Commercial Kitchen Ventilation

An Energy Efficiency Perspective!

Winnipeg Hospital (My first CKV project)

Design Approach:

- Reduced exhaust and makeup air (from 34,000 cfm to 12,000 cfm)
- Side panels and glass back wall for single island canopy
- Filter blanks in sections not over appliances
- Air-to-air heat recovery to preheat makeup
- Two-speed system (3000 ft/min duct velocity on high speed).

The Results

21 ft. single island canopy hood over baking line

27 ft. double island canopy hood over cooking line

• Concept Design	34,000 cfm
• Preliminary Design	21,000 cfm
• Final Design	11,000 cfm

Plus: 2-speed control and exhaust air heat recovery

Glass back wall

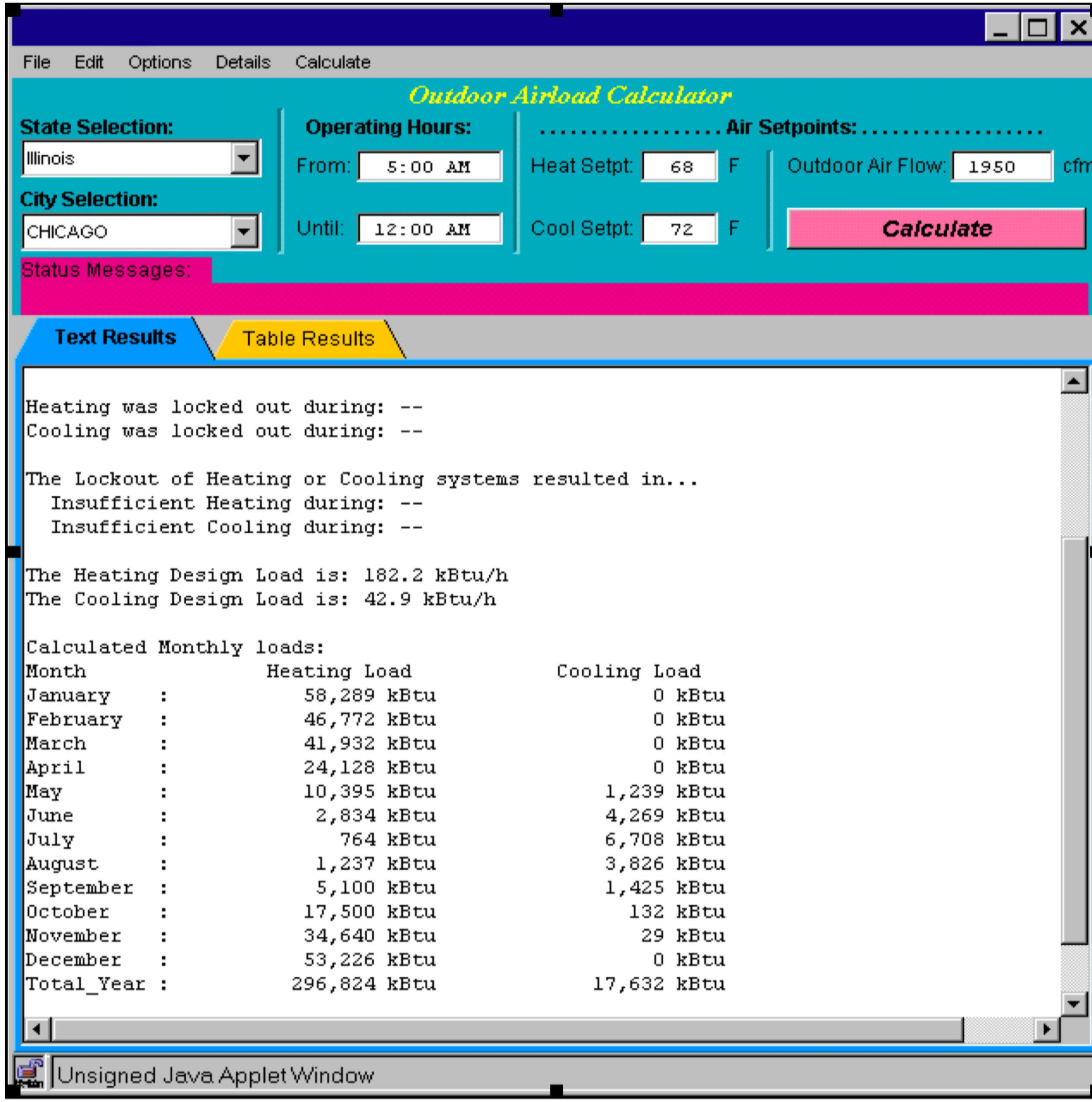
Predicting ENERGY Consumption

… and Cost for Commercial Kitchen Ventilation Systems

Outdoor Air Load Calculator

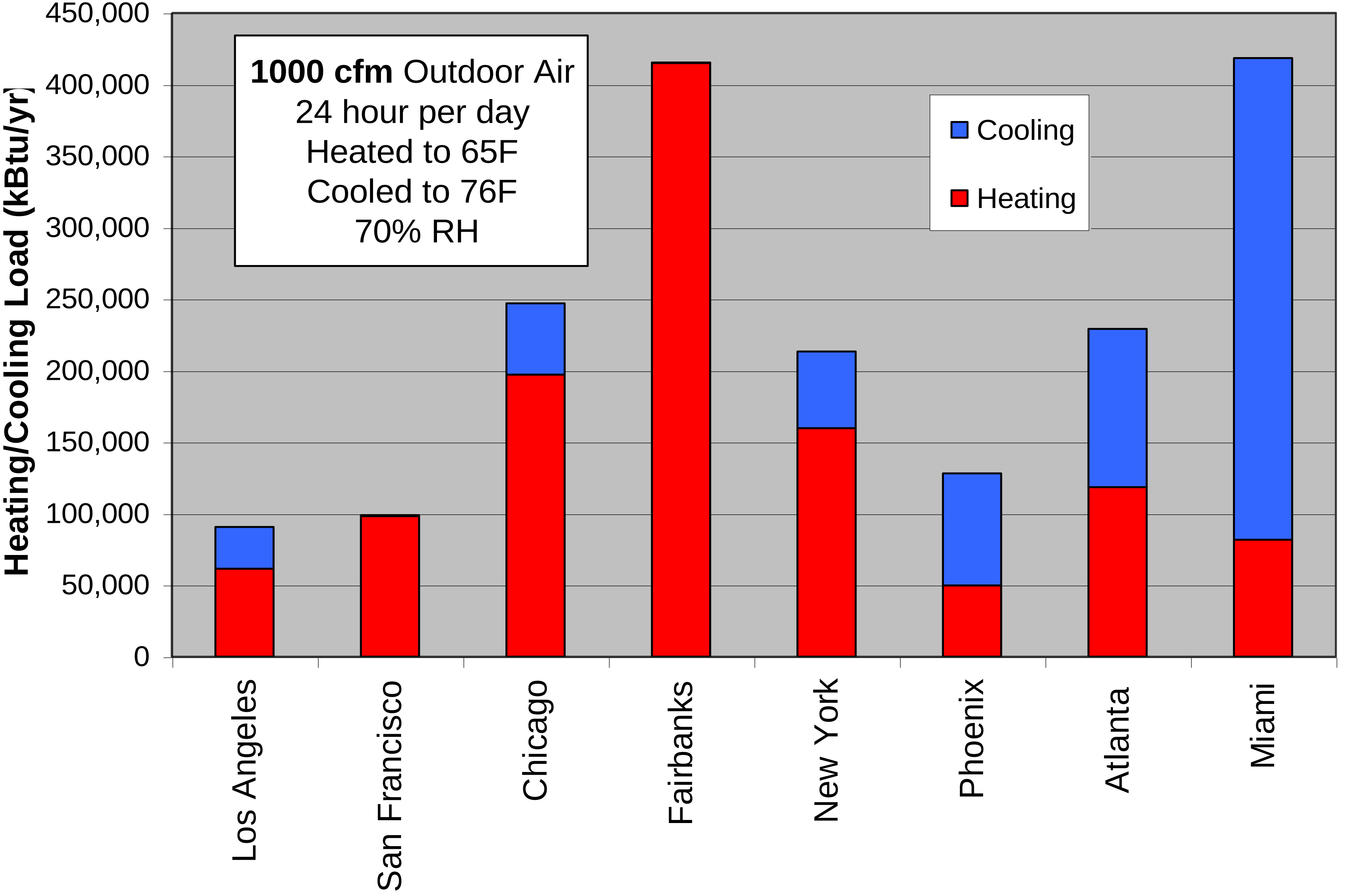
and

Fan Energy Estimator



Free Download: www.archenergy.com/AECHome/ckv/oac/default.htm

Climate Effect



Hotel in San Francisco

…50,000 cfm exhaust from kitchens!

Makeup air temperature 70ºF

Outdoor air temperature = 50ºF

Simultaneous cooling!

Turned down all the duct stats!

$50,000 per year saving in gas alone!

Toronto Restaurant

Canopy Hood Over Gas Cookline

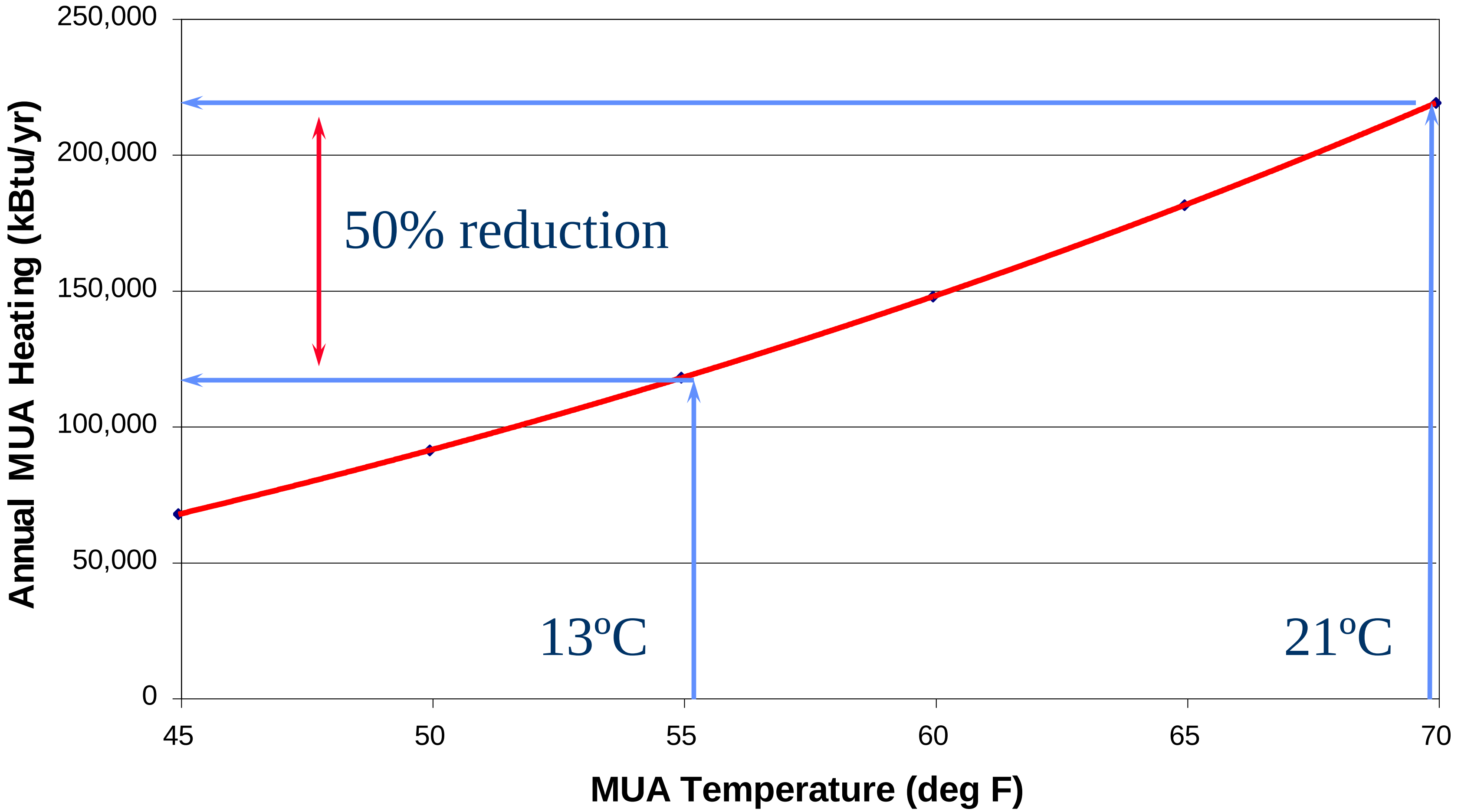
200,000 Btu/h Makeup Air Heater

MUA Discharge Temperature

75° F

Heating Load vs. MUA Temperature

1000 cfm, 24-hour operation, 365 days per year in Toronto

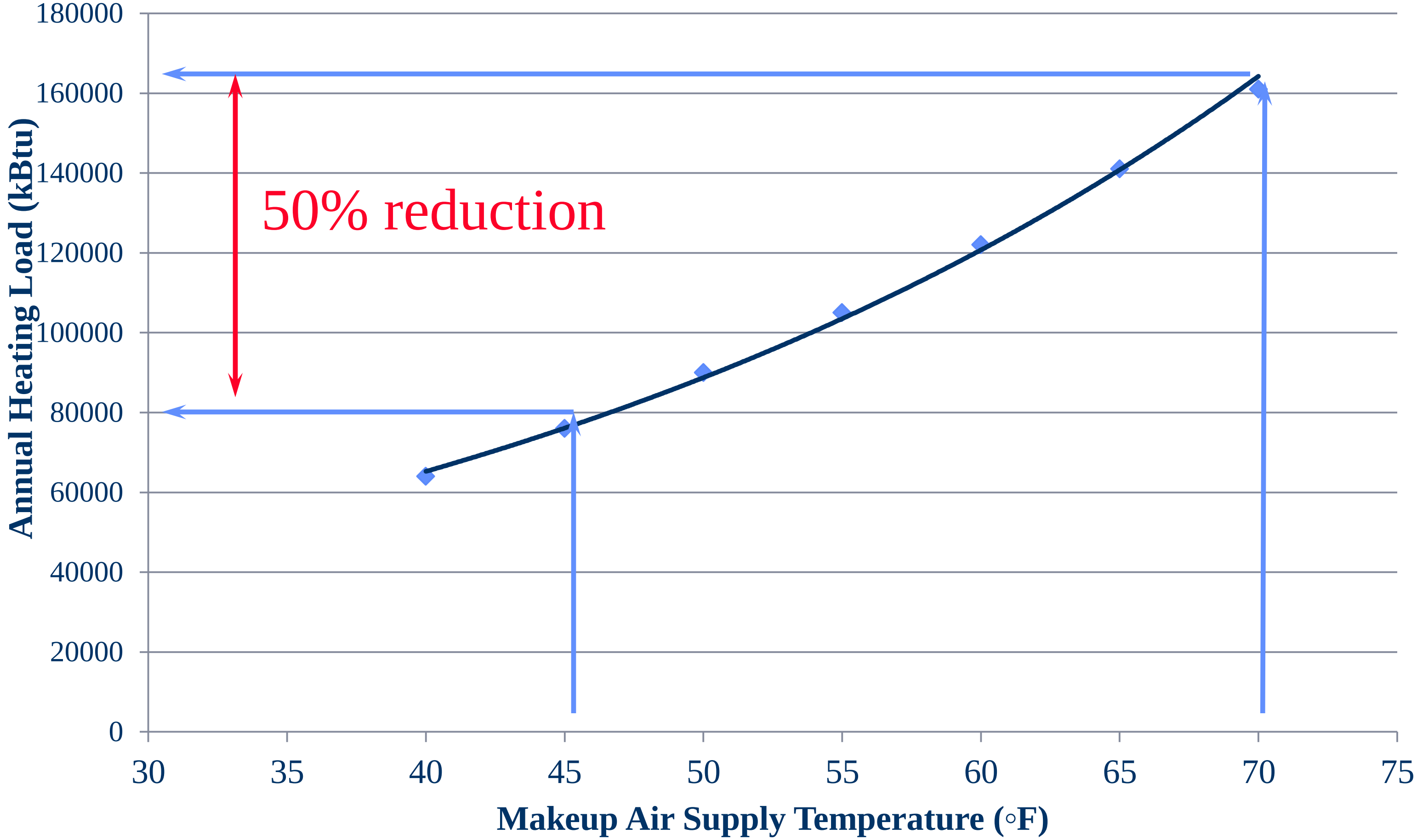


Example: Properly Set Duct Stat

13° C

Heating Load vs. MUA Temperature

1000 cfm, 12-hour operation, 365 days per year in Winnipeg



ASHRAE Standard 90.1

6.5.7.1 Commercial Kitchen Exhaust Systems

6.5.7.1.1 Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10% of the hood exhaust airflow rate.

6.5.7.1.2 Conditioned supply air delivered to any space with a kitchen hood shall not exceed the greater of:

a) the supply flow required to meet the space heating or cooling load
b) the hood exhaust flow minus the available transfer air from adjacent spaces. Available transfer air is that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces

6.5.7.1.3 If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm then each hood shall have an exhaust rate that complies with Table 6.5.7.1.3. If a single hood is installed over appliances with different duty ratings, then the maximum allowable flow rate in each section of the hood shall not exceed the Table 6.5.7.1.3 values for the appliance duty ratings in that section of the hood. Refer to ASHRAE Standard 154 for definitions of hood type, appliance duty, and net exhaust flow rate.

Table 6.5.7.1.3: Maximum Net Exhaust Flow Rate, CFM per Linear Foot of Hood Length

Type of Hood	Light Duty Equipment	Medium Duty Equipment	Heavy Duty Equipment	Extra Heavy Duct Equipment.
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	Not allowed	Not allowed
Backshelf/Pass-over	210	210	280	Not allowed

Exception:

a) At least 75% of all the replacement air is transfer air that would otherwise be exhausted.

Hoods are not created equal…

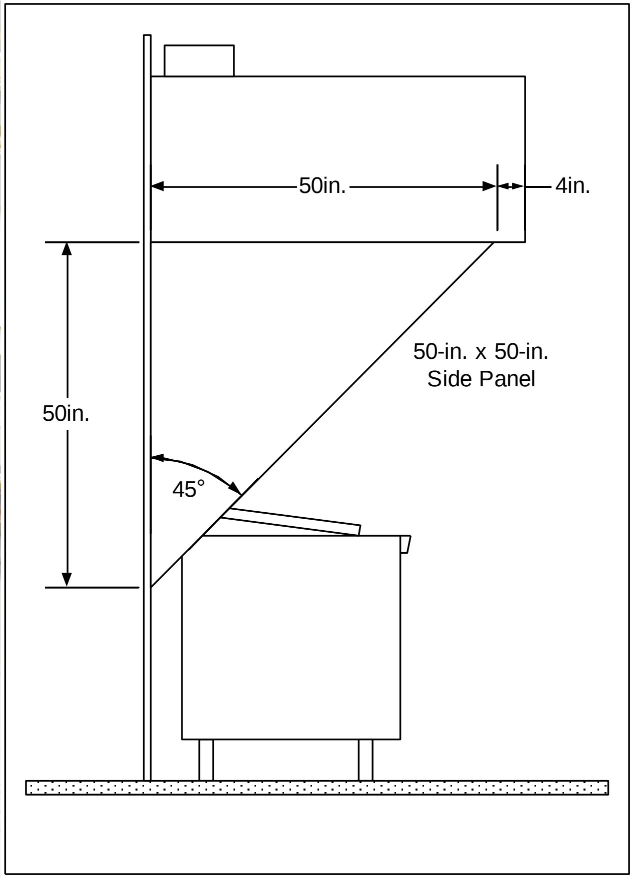
Laboratory Comparison of Wall-Canopy Hood Performance using ASTM F1704 - *Standard Test Method for Capture and Containment of Commercial Kitchen Exhaust Ventilation Systems*

The setup…

The Standard Challenge!

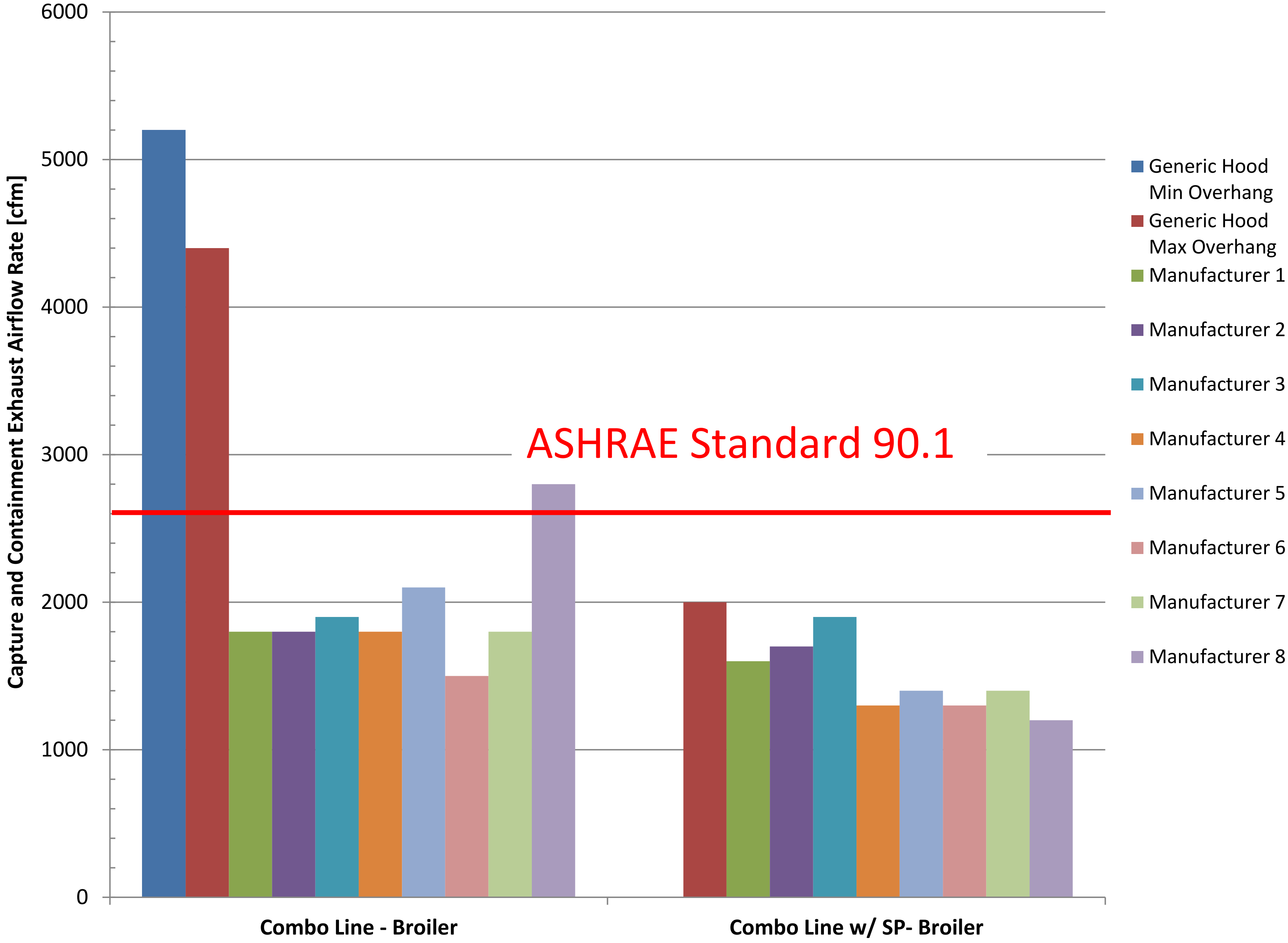
Heavy-duty appliance challenge

With and without partial side panels

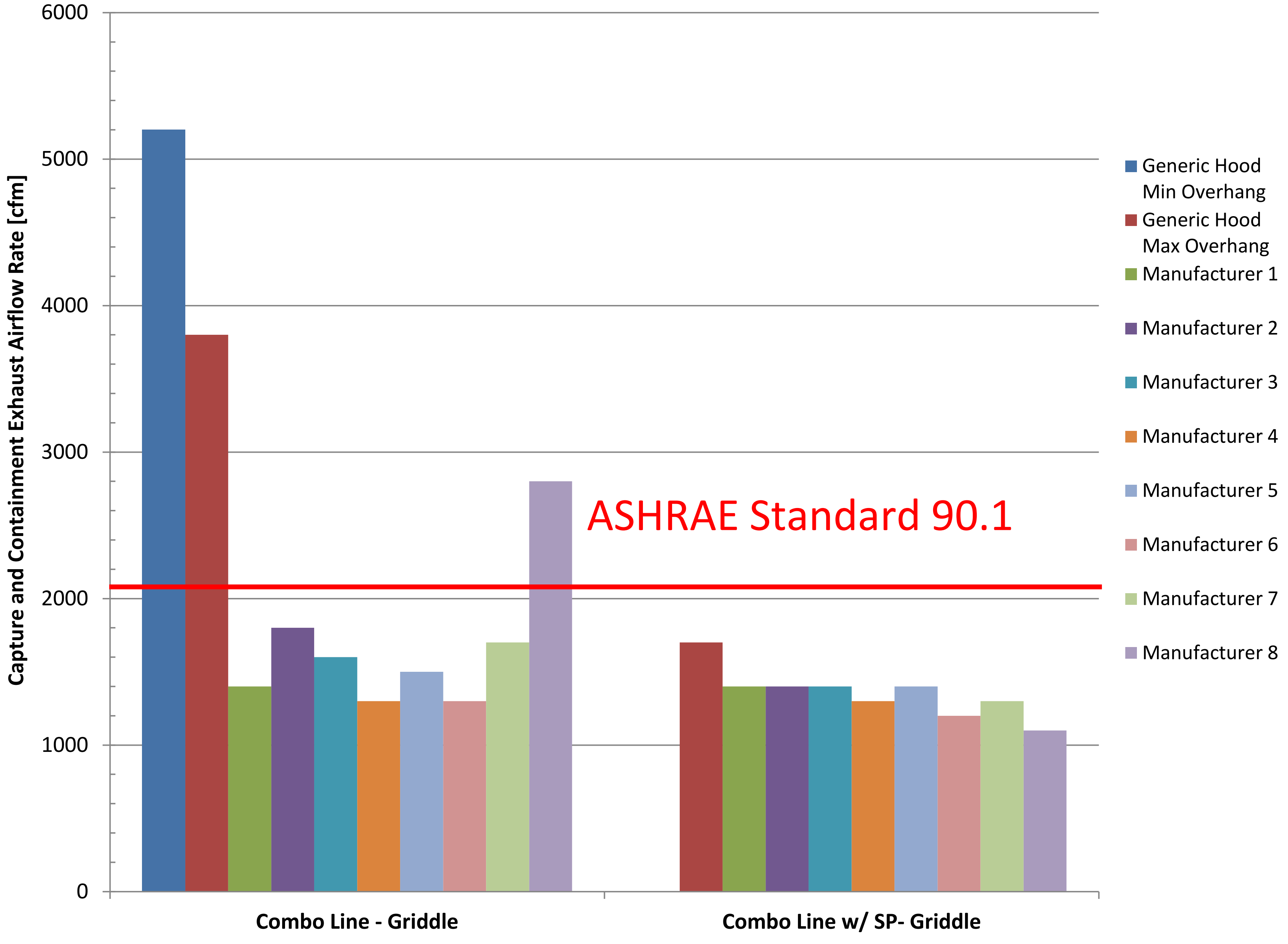


Mixed-duty appliance challenge

…includes walk-by test

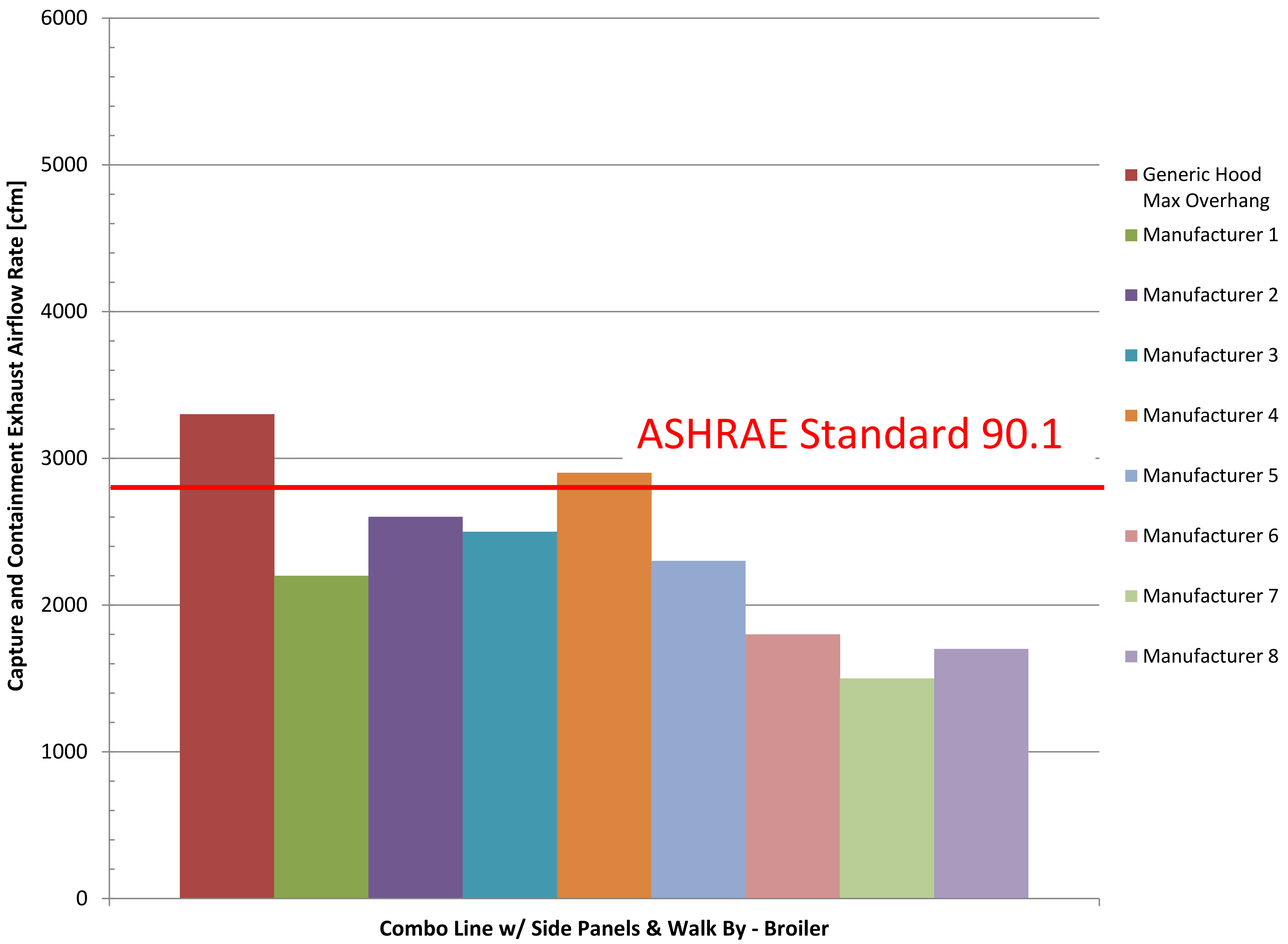


Capture and Containment Exhaust Airflow Rate [cfm]
6000
5000
4000
3000
2000
1000
0
ASHRAE Standard 90.1
Combo Line - Broiler
Combo Line w/ SP- Broiler
Generic Hood Min Overhang
Generic Hood Max Overhang
Manufacturer 1
Manufacturer 2
Manufacturer 3
Manufacturer 4
Manufacturer 5
Manufacturer 6
Manufacturer 7
Manufacturer 8



Capture and Containment Exhaust Airflow Rate [cfm]
6000
5000
4000
3000
2000
1000
0
ASHRAE Standard 90.1
Combo Line - Griddle
Combo Line w/ SP- Griddle
Generic Hood Min Overhang
Generic Hood Max Overhang
Manufacturer 1
Manufacturer 2
Manufacturer 3
Manufacturer 4
Manufacturer 5
Manufacturer 6
Manufacturer 7
Manufacturer 8

Walk by test – C&C failure



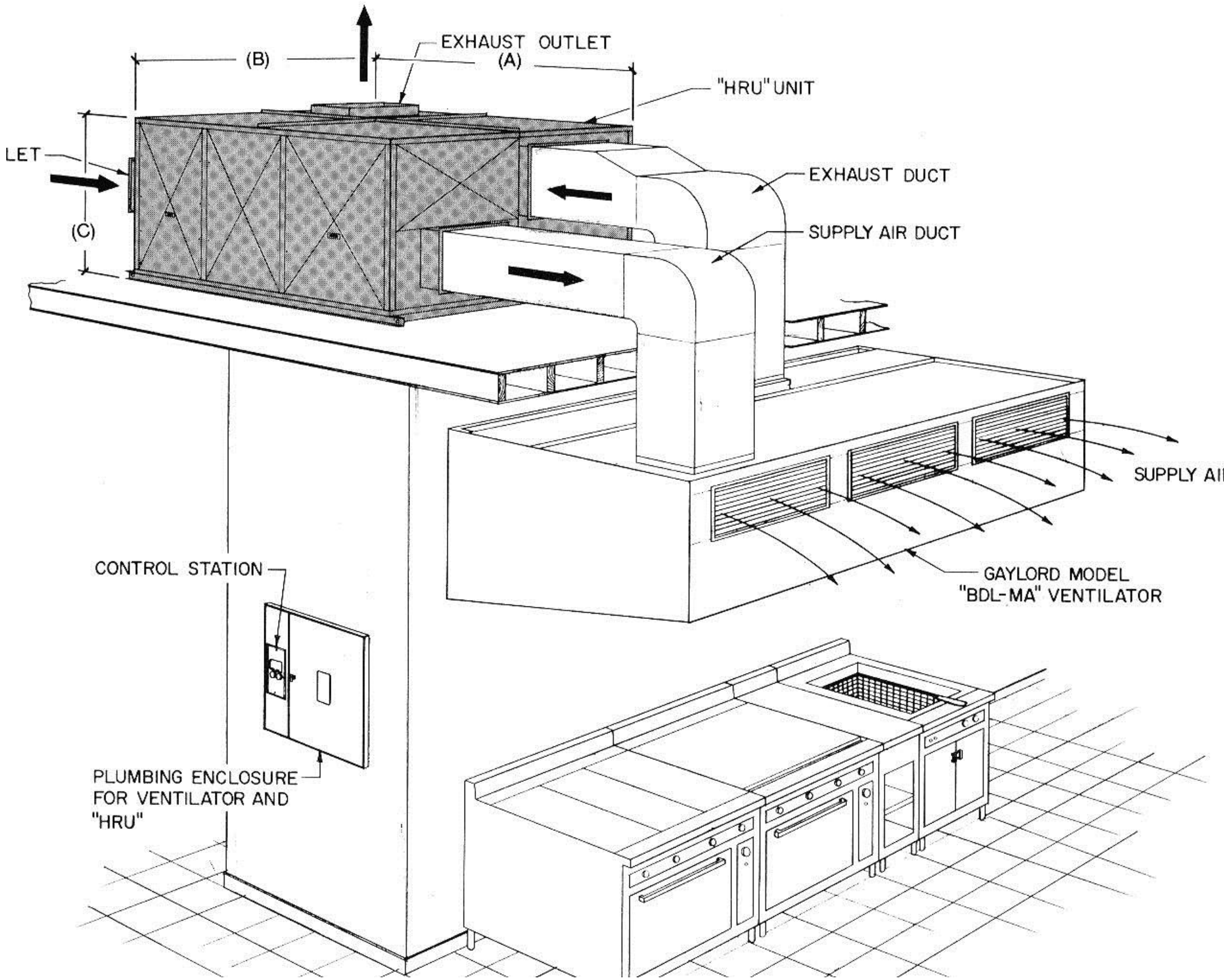
6000
5000
4000
3000
2000
1000
0
Capture and Containment Exhaust Airflow Rate [cfm]
ASHRAE Standard 90.1
Combo Line w/ Side Panels & Walk By - Broiler
Generic Hood Max Overhang
Manufacturer 1
Manufacturer 2
Manufacturer 3
Manufacturer 4
Manufacturer 5
Manufacturer 6
Manufacturer 7
Manufacturer 8

Exhaust Air Heat Recovery

in

Kitchen Ventilation?

Air-to-Air Heat Recovery Unit



What Are the Challenges for Using Air-to-Air Energy Recovery for Commercial Kitchen Ventilation (CKV) and 90.1 Compliance?

Standard 90.1 - 2010

If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm then it shall have one of the following:

a) At least 50% of all replacement air is transfer air that would otherwise be exhausted.

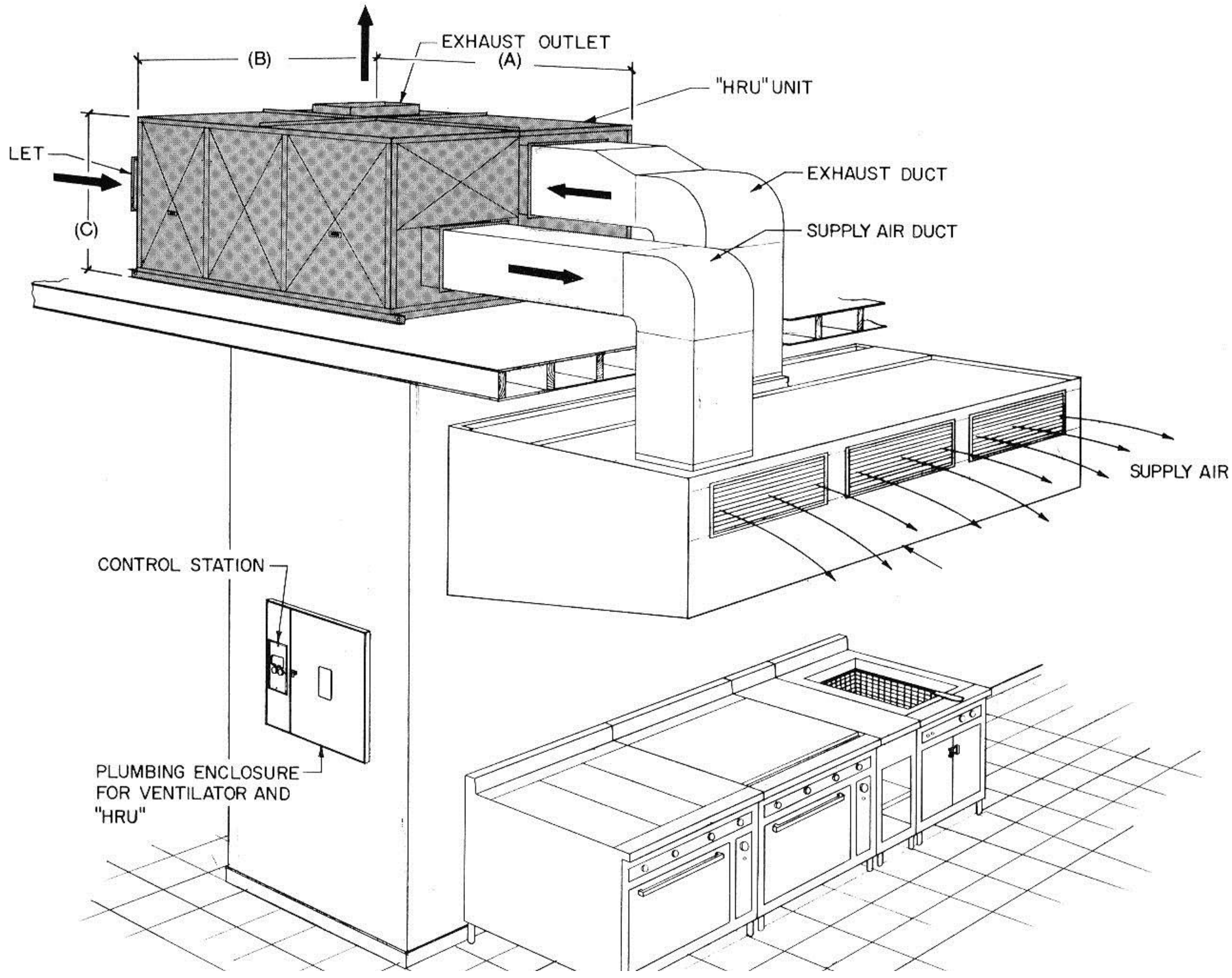
b) Demand ventilation system(s) on at least 75% of the exhaust air. Such systems shall be capable of at least 50% reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.

c) <u>Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow.</u>

Exhaust Air Heat Recovery

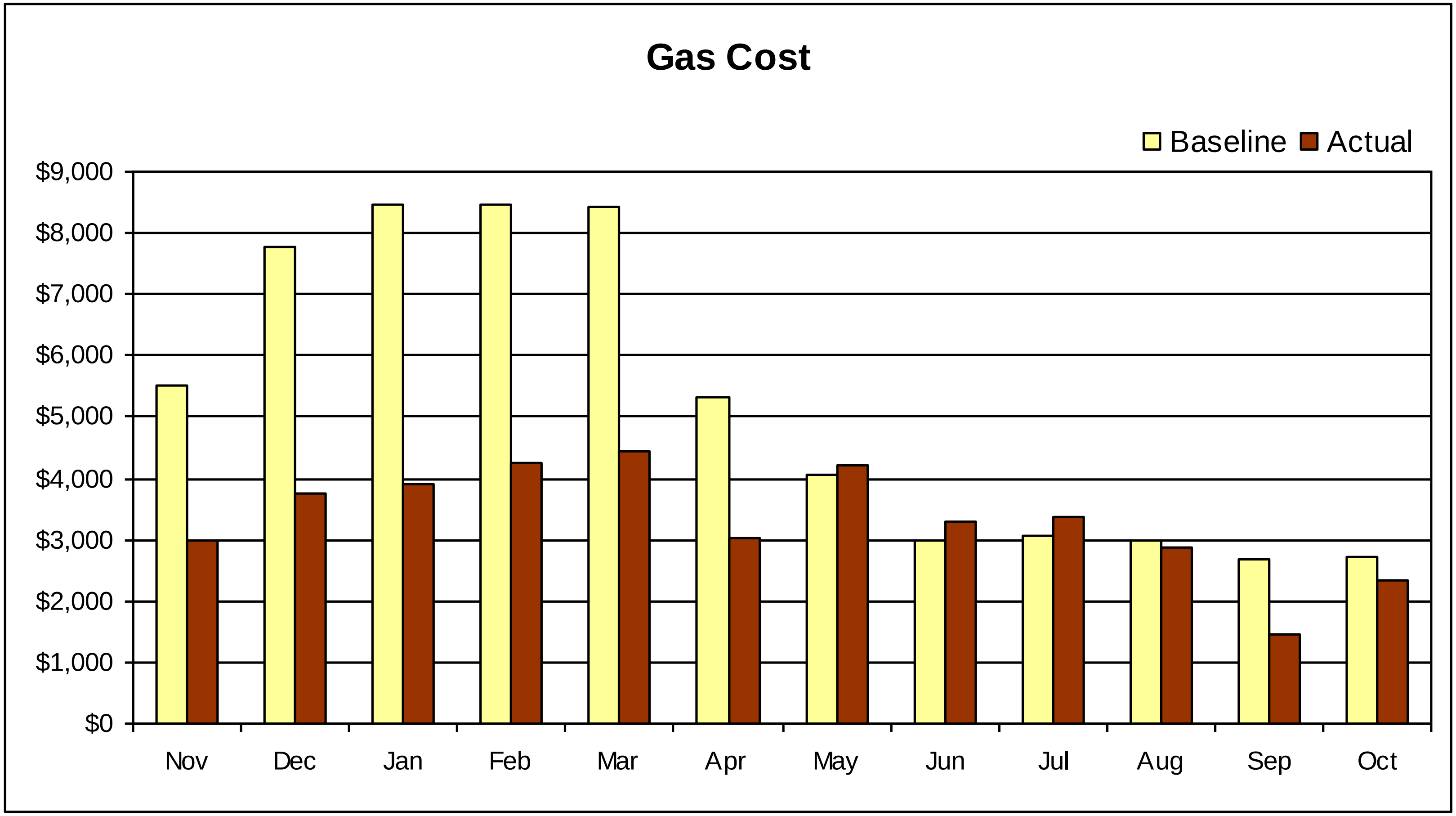
Can It Be Applied to Commercial Kitchen Ventilation?

Air-to-Air Heat Recovery Unit



West Point

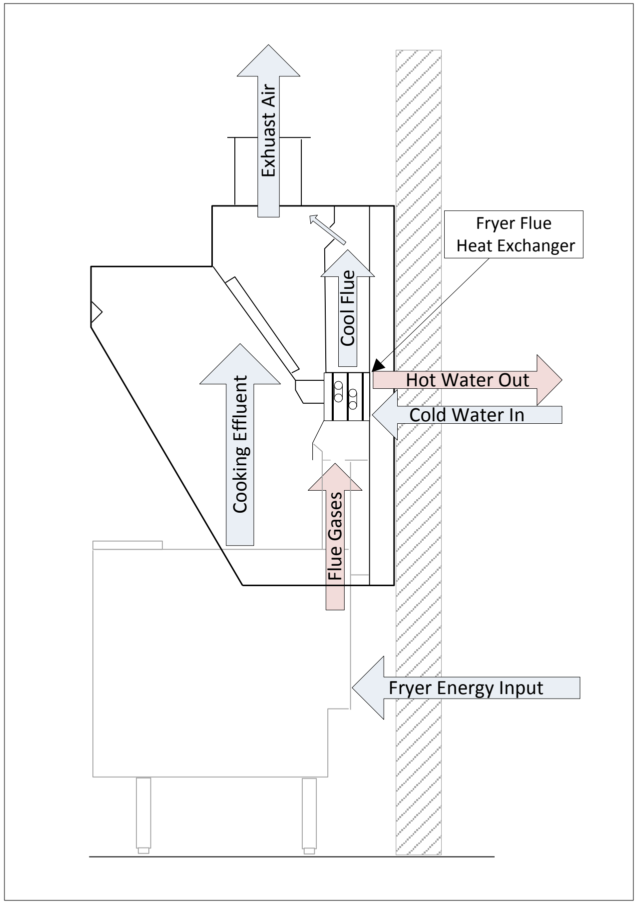
Air-to-Air HX – Toronto Restaurant



36% reduction = $22,600 per year!

(at $1.30/therm)

Flue Gas Heat Recovery



DCV, Heat Recovery & Strategic Introduction of MUA could potentially…

Applying Demand Ventilation Control to Commercial Kitchen Ventilation

1500 ft/min minimum now 500 ft/min (thanks to ASHRAE TC 5.10 Research by U of Minn).

Errata

NFPA 96

Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

2001 Edition

Reference: 8.2.1.1
Errata No.: 96-01-01

The Committee on Venting Systems for Cooking Appliances notes the following error in the 2001 edition of NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.*

1. In section 8.2.1.1 revise to read as follows:

8.2.1.1 The air velocity through any duct shall be not less than 152.4 m/min (500 ft/min).

Issue Date: January 10, 2002

Demand Controlled Ventilation (DCV) Strategies

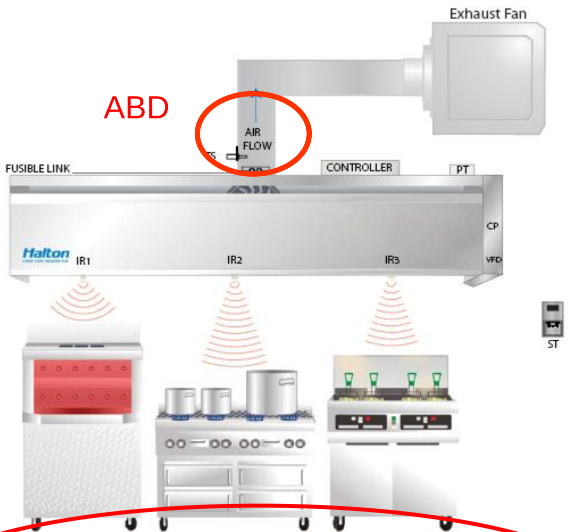
- controlled on a time-of-day basis (EMS?)
- proportional to appliance energy use
- controlled by exhaust temperature
- controlled by sensing smoke or steam produced by cooking process
- controlled by measuring cooking surface temperature or activity
- controlled by direct feedback from cooking equipment (NAFEM Online Protocol)
- controlled by combinations of the above

Appliance Control

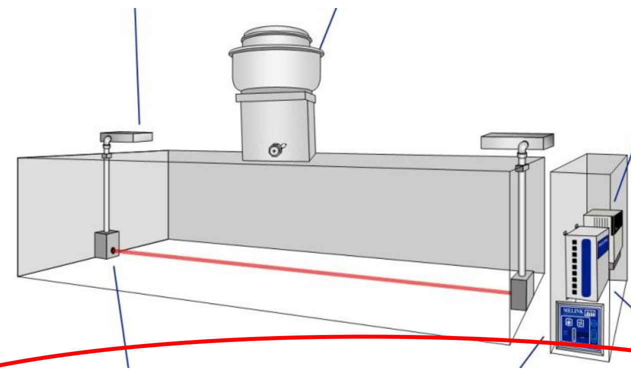
No Load - Low Speed!

2-Speed Fan Interlocked
with
2-Sided Griddle

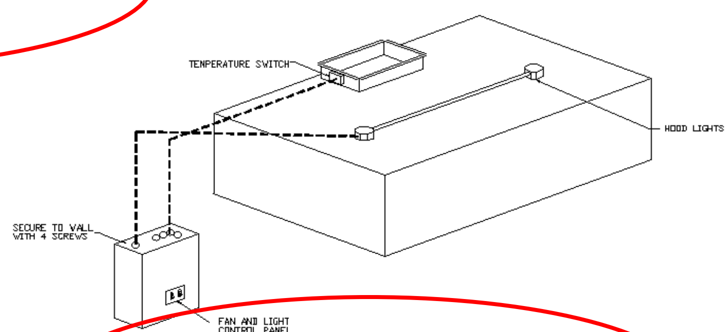
Demand Ventilation Control Technologies



Duct Temperature Sensor & Infrared Sensors



Duct Temperature Sensor & Smoke Detection



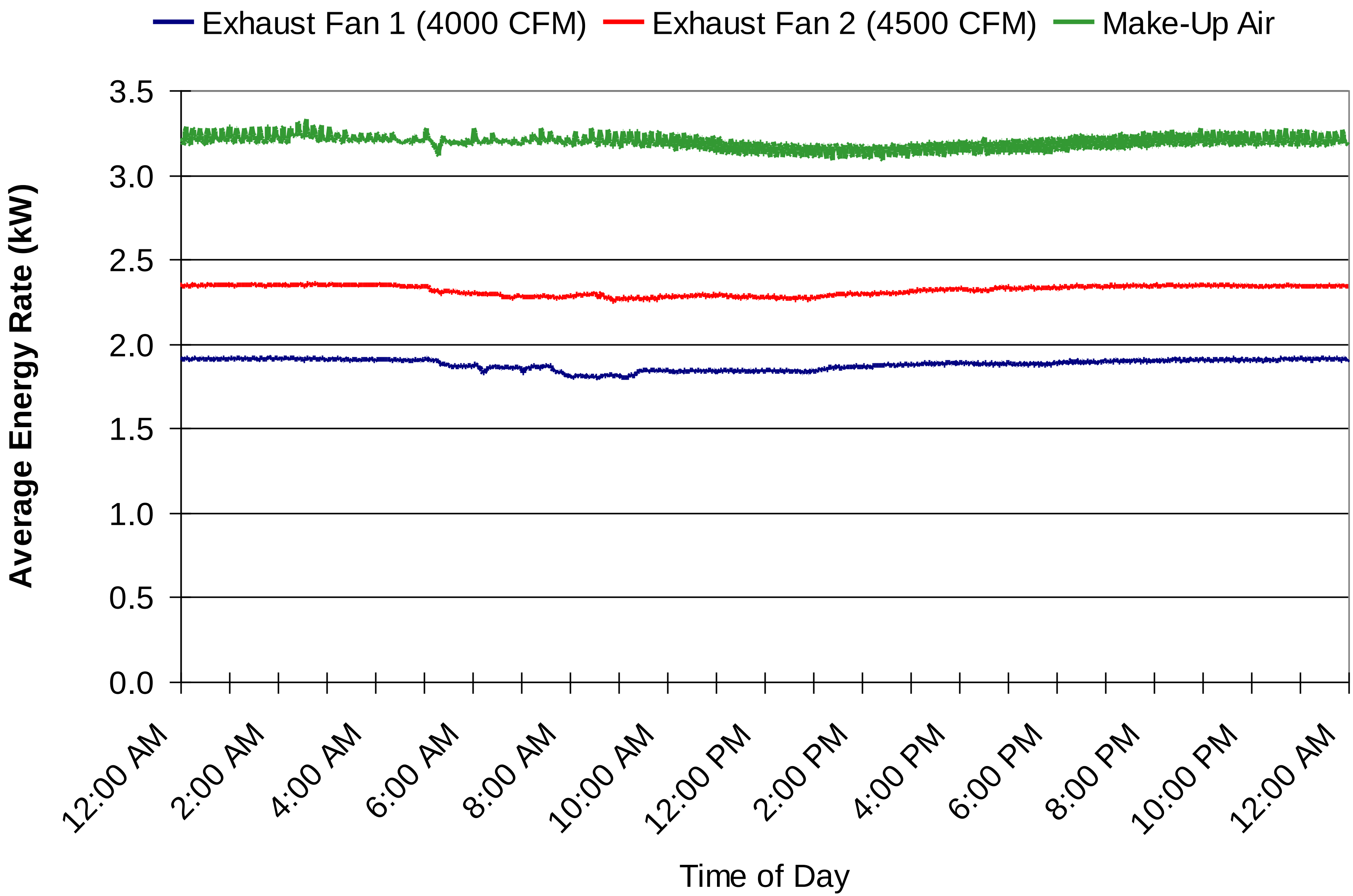
Duct Temperature Sensor

Variable Frequency Drives (VFD)

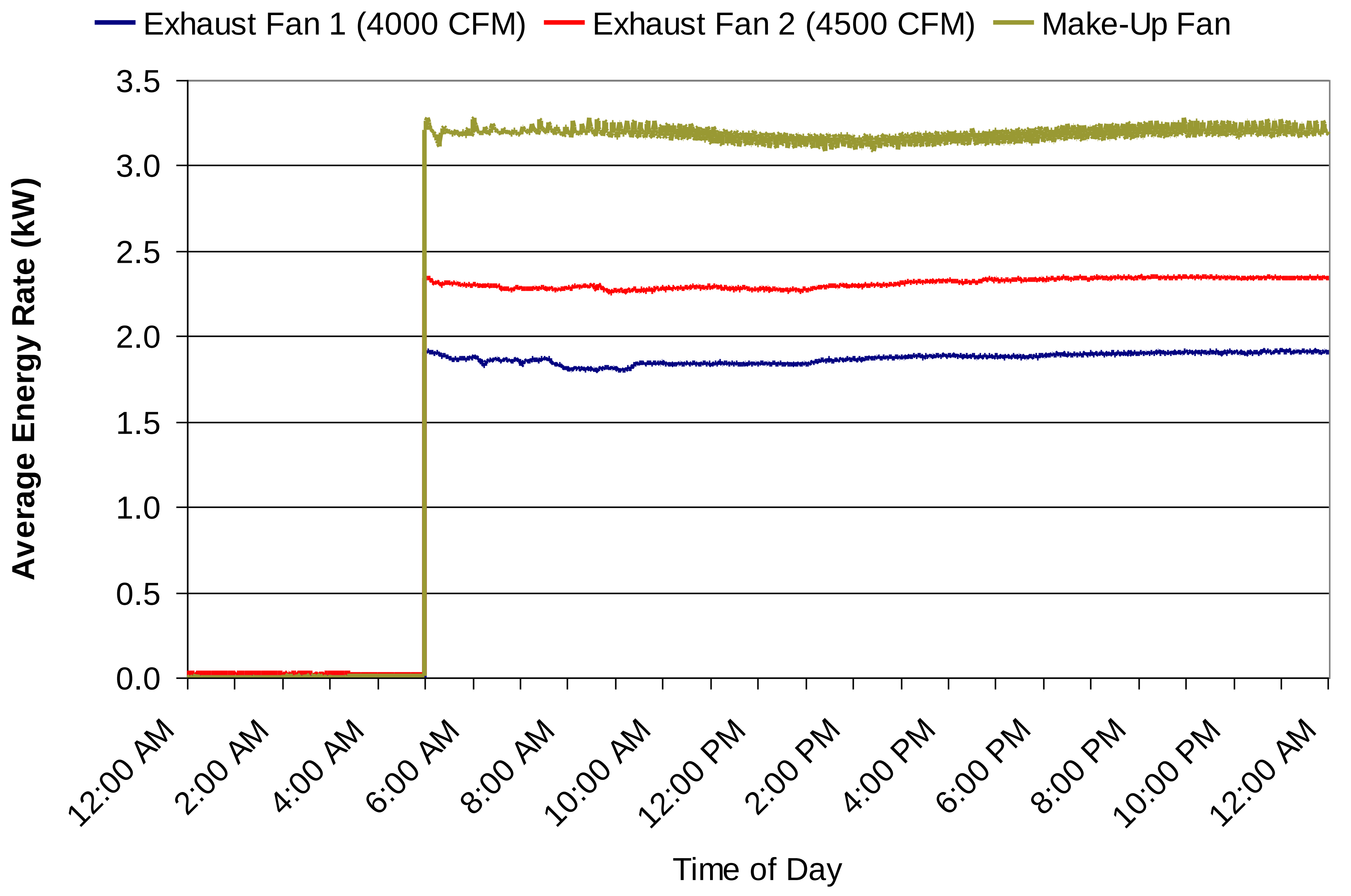
- Essentially electronic motor starters that replace magnetic starters
- Add flexibility to direct drive fans
- Separate Value Proposition from Demand Ventilation Controls (i.e., variable speed)

Corporate Cafeteria

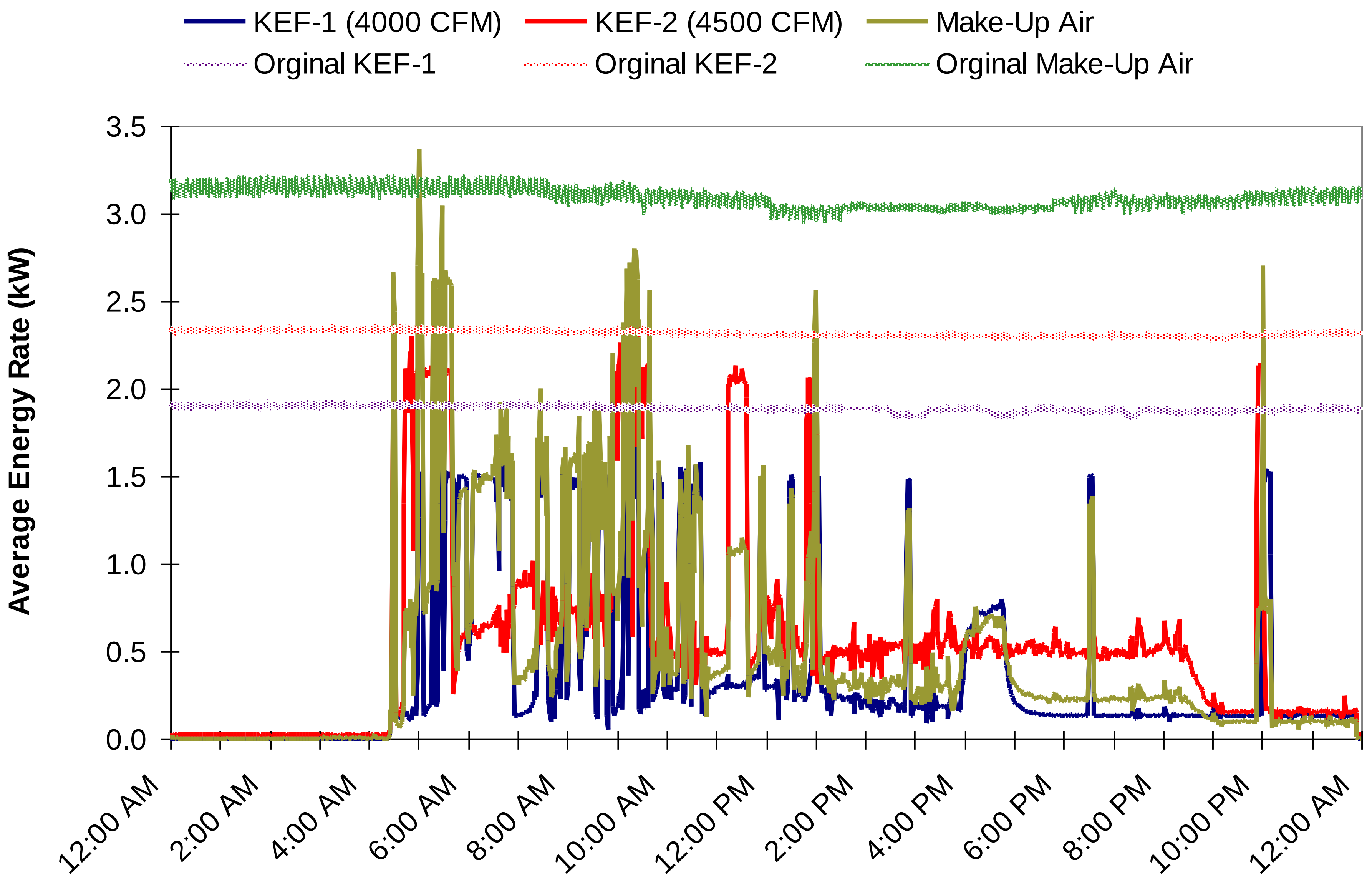
Exhaust System (w/o EMS)



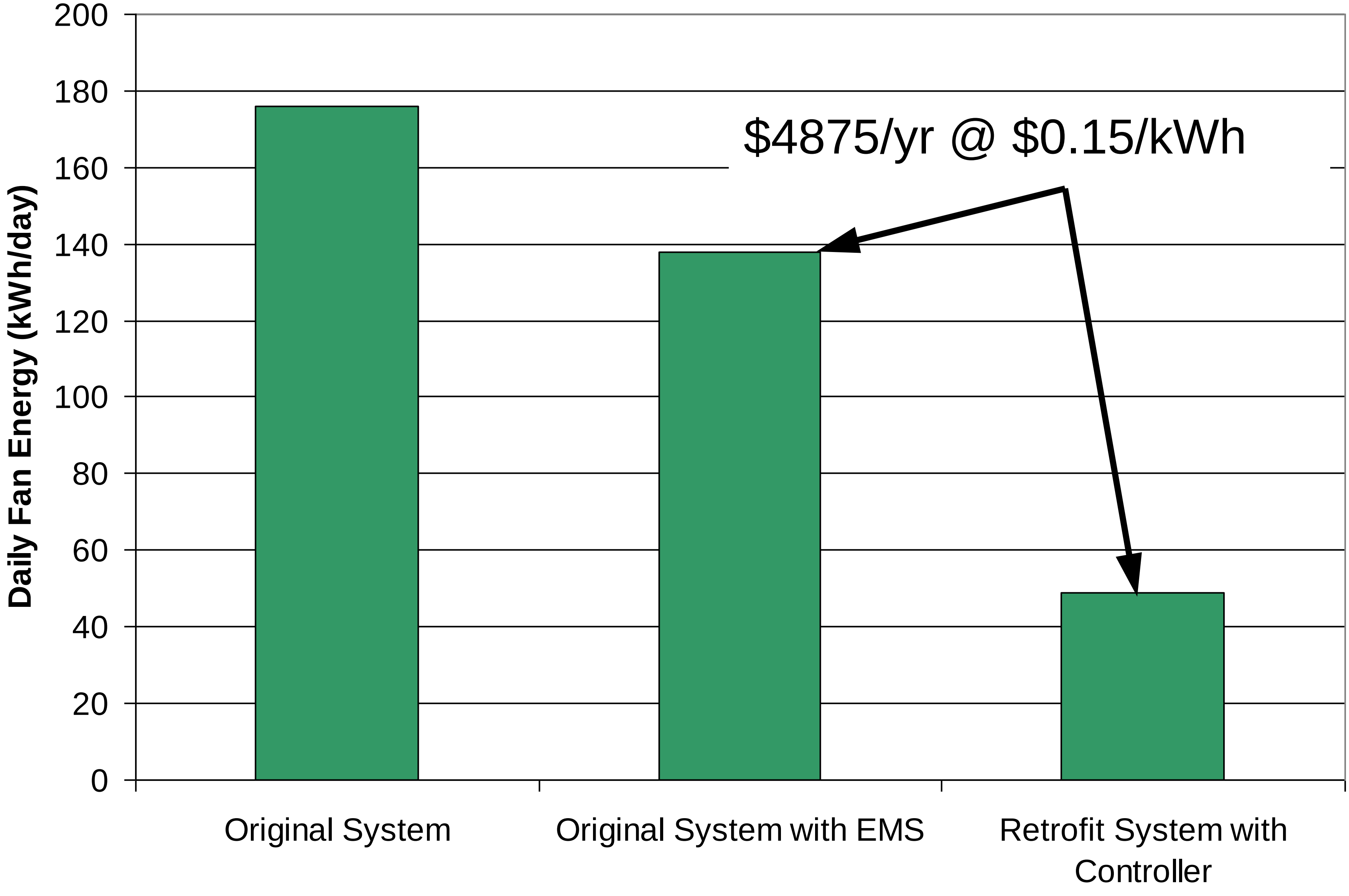
Exhaust System (with EMS)



Exhaust System with DCV

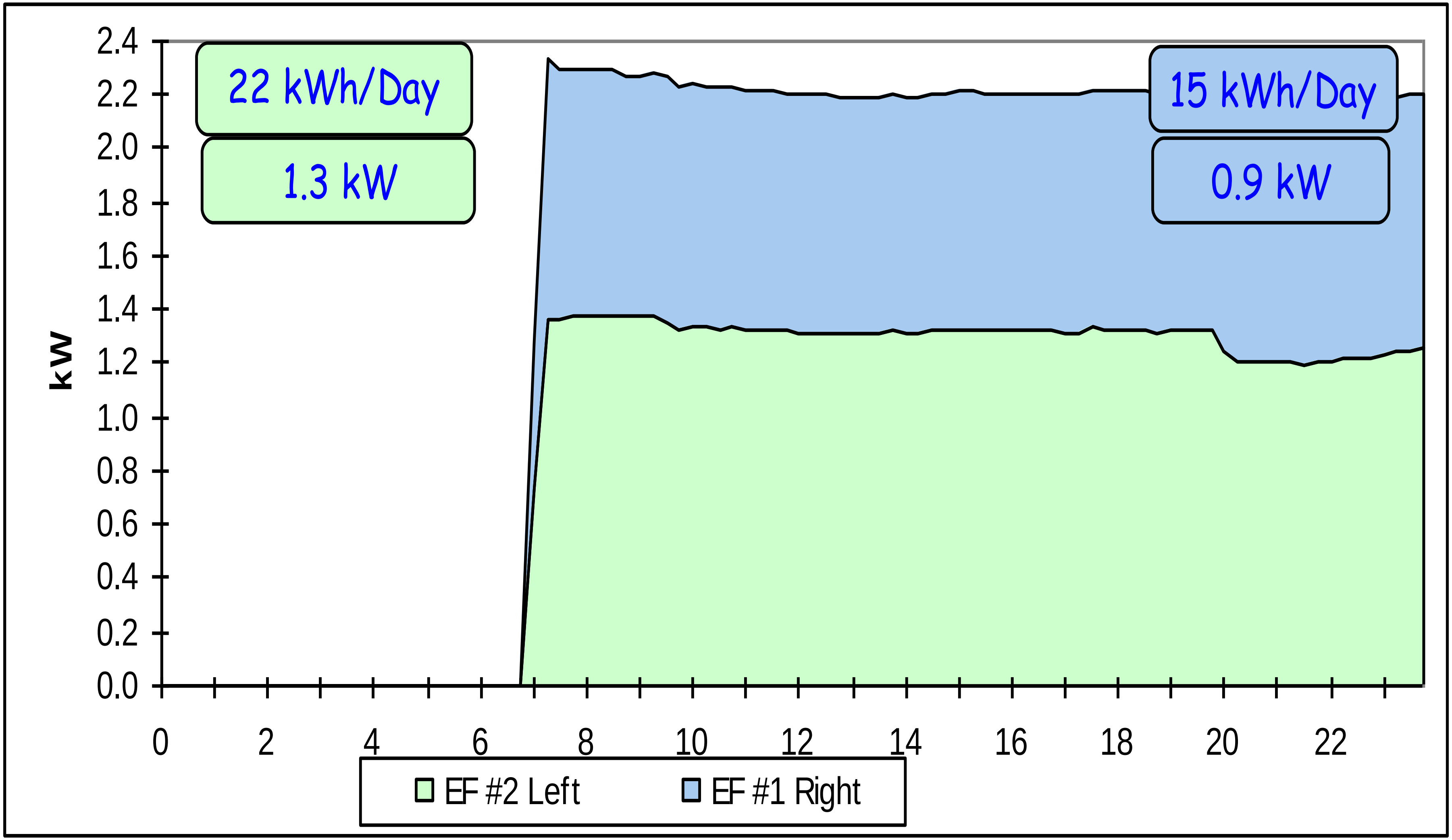


Total Daily Fan Energy

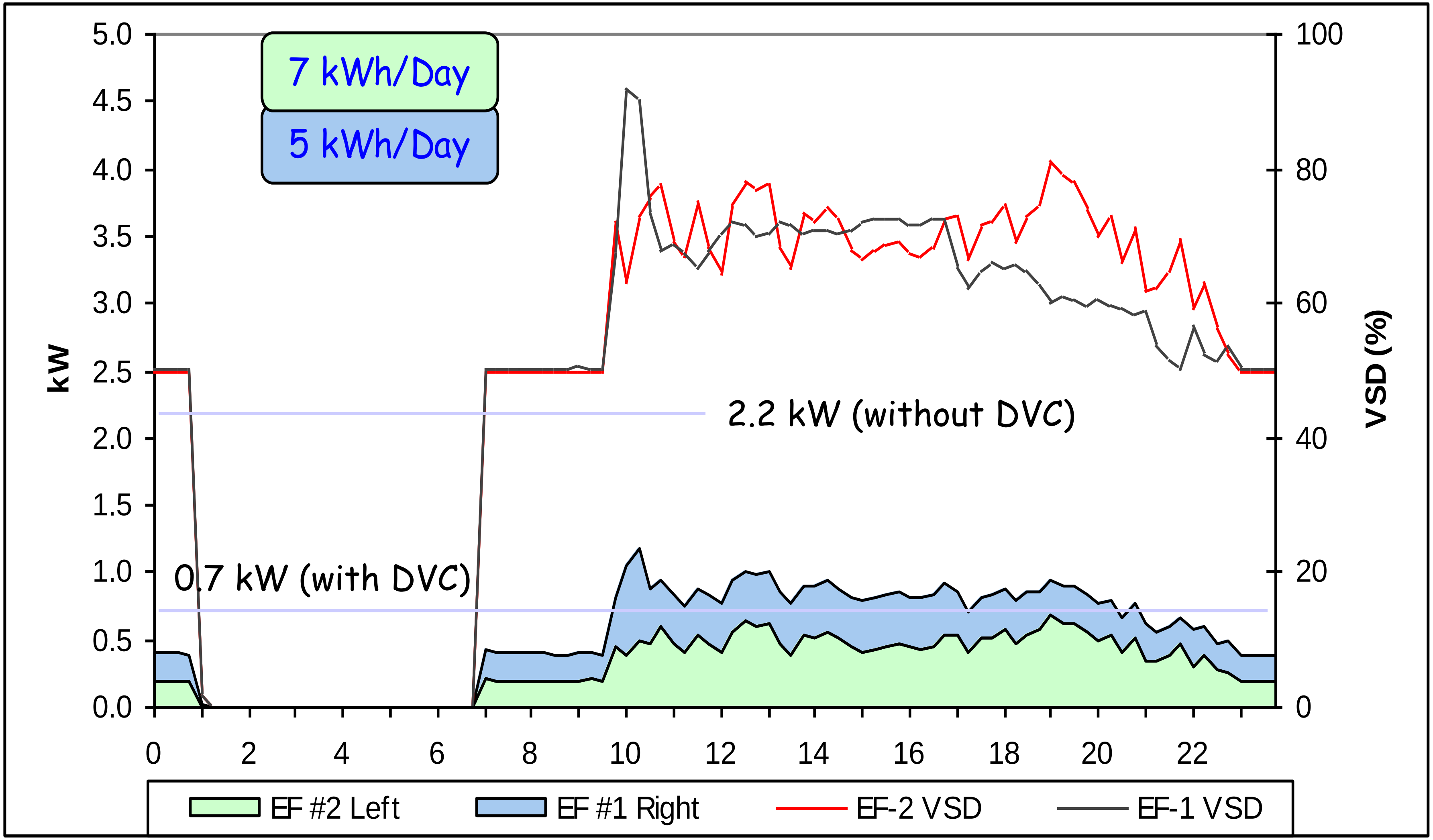


Casual Dining Restaurant

Exhaust Fans without DVC



Exhaust Fans with DVC

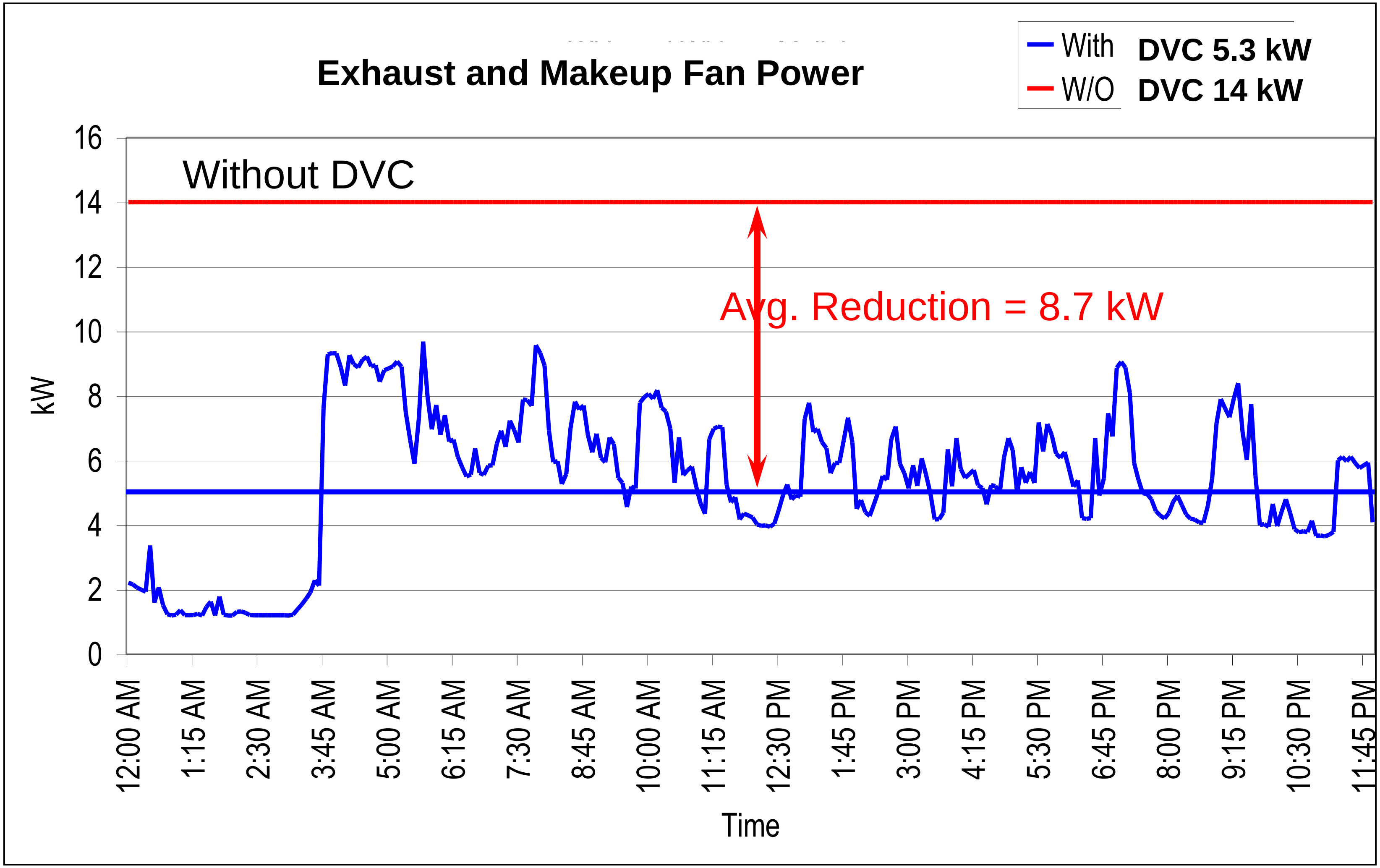


Large Hotel Kitchen

The Kitchen: 24/7

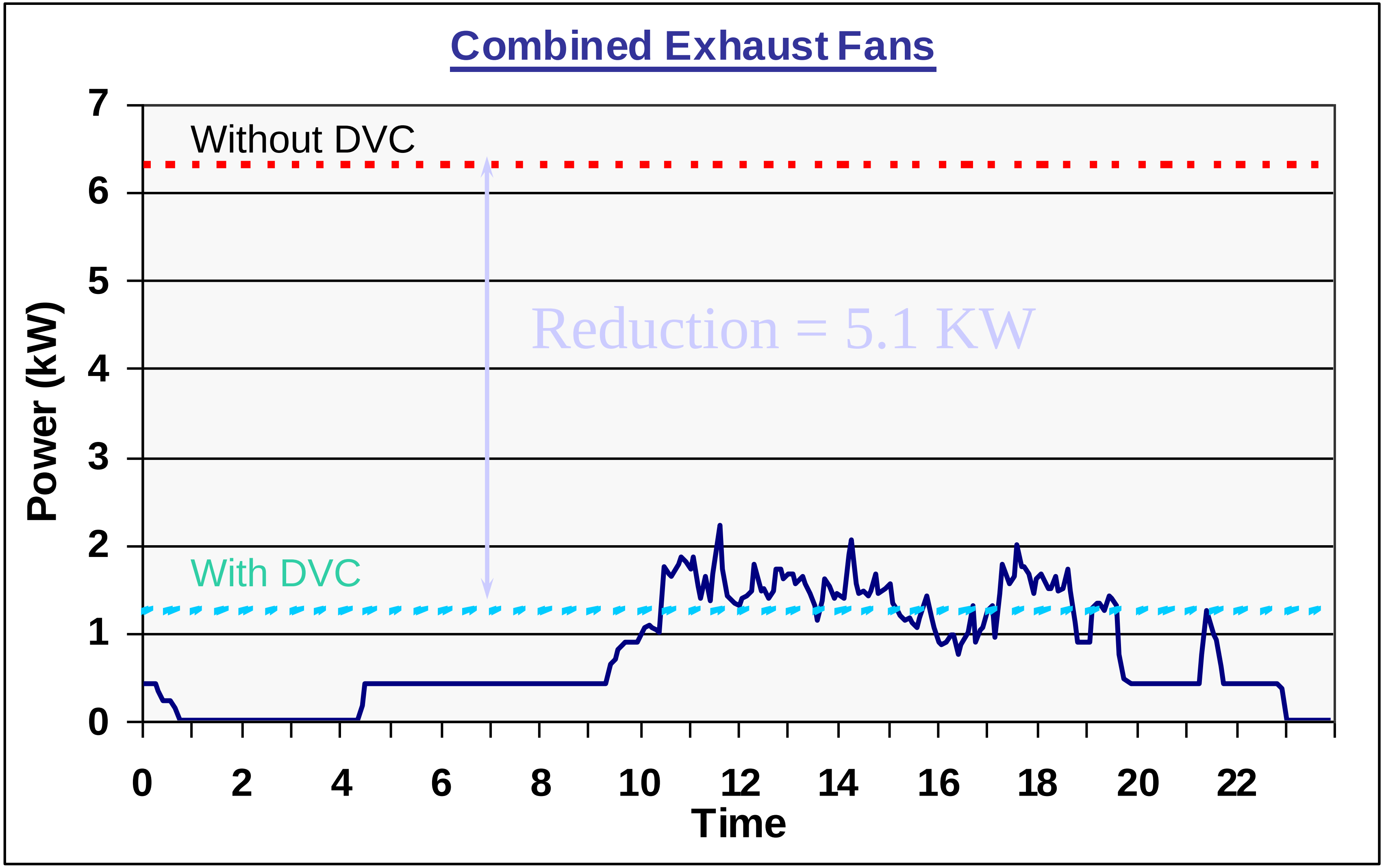
Front Line

Back Line



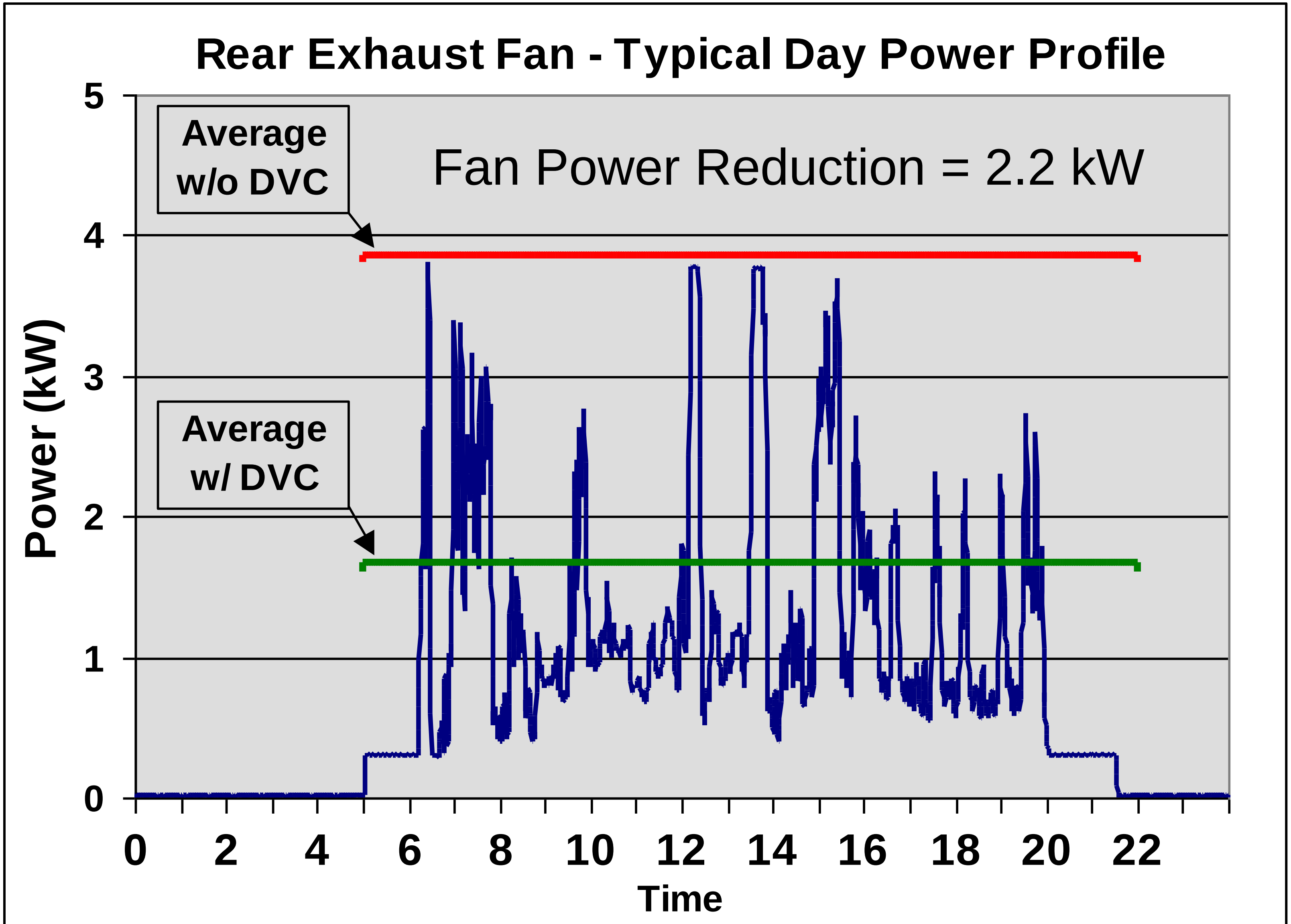
Exhaust and Makeup Fan Power
With DVC 5.3 kW
W/O DVC 14 kW
Without DVC
Avg. Reduction = 8.7 kW
kW
16
14
12
10
8
6
4
2
0
12:00 AM
1:15 AM
2:30 AM
3:45 AM
5:00 AM
6:15 AM
7:30 AM
8:45 AM
10:00 AM
11:15 AM
12:30 PM
1:45 PM
3:00 PM
4:15 PM
5:30 PM
6:45 PM
8:00 PM
9:15 PM
10:30 PM
11:45 PM
Time

Super Market



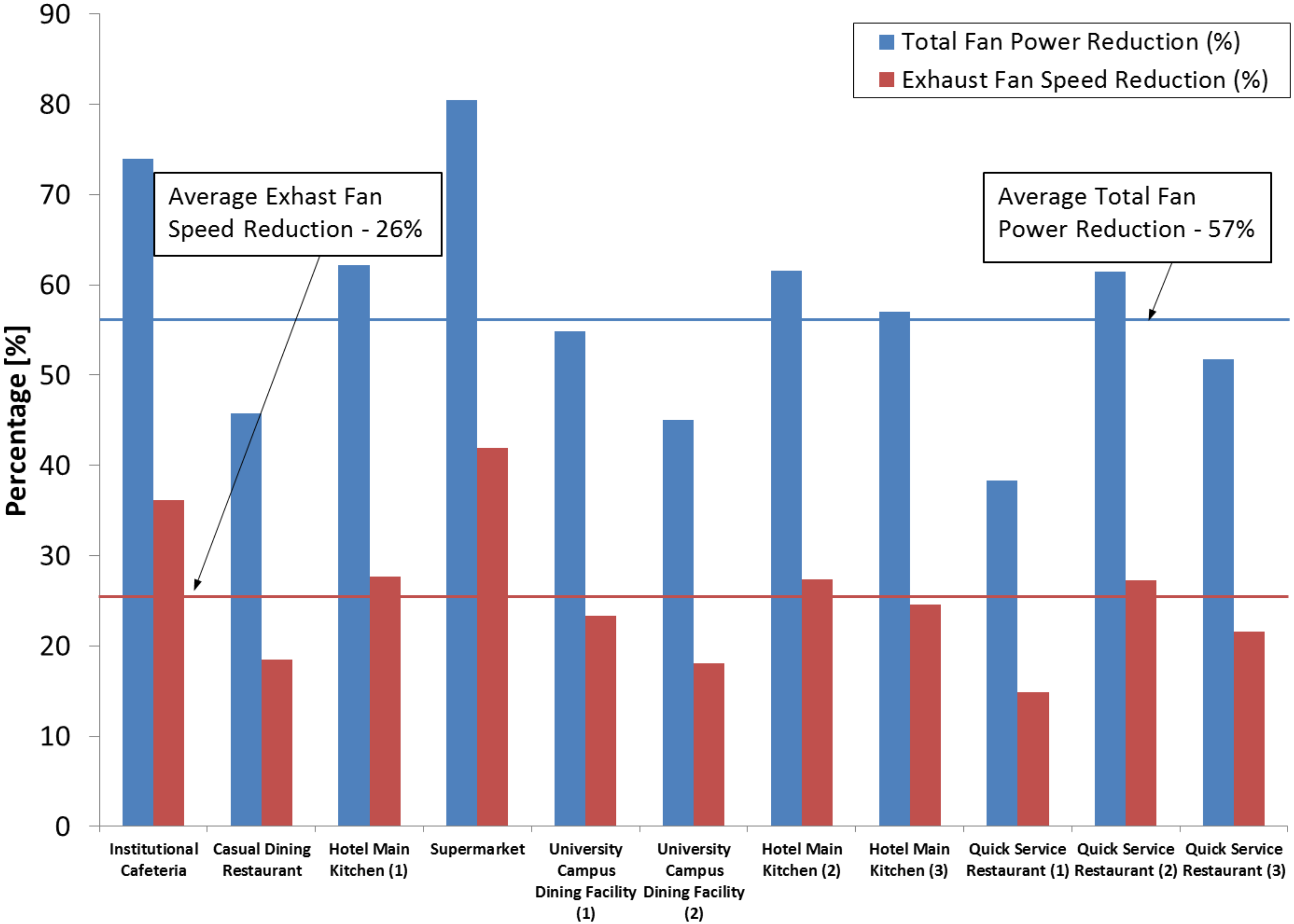
Combined Exhaust Fans
Power (kW)
7
6
5
4
3
2
1
0
Without DVC
Reduction = 5.1 KW
With DVC
0
2
4
6
8
10
12
14
16
18
20
22
Time

College Dining



Rear Exhaust Fan - Typical Day Power Profile
Average w/o DVC
Fan Power Reduction = 2.2 kW
Average w/ DVC
Power (kW)
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18
20
22
Time

California DCV Case Studies



Technical Feature: ASHRAE Journal February 2013

Future of DCV For Commercial Kitchens

By Don Fisher, P.Eng., Associate Member ASHRAE; and **Rich Swierczyna,** Associate Member ASHRAE; **Angelo Karas**

CAUTION:

The CKV system must work effectively as single-speed system before DCV is applied.

ASHRAE Standard 90.1 - 2010

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c) Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow.

DCV Recap…

- With the specification of a DCV system, there is no need to take chances with a design exhaust ventilation rate that is too low.
- Effective commissioning of a DVC system can maximize its performance.
- The CKV system must work effectively as single-speed system before DCV is applied.
- Until appliances communicate directly with the DCV system, the DCV technology application will not realize its full “return on investment” potential.
- The DCV system should integrate with the EMS.

Energy Management Systems

Wiring the Intelligent Kitchen

Food Service
Technology Center

100

Atlanta 1996

The Energy Efficient McDonald's (T.E.E.M)

TABLE 3
Summary of Estimated Savings, Estimated Installed Costs, and Payback Period for Technologies Applied at the Demonstration Restaurant

Technology	Estimated Savings ($)	Estimated Incremental Installed Cost ($)	Payback Period (yr)
Controllable ballasts	702	620	0.9
Low-temperature occupancy sensors	327	340	1.0
Two-speed exhaust fan*	230	400	1.7
Energy management system*	3254	12,000	3.7
High-efficiency air conditioning*	480	600	1.3
Kitchen evaporative cooling*	648	1200	1.9
Play area evaporative cooling*	936	0	0.0
Evaporative precoolers on AC units*	76	1000	13.2
Spectrally selective glazing†	3950	6000	1.5

* Energy savings for these technologies were dependent on the location and weather at the demonstration project.
† The savings for the spectrally selective glazing includes $450 for energy savings and $3500 for reduced capital cost of air-conditioning units.

The EMS system was absolutely crucial to the success of the TEEM project.

london

TM

Question: Have you been involved in a project that included an Energy Management System?

Yes?   No?

Question: If your answer was yes, was your experience with the EMS a positive one?

Yes? No?

What were the challenges?

Hassle for the Operator

What were the challenges?

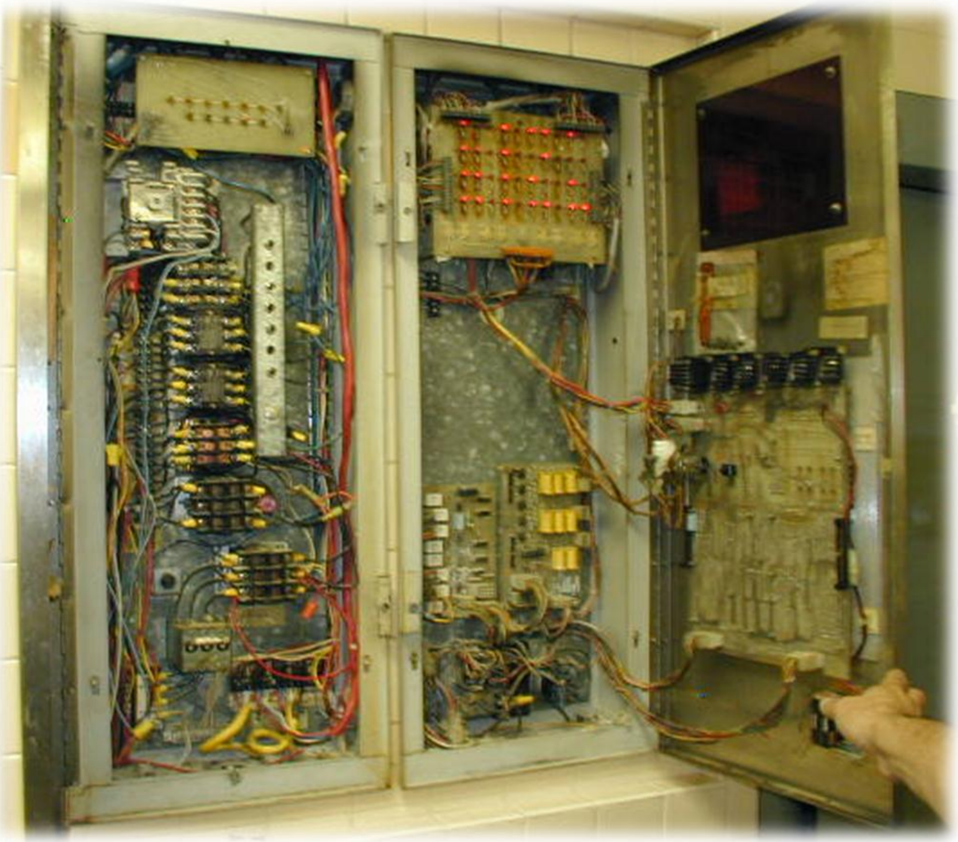
Slow Communications

Call Centers

What were the challenges?

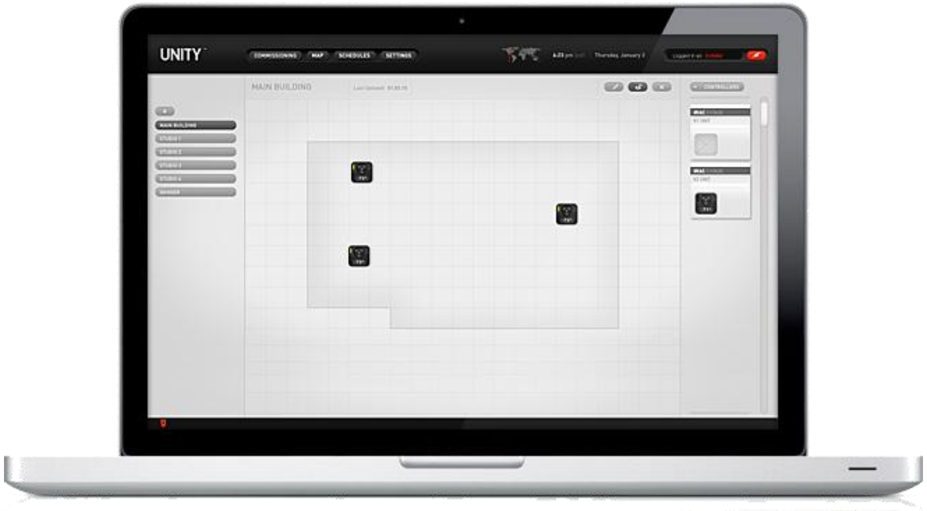
Proprietary communications protocol

EMS companies did NOT understand restaurants (or really care)



16 Years later…
Many Technological Advances

Small Inexpensive Electronics
Wireless and the Internet
Handheld Devices



kiteandlightning.com

And…other positive influences:

Higher Energy Prices  Renewed Interest

Information Boom – this is no longer “weird”

Small and nimble tech companies with more understanding of restaurants.

Question: Do you feel that EMS systems will be standard equipment in restaurants in the next 10 years?

Yes? No?

What will make EMS practical?

1. Controls integrated into smart appliances
   – NAFEM Protocol
2. Adaptive logic – don't bug the humans
   – Nest Thermostat

3. Continuous commissioning of systems
4. Control of more systems – CKV?