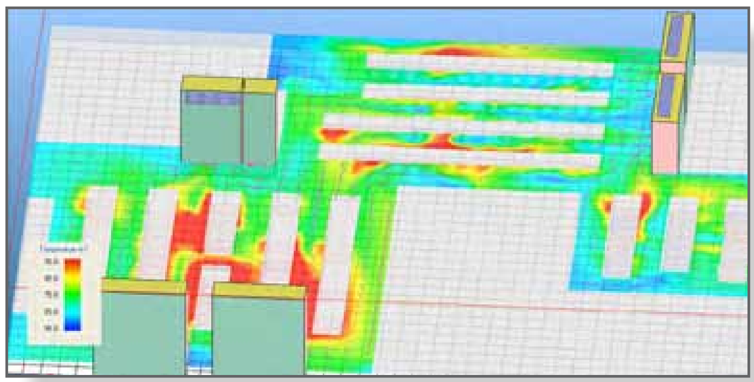
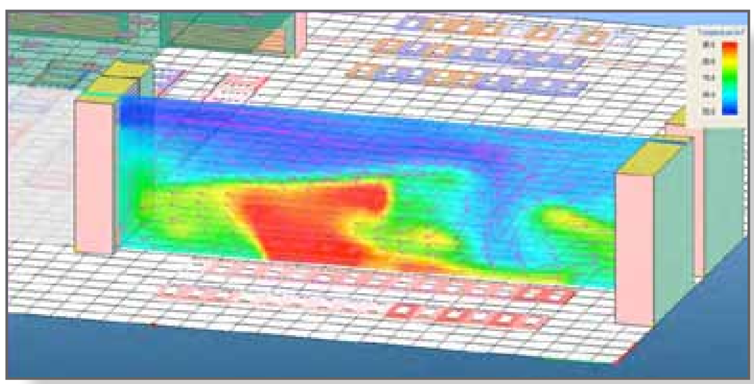
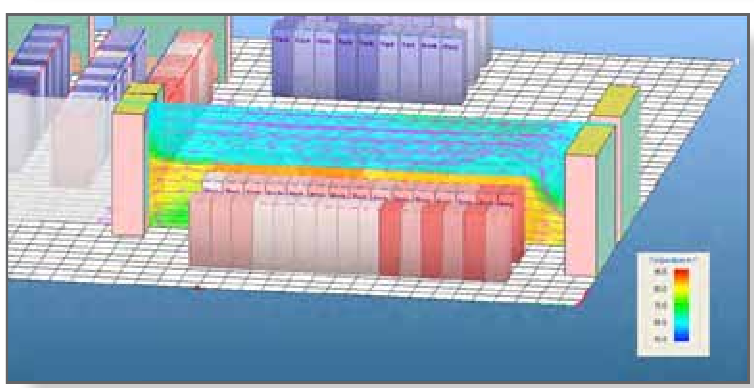
EASYSTREET
ADVISOR SERIES

Airflow Management Project:

How to implement hot/cold aisle containment in an operational data center to improve energy efficiency while keeping your customers happy.







Efficient cooling is a critical factor in data center operations, directly influencing the cost of power and longevity of computing equipment. The challenge is especially acute for older data centers that may lack the airflow dynamics for effectively handling the higher temperatures today's IT gear generates.

EasyStreet® Online Services — Oregon's leading colocation and cloud services provider — recently confronted that very situation. Founded in 1995 and at its current location in Beaverton since 1998, EasyStreet has systematically added onto its SAS 70 Type II audited Data Center 1 to accommodate a steady growth in customers. But cooling technologies in the older sections of the data center had grown less efficient and were creating complex bypass airflow problems even in newer sections.

Meanwhile, EasyStreet opened the larger and "greener" Data Center 2 in early 2011. Its design phase brought EasyStreet into contact in 2009 with Energy Trust of Oregon, a relationship that led to a significant airflow management project greatly improving cooling efficiencies in the existing data center. Energy Trust began operation in 2002 as an independent nonprofit to provide services, cash incentives and solutions to help Oregonians save energy and utilize renewable resources.

Results of the extensive airflow management project already are reducing runtime and maintenance on the center's large air-handling units — saving energy costs and improving cooling efficiencies in the process — plus are benefiting customers who have servers in EasyStreet's colocation aisles. Knowledge gleaned from EasyStreet's experience will pay technology dividends in its new data center and can provide helpful information for many of the area's corporate data centers facing similar cooling challenges.

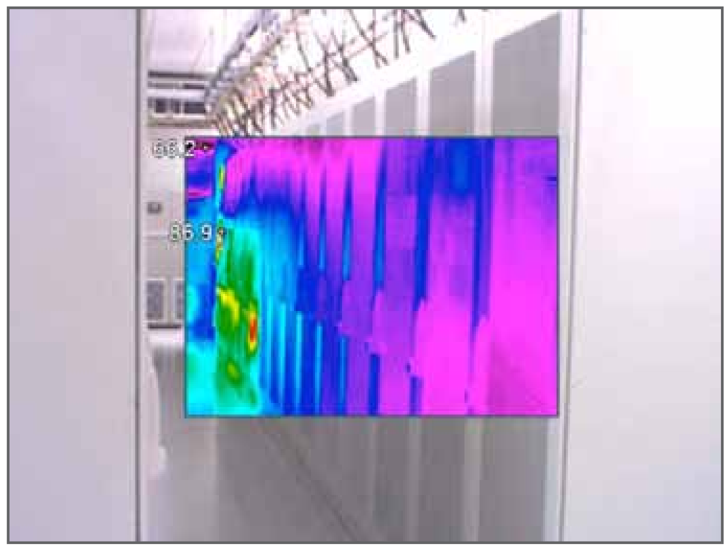
IDENTIFYING AIRFLOW

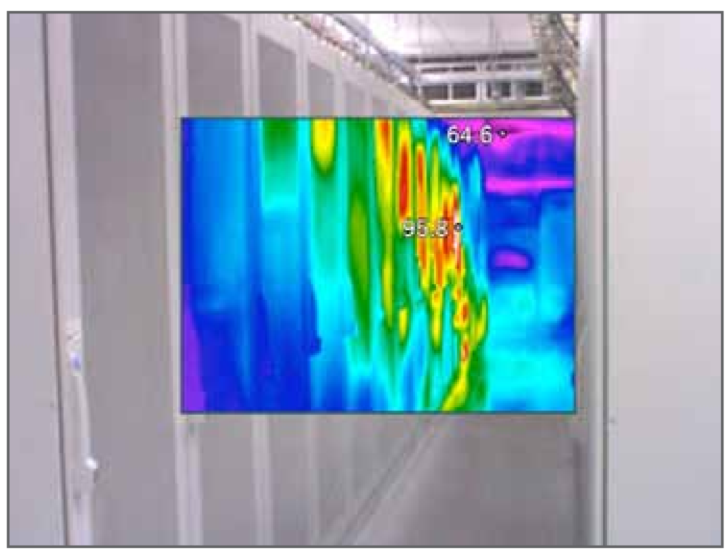
EasyStreet's airflow management project began, in a way, with an EasyStreet commitment a few years ago to obtain half of its power from green sources, specifically Portland General Electric's (PGE) wind farms. PGE in 2009 suggested that EasyStreet huddle with the Energy Trust of Oregon to firm up development plans for the new data center and to explore financing opportunities for implementing its green initiatives.

"EasyStreet is passionate about being green," says EasyStreet CFO Jack Flug. "There are a lot of different programs — low-cost loans and similar incentives — that can make it cost-beneficial for you to actually do an energy conservation or renewable resource project. Energy Trust turned us on to new ways of thinking about hot-air containment and different technologies controlling airflow throughout Data Center 1.

Ultimately, the audit concluded that hot spots existed as a result of "bypass airflow" — responsible, on average, for 70 percent of cooling-capacity waste in data centers, according to the Uptime Institute — and that cooling could be made much more efficient throughout the facility. The recommended improvements, however, would involve several important steps.

"Energy Trust presented us with the data and some examples of how separating the hot and cold airflows and using containment techniques might improve efficiency," says Eric Bourassa, EasyStreet's senior engineer. "We agreed the project could provide considerable cost savings, so we decided to pursue it. We wanted to accomplish it as efficiently as we could and with as little disruption to our customers as possible. After all, this is an operational colocation data center, so deciding to implement





Thermal imagining helped map hot and cold spots in the colocation area as part of the baseline audit.

something like this had the potential to have a significant impact on our customers. We kept that in mind every step of the way."

CONFRONTING LEGACY SYSTEMS

Cooling challenges in today's data centers radiate from a very fundamental situation. IT equipment, especially servers, are running at increasingly higher speeds and generating considerable internal heat. Semiconductor industry statistics show that over the last decade, the combined effect of Moore's law — that semiconductor processing power will double every 18 to 24 months — plus technology compaction has been a 17 percent annual increase in the density of power consumed and heat dissipated by IT products.

To cool these ever-hotter computers, they pull cool air into the front of the unit, flow it across the hot components and then expel the resulting hot air out the back. It sounds straightforward, but something as simple as hot air rising and cold air falling can result in complicated airflow dynamics.

"EasyStreet's Data Center 1 was built in several stages over the years to accommodate growth," Bourassa explains. "In the early stages, the amount of heat and cooling airflow was regarded as inconsequential to the efficiency of the data center and to equipment lifespan. But as power and densities increased, the industry became aware of these things and facilities were adjusted accordingly."

Sections of Data Center 1 employed airflow dynamics corresponding to the periods in which they were built. For example, the earliest section originally made no allowance for separating hot and cold air — the era's slower, cooler-running servers didn't require it. But later, as equipment temperatures rose, cold air was pumped directly down onto specified data center aisles via a network of ductwork and vents called "diffusers" emanating from the cooling units, or air handlers.

A more recent section of Data Center 1, however, was set up with designated hot and cold aisles, but had cold air from the air handlers blowing freely over the top of all aisles, a no-longer-viable solution now that equipment exhaust temperatures have risen even higher and are more prone to heating up the cold-air aisles with bypass airflow.

> *"Energy Trust of Oregon turned us on to new ways of thinking about hot-air containment and different technologies for cooling our facility."*

As a result of variations in EasyStreet's legacy cooling techniques, the airflow management project would involve different strategies to address the data center's several areas.

KEY PROJECT BENEFITS:

- Less energy consumed
- Less wear and tear on AC components
- Server life extended
- Keeps customer power costs down

WORKING WITH CUSTOMERS

EasyStreet's customers own the servers and network gear located in the Data Center 1 colocation area, with this equipment residing in nearly 300 cabinets located on a grid of aisles. It was clear from the outset of the airflow management project that the servers and their cabinets would be affected.

"A goal of the entire project was to keep disruption to customers to a minimum," Bourassa says. EasyStreet held a series of "lunch and learn" sessions to explain the project and its progress to its customers. "These gave us an opportunity to present what we wanted to do, what our customers were going to need to do, and how it was going to improve things for them."

When the project was completed, the customers learned, their equipment would be cooled more effectively, reducing strain on the equipment's own cooling mechanism and extending their servers' lifespans. They also realized that EasyStreet's goal was to improve energy efficiencies, which could financially benefit customers in the event of anticipated future electric-rate increases.

"Understanding that they'd face some disruption, several of our customers were, at worst, neutral, and a number of them were quite positive about the improvements," Bourassa explains.

The energy audit of EasyStreet's Data Center 1 had determined that bypass airflows could be reduced if servers were correctly aligned in their cabinets — making sure the hot-air exhaust flowed into a designated hot aisle — a task that directly affected customers because the customers would either moving their equipment themselves or someone else would moves it at a time convenient to the customer.

"The project design paid attention to how many customers were going to be impacted by this," Bourassa says. "We did everything we could to minimize the number of customers who were going to need to turn equipment around." In some cases, the customers came in and rotated their equipment, in others technicians from either EasyStreet or VARs of the customer's choosing performed the chore. If EasyStreet or a VAR did the work, EasyStreet absorbed the cost, including paying for the VAR's time.

Another chore related to customer equipment was cable management. Over time, the number of cables associated with a cabinet of servers — power cables, networking cables, keyboard cables, as examples — can became an unruly mass, capable of impeding hot airflow at the back of the cabinet. Cable management involves bundling cables together or realigning them to reduce congestion.

"One of our customers didn't believe that doing cable management would change the performance of the cabinet," Bourassa recalls. "The customer finally did do some cable management and the temperature at the top front of the cabinet dropped six degrees. That's significant, and it didn't take very much effort to make such a huge difference."

> *"This is an operational colocation data center, so deciding to implement something like this had the potential to have a significant impact on our customers. We kept that in mind every step of the way."*

REDUCING BYPASS AIRFLOW

Another part of EasyStreet's efforts to block bypass airflow from one aisle to another involved some simple tools — slender pieces of black plastic and some insulating foam — but produced significant strides in hot/cold-air containment.

A data center's cabinets resemble bookcases containing several shelves, or slots, on which servers and networking gear sit, ideally with their fronts facing cold-air aisles and backs venting into hot-air aisles. A seemingly trivial source of airflow — but which turns out to have significant impact on thermal dynamics — are the blank slots where no equipment resides within a cabinet, essentially leaving the front and rear of the slot open for air to flow from aisle to aisle. When this happens, hot air and cold air intermingle in the aisles and throw off the cooling efficiencies of the large air handlers.

Plastic blanking panels snap into the front of a cabinet's vacant slots to block free passage of air through the cabinet. They also discourage hot air from trying to circulate within the cabinet itself, as when a server located higher in the cabinet is exposed to hot air coming from the servers below it.

EasyStreet technicians placed blanking panels on cabinets requiring them, and then further blocked the passage of bypass air with insulating foam around the edges of the racks.

"Looking at them, you wouldn't think the blanking plates would do much," Bourassa explains, mentioning one customer who objected to them and then removed them from the cabinet where his equipment was housed. "He took them out, his server ran hotter. He put the back in, his server ran cooler," as indicated by the server's internal system monitors.

CONTAINING HOT/COLD-AIR

Once all the servers were properly positioned so their exhausts vented into hot-air aisles and blanking panels blocked bypass airflow through the cabinets, the next challenge was keep the hot air contained in the aisles so the air handlers could cool it. Key to the containment phase was relocating the ceiling cold-air diffusers so they furnished air to the cold-air aisles.

"The containment project was to keep all of the hot air in the hot-air areas and keep all of the cold air in the cold-air areas," Bourassa explains. "But before we could start with the containment portion, we had to get the diffusers moved, but we couldn't move the diffusers until after the customers had got their gear turned."

That done, the diffusers and their venting were relocated to furnish cold air coming from the air handlers and blow it down into the cold-air aisles.

The next containment phase was to restrict the flow of air in the hot-air aisles by using plastic caps over the top of those aisles. With the caps in place, any remaining mingling of hot and cold air was sharply curtailed throughout the data center. However, an airflow idiosyncrasy quickly developed.

"The hot aisles would get really warm, but we weren't seeing

EasyStreet used AirBlock™ isolation components from Simplex® to create a shell enclosure around the colocation cabinets.

the same levels of heat at the air handlers' intakes," Bourassa explains. While the plastic caps over the hot-air aisles covered the tops of the aisles themselves, the caps did not extend the several more feet to the intake vents on the air handlers. "Cold air was dropping down and blocking the hot air in the aisles from reaching the air handlers, actually creating a curtain of turbulence there."

The solution was to extend the caps from the hot-air aisles further to the air handlers, blocking the cold air from forming barriers between the hot-air aisles and the air handlers. "When we continued the caps right to the air handlers, that path for cold air went away and the hot air was able to enter the air handlers unimpeded," he added.

FOCUSING ON EFFICIENCIES

With the hot/cold-air containment aspects of the project complete — hot air confined to the hot-air aisles, cold air to cold-air aisles, and bypass airflow now reduced as much as possible — the focus of the airflow management project turned to the units of greatest potential power efficiency gains: the air handlers.

EasyStreet's six 20- and 30-ton Liebert HVAC units are located around the perimeter of Data Center 1, each potentially drawing about 56 kilowatts an hour. As with any automated air-conditioning system, the air handlers are designed to have cooling cycles, meaning they start up when temperatures reach a certain level of heat and turn off when temperatures are lowered to the desired coolness. The problem is, this on-off-on-off pattern, called "short cycling" consumes extraordinary amounts of electricity and is tough on components, particularly the compressors within the air handlers.

Greatest efficiencies are gained when the air handlers acquire a steady stream of hot air, pass it across the cooling coils and then disperse the cooled air into the cold-air aisles, without the start-ups and shutdowns associated with short cycling. The situation is analogous to auto mileage improvements for highway versus city driving.

Thus, a goal of the airflow management project was to keep the air handlers operating steadily and efficiently — and to permanently shut down any that were no longer needed. Bourassa called it "tuning" the air handlers to the data center's improved airflows.

REALIZING EARLY SAVINGS

The "tuning" process proved challenging. "There were temperature fluctuations in the aisles based on the number of servers and other variables," Bourassa says. "All of the cooling units are interdependent, which means that shutting off one affects the load on all of the other air handlers. Tuning has involved understanding which sets of units needed to be running at the same time."

At the time of this writing, at least two of the air handlers have been taken offline, with the remaining three fully able to maintain the desired temperature without the wear-and-tear of short cycling.

The temperature limit set for the cold-air aisles currently is 74 degrees. "I'm delighted to say that every sensor in those aisles has been consistently and notably below 74 degrees," says Bourassa. "We're doing a much better job of allowing the cooling load to match the air handlers' capacities, which means achieving their greatest cooling efficiencies."

With fewer air handlers running — plus no need for on-again, off-again cooling cycles — power usage has dropped dramatically. "It's expensive to turn those units off and on, especially with the power surge required for start-up," Bourassa says, "and it's hard on the equipment."

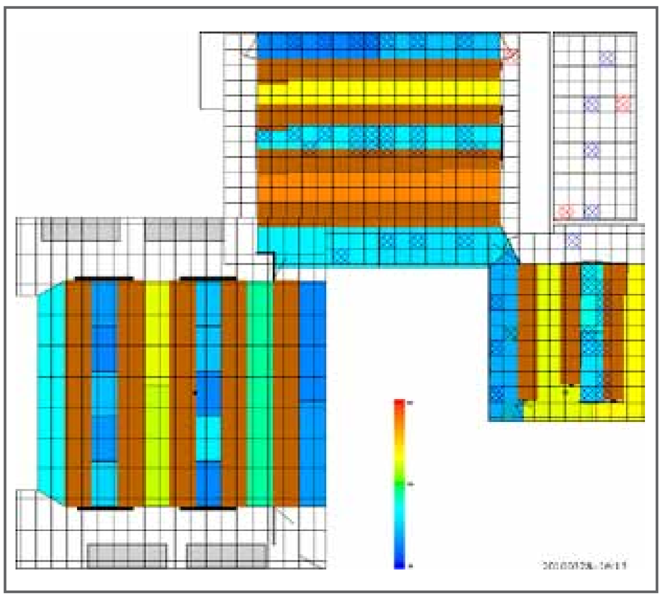
Savings are being realized on lower electrical cost for cooling the data center. "And that's just direct energy savings," says Flug, the financial chief. "We also were burning through three or four compressors a year at a cost of $5,000 a compressor. Just by the fact that we're already turning off two air handlers and not doing the short cycling means I expect a significant reduction in maintenance costs associated with those units. So, there are indirect savings as well."

LESSONS LEARNED IMPROVE NEW DATA CENTER DESIGN

Improved airflow management in EasyStreet's Data Center 1 already is benefiting the companies new Data Center 2, especially in cooling-system design. In terms of energy efficiency, the new facility represents an order of magnitude improvement over the existing one.

For example, Data Center 2 has specialized "chimney" cabinets, featuring hot-air channels on the back of the each cabinet for channeling hot air directly upward into ductwork feeding into cooling units.

"Hot air is on a direct path from the cabinets to the air handlers instead of having to pass through the room, with all of the associated complications," Bourassa notes. "With chimney cabinets, it's far more effective to get rid of heat at the source. Moving it down an aisle as we do today in Data Center 1 complicated, but having it rise into a duct is what heat wants to do anyway. Let it. Cold air wants to fall. Let it."



Sensors throughout the facility feed data into an online dashboard for on-going monitoring of hot/cold aisle temperature fluctuations.

Hot air from Data Center 2 is cooled via state-of-the-art indirect evaporative cooling units on the facility's roof. Indirect evaporative cooling uses an air-to-air heat exchanger to remove heat from the primary air stream without adding moisture, and typically achieves a high effectiveness rating.

"In the new data center, we take hot-air containment and add to it indirect evaporative cooling," Bourassa says, "which takes it all to the next level."

From the financial standpoint, EasyStreet will soon be seeing the positive financial results of its retrofit airflow management project in Data Center 1.

"One thing Energy Trust does, which I like, is show you your payback," Flug explains. "You look at the total cost of what you're going to spend on a project and what the total energy savings are expected to be. For me, as a financial guy, I can say 'I think that one has merit', which is what led us to doing the airflow management project."

"We all learned a lot from working on this initiative," he continues. "We're very open to having Energy Trust come out and learn from what we've learned and then pass it on to others. Quite frankly, even a lot of the corporate data centers in this area could use similar types of systems as we now have, and they could save significant energy, and costs, as a result."

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