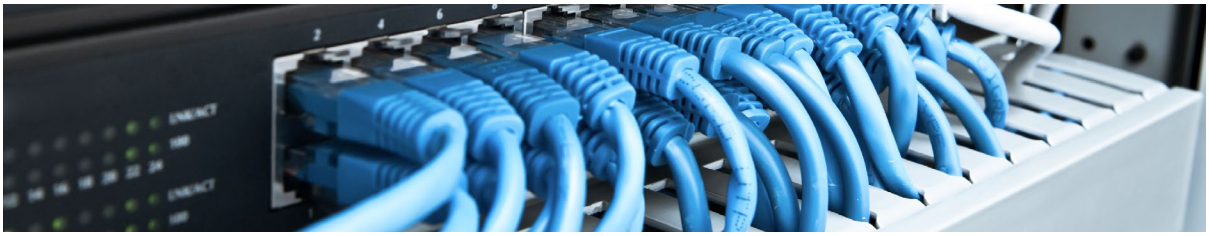
CASE STUDY: THE DISTRIBUTED SERVER ROOM



SUSTAINABILITY OPPORTUNITY

Approximately 2,000 of Stanford's servers are located in satellite server rooms distributed across campus. Often times these rooms were not initially intended to host servers, but were converted over time as the need for computing capacity increased. As a result, these spaces require a lot of energy to support the servers. Stanford's Sustainable IT Working Group (Sustainable IT) conducted a study to determine just how inefficient these server rooms are. The data collected in this study is used to calculate energy savings of relocating equipment to more efficient data centers.

METHOD

Sustainable IT included the following five server rooms in the study, each chosen to represent a different type of air conditioning system:

- Closet with a single water coil with a fan for cooling (additional cooling provided by the building system)
- Growing high-density computing room (Growing HD) with water-chilled racks. Fans in the module move air from the rack equipment through a cooling coil and expel it from the back of the unit
- Raised floor mini data center (Mini DC) cooled with computer room air handler (CRAH) units
- Lights-out cinderblock room (Cinderblock) with electrically-powered direct expansion (DX) air conditioners
- High-density computing room (High Density) with in-row cooling and contained hot aisle—the air conditioning system sits between the racks and takes in hot air from server exhaust, cools it with chilled water, and blows it into the cold aisle

The team installed nearly 400 wireless data collection devices in the five rooms and measured energy used for both IT and cooling during a single time period. This data was used to calculate the PUE for each room, which indicates the room's cooling efficiency.

RESULTS

The table on page 2 summarizes the results of the study, including the room infrastructure, energy efficiency and energy footprint.

Energy Efficiency

Measured PUE is the PUE calculated from the measured data. The measured PUE ranged from 1.27 to 2.94—in the Mini DC the energy to cool the space is almost twice as much as the energy to power the servers.

Normalized PUE makes adjustments to measured PUE assuming that all rooms have the same power infrastructure (e.g. uninterruptable power supply and power distribution units). The normalized PUE can be used to compare the efficiency of the server room to each other and to data centers. Except for High Density,

What is PUE?

Power usage effectiveness (PUE) is a measure of how efficiently a computer data center uses energy. Specifically, it's the ratio of energy used by the computing facility as a whole, including cooling and other overhead, to the energy just used to power the computing equipment.

$$PUE = \frac{\textit{Total Facility Power}}{\textit{IT Equipment Power}}$$

The lower the PUE is, the more energy efficient the facility. The theoretical minimum a PUE can reach is 1, meaning all energy is being used only to power computing equipment.

CASE STUDY: THE DISTRIBUTED SERVER ROOM

all other rooms have a normalized PUE that is significantly higher than that of Stanford's data centers, which fall in the range of 1.2 to 1.4.

The higher efficiency of the High Density room is expected, as the room was originally built to house servers and was designed with efficiency in mind. Most server rooms, however, were not originally planned for, and the servers in these spaces would be supported much more efficiently if relocated to data centers.

If relocation is not an option, the server rooms can often be retrofitted to improve efficiency. All rooms were found to be overcooled, and could be run with 30-60% less air flow. The table includes recommended retrofits for each case, and the new efficiency is captured by the target PUE. The normalized target PUE demonstrates that even with energy efficiency improvements, many server rooms will never be capable of running as efficiently as a well-planned for data center.

The team had expected a higher efficiency for the Growing HD room. However, many servers in that room were only running at partial load but being cooled at full load. The team calculated that if the servers were being run at full capacity, the normalized PUE would drop down to 1.47. This is a good example of when consolidating servers through virtualization would decrease both electricity and cooling energy consumption.

Results of Satellite Server Room Energy Efficiency Study

The table summarize the results of the study for each satellite server room, including the room infrastructure and recommended retrofits, PUE, and energy footprint.

	Closet	Growing HD	Mini-DC	Cinderblock	High Density
Room Infrastructure					
IT Load (kW)	10	41	44	59	223
IT load intensity (W/sf)	83	34	30	50	278
Cooling Method	Fan Coil	Chilled Water Racks	CRAH Units	DX Units	In-row Cooling
Cooling Efficiency					
Measured PUE	2.14	1.78	2.94	1.70	1.27
Normalized PUE	2.36	2.00	3.14	1.70	1.42
Recommended Efficiency Measures	• Install blanking plates • Replace fan coil • Increase inlet temperature	Install variable frequency drives (VFDs) and run chillers in parallel	• Install blanking plates • Seal floor • Rebalance floor tiles • Install VFDs	Install VFDs on air conditioners	• Install blanking plates • Install cold-aisle Containment
Target PUE	1.43	1.77	2.43	1.54	1.23
Normalized Target PUE	1.65	1.99	2.63	1.54	1.38
Energy Footprint					
% of Building Space	0.2%	1.2%	1.5%	100%	2.7%
% of Building Energy Use	6.7%	13%	22%	100%	41%
Annual Energy Cost	$19,000	$63,000	$142,000	$72,000	$260,000
Average daily cost/kW IT load	$5.11	$4.19	$6.55	$4.44	$3.21

CASE STUDY: THE DISTRIBUTED SERVER ROOM

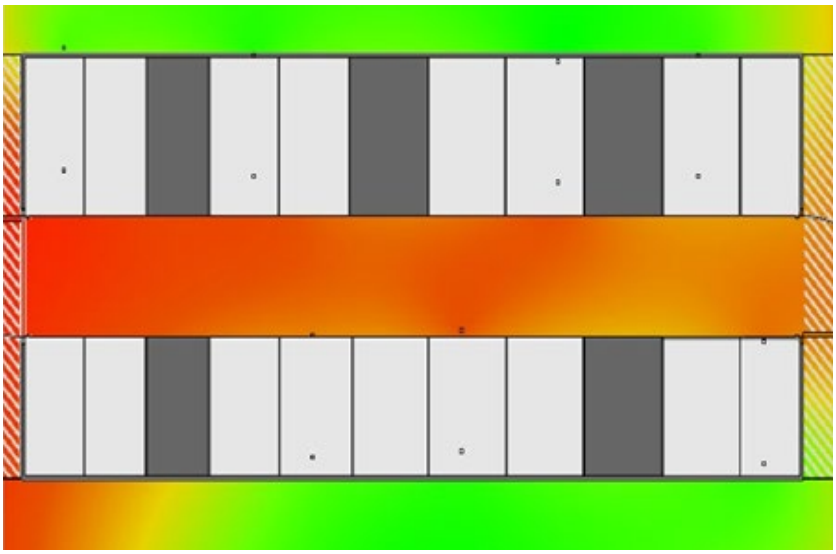
Energy Footprint

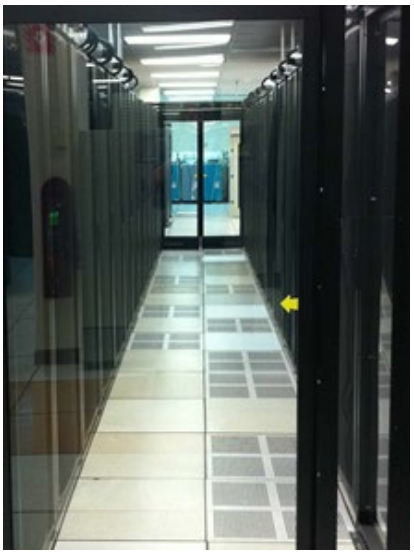
Although the server rooms are small, occupying just 0.2% to 2.7% of the entire building, their energy consumption is significant. The High Density room is less than 3% of the building's footprint, but consumes 41% of the building's energy! The Cinderblock room, which is a building dedicated to hosting servers, is an exception.

The average daily cost per kW IT load allows for comparison of costs across server rooms and demonstrates that costs can be highly variable based on the energy efficiency of the room and energy source. The costs range from $3.21 to $6.55 per kW IT load per day. The Cinderblock has the highest unit cost because it is the only room cooled by electricity instead of chilled water from the Central Energy Facility.

Although significant, prior to the study, the energy costs of running these server rooms were unknown. This study highlights the high cost of running distributed server rooms, and hopefully provides the evidence and motivation necessary for Stanford departments to choose the most efficient option for their servers.

Above- The single fan coil does not meet the cooling load of this server closet. Cooling is supplemented by the building HVAC system, requiring it to run all the time. This inefficiency results in a PUE of 2.14.





Above- A contained hot aisle of the high-density computing room prevents hot air from mixing with cool air, reducing the energy needed to air condition the room. This efficiency results in a PUE of 1.27.

MORE INFORMATION

SUSTAINABLE INFORMATION TECHNOLOGY

http://sustainable.stanford.edu/sustainable-it-initiatives

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