered in the implementation of Microsoft's Energy-Smart Buildings program.

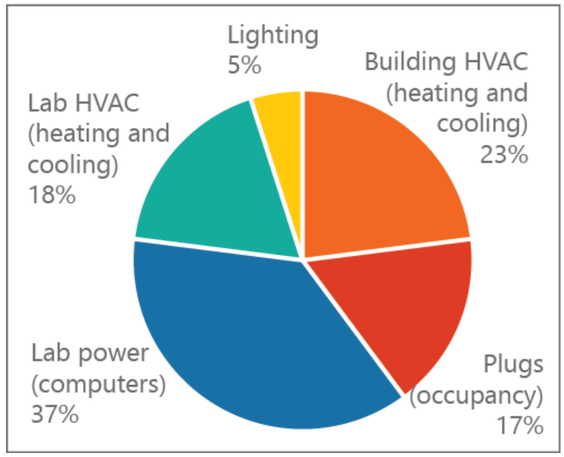
Darrell Smith, *Director of Energy and Buildings Technology*, Microsoft
Redmond, Washington

Where we started

Microsoft's headquarters in Redmond, WA is made up of 15 million square feet in 125 buildings, providing office and lab space for 59,000 people. A small city, in many aspects. These buildings were constructed over several decades and use a variety of systems to control their HVAC (heating and cooling) systems.

Prior to 2011, we employed several strategies to reduce power consumption on campus:

Electricity usage at Microsoft, 2013



- **IT solutions.** We use the automatic sleep feature in the Windows operating system to reduce the power consumption of computers.
- **Lighting strategies.** Lights shut off automatically during non-peak hours, and lights in public spaces like conference rooms are tied to motion sensors.
- **Temperature schedule.** We use a night setback to turn off the air conditioning during non-work hours.
- **Re-commissioning buildings**. In general, buildings are thought to be in peak form when they are first commissioned for use, and then over time, the energy efficiency degrades. There are mechanical failures – a damper that gets stuck open or closed, a temperature sensor that gets dirty or stops operating properly. There are scheduling mistakes – an exhaust fan running at the wrong time of day, or lights that are left on when no one is using the building. The same way a car needs regular tune-ups to keep running well, a building does, too.

Building efficiency with re-commissioning

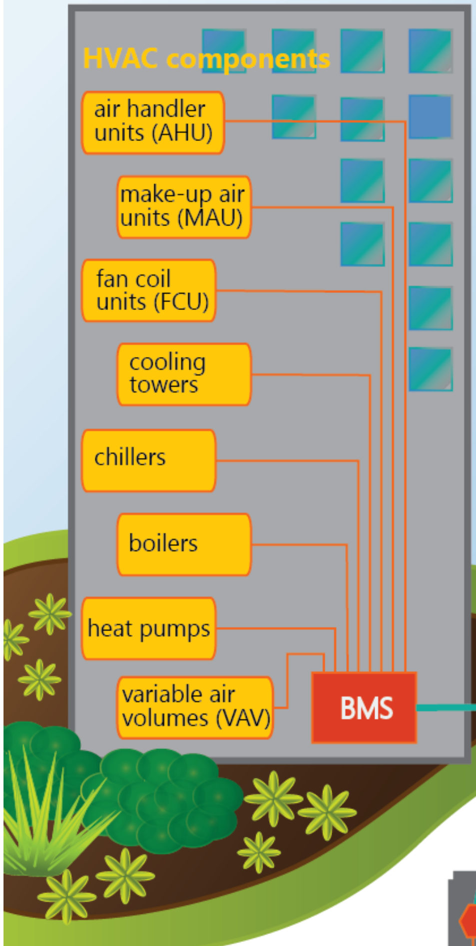
Microsoft's rhythm was to re-commission each of its buildings once every five years. A building took two weeks to re-tune, and the engineers fixed about 200 pieces of equipment. This reclaimed some, but not all, of the lost efficiency. Microsoft saved $250K in energy costs each year with its re-commissioning program.

Taking the next step

Prior to the Energy-Smart Buildings (ESB) initiative, it was difficult to get a clear picture of how well the buildings were performing. We could piece together a view of the energy consumption a month or two after the fact by looking at the energy meters and utility bills. Or we could go building-by-building and inspect the control panels and ventilation systems in person. Both options were time consuming, and neither provided enough granularity to make intelligent, strategic changes.

In 2011, we began a pilot for the ESB project. The goal was to use software to pull data from each building about its operating conditions, and then evaluate that data by using a strategy called fault detection and diagnostics to find opportunities to save electricity and money.

How Energy-Smart Buildings work



1 **HVAC components** use energy to run. Each HVAC component in a building has sensors built in to measure things like temperature, damper position, fan speed, etc. These sensors help the component run.

Every measurement taken by an HVAC component's sensor is a data point that we can use to save energy.

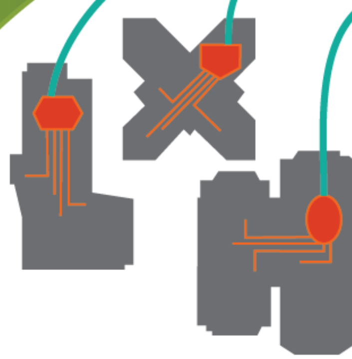
2 The **building management system (BMS)** controls all of the system components used for heating, cooling and ventilation. It issues instructions about when to run, and can also notice when components are failing and sound an alarm.

The BMS communicates with the HVAC components by using an MSTP protocol over a wired connection. BMS systems use different MSTP protocols, depending on the type of BMS.

3 The **Energy-Smart Buildings software** adds a layer of intelligence on top of the BMS logic. It compares the current operating parameters of each HVAC component to a list of energy-wasting usage patterns called "faults".

So, if a heater is on when it's already hot outside,
a fan is running when the building is empty, or
a damper gets stuck so that the air has to be heated after being cooled, those are all faults.

Each fault that we fix saves energy and money.



There are 35,000 HVAC components in 125 buildings acting as data sources on our campus. Each component is given a unique name that includes the building name, floor, and type of component, so that it's easy to find if it produces a fault.

The software checks some components every 5 seconds for new data, and others every 15 minutes. We pull in half a billion data points each day.

We look for 90+ different kinds of faults. Each fault type is associated with an annual energy cost savings ranging from $7 to $40,000. Even small faults can add up quickly.

Engineers monitor the software in real time, but we also generate 20 types of custom reports for budgeting and analysis.

Software for fault detection and diagnostics

Fault detection and diagnostics (FDD) is a powerful tool for managing buildings. Our software continually pulls data from the campus's many different HVAC systems and building management systems (BMS). The software compares the current operating conditions to a list of rules for "normal" operating conditions, and flags discrepancies as faults. Each fault shows where equipment is wasting electricity because the equipment has failed or needs maintenance, or because of human error (such as a building engineer adding set-points outside the normal range of temperature or time values).

We can use past energy reports and the current operating conditions to associate a cost with each fault — the higher the cost, the higher the priority to fix the fault. The faster we notice a problem, the sooner we can save energy and money. The software makes the invisible visible. We can catch quiet failures and cascading problems right away before they damage equipment due to overheating or overuse.

Third-party solutions built on Microsoft platforms

For the ESB program, we tested commercially-available options for building-management software. All were built on Microsoft platforms, including Windows Server, Windows Azure, SQL Server, .NET, Bing Maps, SharePoint, Office, and Power BI. We especially value the security, scalability, and business intelligence that Microsoft platforms provide.

Customized information

We pull in extra information to help us evaluate our energy usage patterns over time, such as local weather conditions, headcount/occupancy data, and utility data. The dashboards, graphs, and reports use this data to generate meaningful metrics and display key performance indicators (KPIs) in real time.

Benefits of big data

There are dozens of software options to help buildings save energy and run with greater performance, and increasing numbers of buildings that incorporate some sort of energy-saving automation. The ESB program at Microsoft is unique because of our centralized management and the sheer scale of our operations. However, you don't have to operate at the scale of the Microsoft campus to benefit from fault detection and diagnostics. It works for a handful of buildings as well as it does for a city.

What big data looks like in facilities management

Every time we add a new building to the Energy-Smart Buildings program, there is a new deluge of faults that were previously invisible. **These numbers are large and variable enough that it would be difficult to spot trends or prioritize fixes without the help of intelligent software**. For example, we see an average of 2,000 active faults at any one time, and about 7,000 unique faults over the course of a week. Many faults only rise when certain conditions are met—the outdoor temperature is below freezing, for example, or it's a sunny day, a night, or a weekend.

Even in cases where the savings for each fix are small, such as an individual VAV unit that's only wasting about $100 per year, the data provide important visibility into how a building works as a system. Our building engineers receive thousands of service requests per month to fix offices that are too hot or too cold. Based on the calls, we can treat the symptoms, but with the Energy-Smart Buildings software, we can get to the root cause: a cascading problem where many pieces of equipment are not running properly, or equipment that's not geared to run within standard set-points.

Reports

Before we rolled out the ESB program, compiling reports used to be a manual process, based on sifting through utility bills, meter reports, and screen shots from the BMS. We had no way of exporting data from the building systems, and it was very hard to see patterns, understand trends, determine real-time power usage, or create a strategy to reduce electrical costs on campus. Now, we can easily produce charts and graphs that help us visualize the data for many purposes:

- **View the "Top 500"** – These are the day's most expensive faults across campus, with the highest potential for energy savings. These are generally the highest priority fixes.

- **Perform measurement and verification** – Our utility is providing rebates against our initial investment cost as we demonstrate energy savings. The software-generated reports show that our actions are reducing energy consumption on campus.

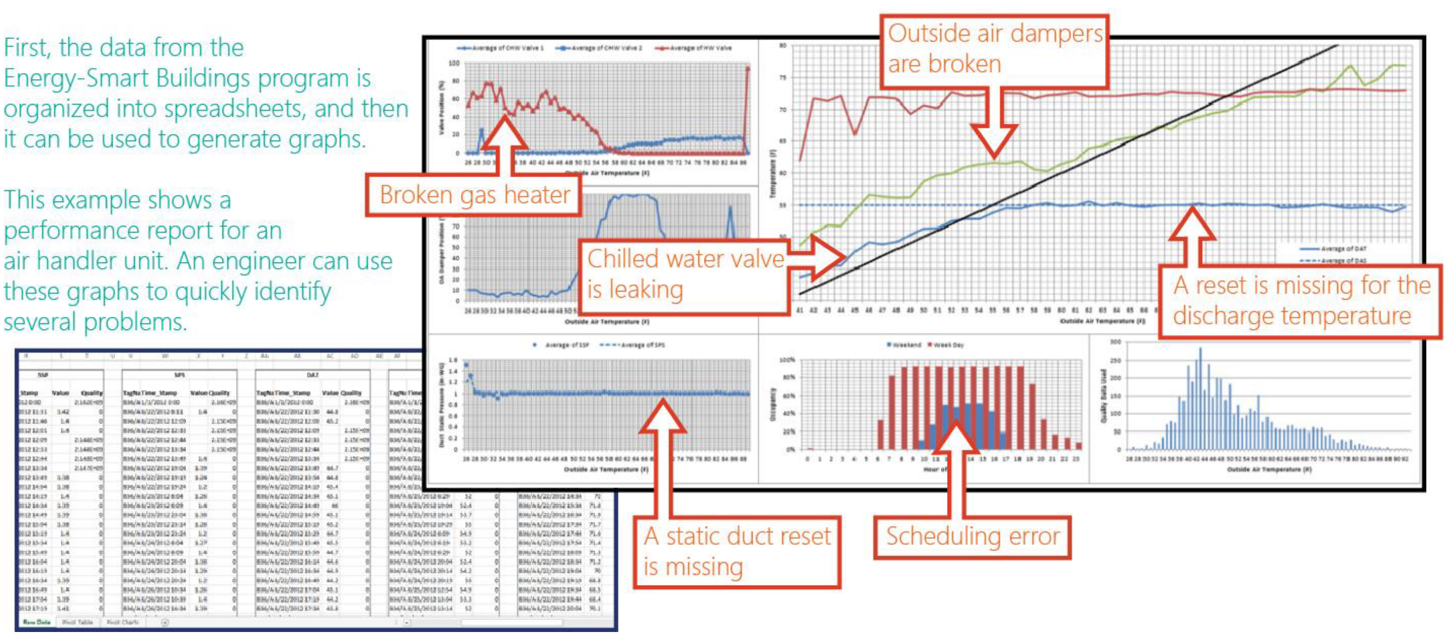
- **Identify complicated problems** – Thanks to the map view, we can now tell at a glance if all of the buildings under one chiller plant, generator, or electrical substation are experiencing the same problem. Then we don't have to waste time debugging building-by-building; we can send technicians straight to the real issue. Similarly, when one component's erratic behavior causes reflexive malfunctions in other components, we can now diagnose all of the issues as a group.

- **Take care of "easy fixes"** – If a technician is already responding to an issue in one building, the extra data can suggest when it's convenient and cost-effective to fix a few other nearby issues. This degree of labor optimization was very difficult before the ESB program.

- **View statistics for individual pieces of equipment** – We can see how our assets are performing over time, across seasons, and compare them to similar units. We can identify which assets need to be replaced, and we can use graphs and charts to find operating errors, as shown below.

First, the data from the Energy-Smart Buildings program is organized into spreadsheets, and then it can be used to generate graphs.

This example shows a performance report for an air handler unit. An engineer can use these graphs to quickly identify several problems.



Results

Our investment in ESB has a payback of 2.5 years. We've brought the campus online in ESB, and are starting to work through the backlog of issues that the software has uncovered. Now that our campus is running in ESB, we anticipate an energy savings rate of over 10%. Our costs included the software, minor BMS upgrades and configuration work, and a team of seven people: a program manager, two controls engineers, three mechanical engineers, and an IT manager.

Why it saves money:

- Visibility into the current state of all equipment across campus in one app.
- Ease of identifying the most costly issues quickly.

  We have found and fixed single faults that cost $20,000-$40,000 annually. A huge savings.
- Low setup cost: no replacement of equipment, rewiring, or displacement of building occupants.

  The biggest challenge was going into each BAS and renaming each HVAC component across campus with a unique, standardized name so that it was easy to tell where to send a crew for fixes.
- Ability to group similar problems for faster treatment and to help the building technicians identify root causes for large or complex failures.

Case study: using ESB to uncover construction mistakes

One of the unanticipated but valuable results of ESB has been the extra degree of visibility we have in working with vendors. In one example, Microsoft was fully renovating one of the older buildings on campus under our Workplace Advantage program. In parallel, our Energy Smart Buildings team was reconfiguring the ESB software to reflect the building's new layout and HVAC systems.

During project handover, we realized by using our software that several of the VAVs weren't achieving the expected CFM flow rates. Upon investigation, we discovered that a smaller, less powerful VAV had been installed instead of the higher-flow VAV in the specification.

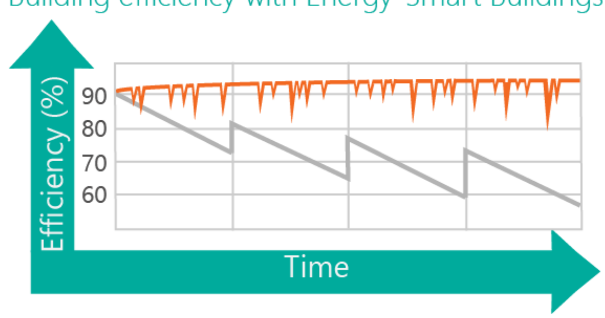
This sort of construction error would have been mostly invisible before, and difficult to catch in time to negotiate a fix with the vendor. With Energy-Smart Buildings, the discrepancy in flow rates was obvious, and the source of the problem was easy to discover.

Faults + re-commissioning

We continue to make a sizeable impact on energy reductions by re-commissioning, or re-tuning, each building. But now instead of waiting five years before recalibrating, we can address major problems immediately by using the data from the ESB software to identify and fix faults. Even better, we have visibility into the operating conditions for every single piece of equipment in the building — instead of just looking at 200 units, we can use current building data and the Top 500 list to ensure that the engineers work on the components that need it the most.

This makes an enormous difference over time. The graph at right shows two efficiency curves: the effect of re-commissioning every five years is in grey, and ESB is in orange. We anticipate that we can even improve the average efficiency above a "like new" building thanks to the extra data from the software.

Building efficiency with Energy-Smart Buildings



Make your own buildings energy-smart

There isn't a one-size-fits-all solution for running buildings more efficiently. The best options will depend on many factors and constraints. This section will help you evaluate your needs and narrow your options.

1 What problems am I trying to solve?

- Reduce total electricity usage?
- Reduce peak usage?
- Make budgeting easier and faster?
- Understand my buildings' energy usage so that I can devise a strategy?

2 What do I want to use the software to do?

Dashboard
What KPIs do I want to see?
- energy usage/building
- energy usage/headcount
- peak load

Go back to step #1 - how do I measure what I want to do?

Fault discovery & detection
(FDD) Find equipment that's not running well and fix it for energy savings.

Reports
How well are my systems performing over time? By season? Are some buildings performing better than others? Are some pieces of equipment ready to be replaced?

Persistence
Over time, how do I keep equipment running in the right temperature ranges and on the right schedule? How do I incorporate smart data into my building engineer's daily work?

3 What software should I use?

Iconics
Great visuals, customizable FDD, BMS integration, reporting.

KGSBuildings
Algorithmic FDD libraries, customizable, built on Azure.

OSIsoft
Data platform at city-scale, built on Azure and Power BI for Office 365.

Switch Automation
Low-cost dashboard for tracking energy trends.

4

Great, I'm ready!
Awesome! Your next steps are:
1. Decide which software to use.
2. Make sure you have the right people or vendors in place.

or

This sounds great, but what if it doesn't work for us?
Consider a pilot program with just a few buildings, and then evaluate whether it's producing results.

or

We're not ready.
In the meantime, use a re-commisioning program to save energy.

5 Can I figure out how to do this myself, or do I need help?

I can figure it out myself. I already have these roles in house, can hire them, or work with a vendor that provides them.

Integration
A systems integrator can evaluate the building systems, devise a naming scheme, hook up networking, and configure all of the equipment.

Fault rules
Programmers write fault rules and cost savings algorithms based on the load sheet.

HVAC
Engineers use faults and trends provided by the software to tune their buildings.

I need to understand my options better. This sounds great, but I have no idea what to do next.

Hire a consultant to build an energy-smart building strategy.

I just want it to happen. I will bring in third-party expertise to get us up and running.

Hire a consultant to run your program and make it operational.

Any questions?

Is the software "there" yet, or should I wait?

We think that everything that you need to run an energy-smart campus is available now. There are software options that are inexpensive, intelligent, secure, and fully-featured. You can use existing building hardware, electrical sub-metering, and a BMS to generate the data. Then use Windows Server to store the data on premise, or Azure to host it in the cloud. A third-party software solution can help you run analytics, view KPIs, evaluate usage and cost trends, and find faults.

Was it expensive?

It was a great investment. Given that we were able to use existing building systems as they were, the major expenses were buying and tuning the software. Also, to recoup our investment faster, we participated in a rebate program with our utility company. Washington State actually has one of the lowest electricity rates in the US (at 7.24 cents/kWh in 2013, it was the second-cheapest state). In markets with a higher energy rate, you can expect a shorter payback and a higher rate of return. Compare average state rates in table 5.6.A at http://www.eia.gov/electricity/monthly/.

How long did it take?

We ran a pilot program in 2012 with 13 buildings. It took us nine months to plan, write fault rules, do an initial tuning, and get the first buildings running with meaningful results. After we committed to a full installation across the rest of the corporate campus, we brought 93 more buildings online in 16 months. Now, some engineers are fixing the work items we've uncovered, and others are continuing to evolve more complex analytics.

How much headcount did you have to add?

Hiring and training the right skill sets has been one of the most challenging parts of this project. For the initial 13-building pilot, we needed five people: a project manager, two controls engineers, a mechanical engineer, and an IT manager. We added two more engineers for the full installation a year later. Now that we're running the Energy-Smart Buildings project across our campus with 15 million square feet, we are training our other building engineers to use the software, too.

Is it worth it?

Yes!

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