Energy Reduction in Commercial Kitchens

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Introduction

America has the highest carbon footprints in the world, consuming 20 metric tons per person compared to an average of 4 tons worldwide[1]. An average American eats out more than 180 times a year[2], and over a quarter of the US population is indirectly involved in the foodservice industry[3] which consumes millions of therms of gas and megawatts of electricity emitting greenhouse gases.

Cooking initially started out with placing food next to the fire and has evolved into a more controlled process. Some food even until this day gets cooked on underfired broilers by a direct flame underneath, while other cooking is done by injecting precise amounts of steam. A single commercial fryer in a restaurant often consumes more energy than an entire residential household and a quick service restaurant monthly energy bill can easily reach five figures.

The state of California cannot build more power plants and renewable energy cannot keep up with the state's population growth. Energy reduction should precede new energy generation and foodservice facilities consume over 250 kBtu/h per square foot compared to an office building which consumes less than 100 kBtu/h/ft2[4]. Foodservice is a difficult industry that adapts slowly to the new technologies. The biggest expense for the restaurant operator is labor then cost of food followed by rent. Energy bills are very high for the operator, however are cheaper than the other expenses. Lowering the energy bill can be a simple task requiring changing light bulbs, or can be much more difficult requiring ventilation system and cook line retrofits.

The challenges to energy reduction in the foodservice industry include the following:

- High stress environment where speed of service is key
- Equipment operators get paid low wages and do not have incentives to reduce energy
- Some inefficient equipment is easier to operate than energy efficient equipment
- Energy efficient equipment is more expensive and often requires more maintenance

This study will examine these challenges in different foodservice scenarios and identify the highest energy use appliances. The appliance energy use profiles will be characterized and related to operator behavior. Inefficient appliances will be replaced with efficient alternatives and submetered in order to document the energy savings. The findings from this study will be utilized in order to financially incentivize energy efficient equipment for restaurant operators by the gas and electric utilities. This research was commissioned by the California Public Utility Commission with a focus on Natural Gas Savings. The research was conducted by Fisher Nickel who runs the Foodservice Technology Center for the Pacific Gas and Electric Company.

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[1] Timothy Gutowski, MIT
[2] Annual restaurant visits per capita in 2010 by country, Statista
[3] Richard Young, Foodservice Technology Center
[4] Sustainable Foodservice Consulting

Foodservice Appliance Types

A typical foodservice facility will have a range, an oven, a griddle or a broiler and a fryer. Quick service restaurants often use griddles and fryers to cook the most popular items. Cook to order restaurants use ovens and ranges to cook their most popular items, but the appliance lines vary from restaurant to restaurant. The appliances have to be placed under a ventilation hood; larger institutional facilities have several ventilation hoods and quick service facilities may have individually designed hoods paired with each appliance type.

Range

Ranges are some of the most popular appliance types, heating a pot or a pan by direct flame. Fine dining and cook to order restaurants have several ranges mostly using smaller pans where food is heated for a short period of time 3-10 minutes. Stocks and soups are also prepared on ranges in larger pots and are simmered for hours.

Figure 1 six burner range at Werewolf

Figure 2 back range at Doubletree

Restaurant range design has not changed much over the years. A typical range will have six burners. Gas is supplied to the front of the appliance through a manifold and then supplied to each burner through a cast iron tube and a nozzle. The burners are usually circular in shape, however star shaped burners also are available. Each of the burners has a pilot next to it which remains lit 24/7 and consumes close to 0.5 kBtu/h per burner when properly adjusted. Fine dining restaurants with several ranges can have up to a therm per day per range attributed to the pilot.

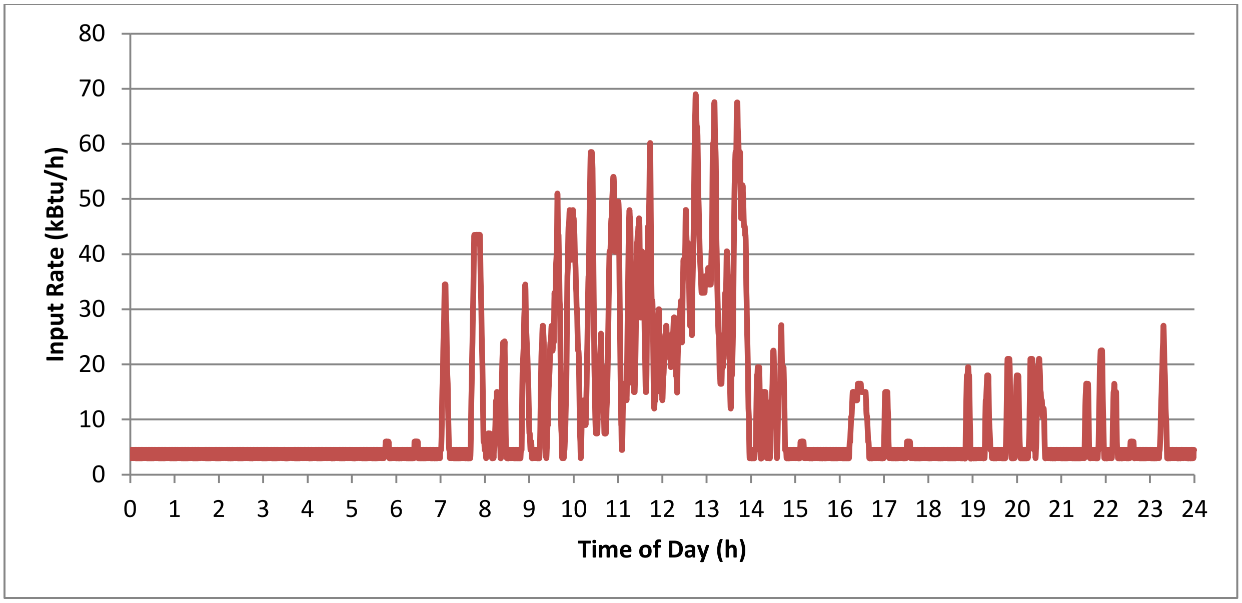

Figure 3 Typical Range Energy Use Profile

Spark ignition systems have been widely used in the residential sector; however have not been adapted by the commercial foodservice industry due to reliability issues. For automatic ignition, there needs to be a wire running to each burner in order to create a spark. When staff cleans the equipment, wires are often disturbed and the top of the spark contact often gets fouled with spilled food or bent by cleaning practices.

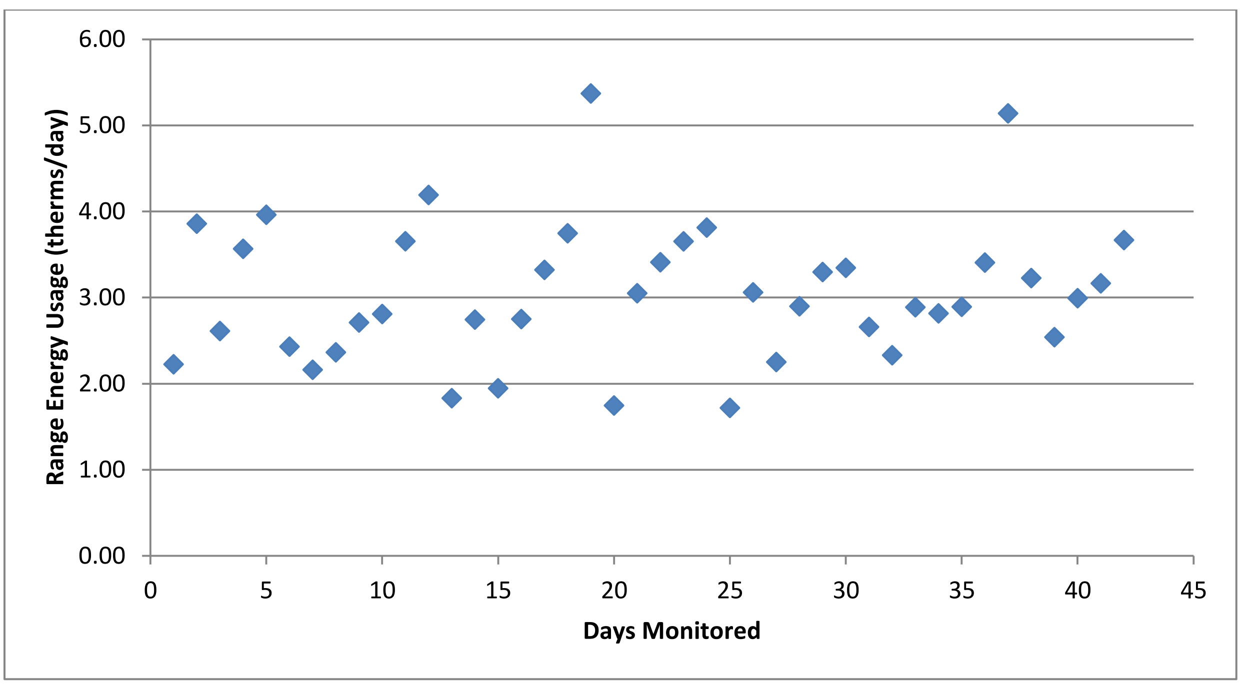

Figure 4 Range Energy Usage Consistency

Comparison of different burner designs on the market has not shown energy savings of one design over another. The only energy savings opportunity besides pilot energy reduction is the cooking vessel itself. Pots and pans with a heatsink on the bottom have been proven to save energy and reduce cooking times. Energy usage of ranges is relatively low compared to other appliances, because the operator can see the cooking flame and knows that if the flame is on and nothing is being cooked the kitchen is heated up. Other appliances do not have an exposed flame and the operator does not always know when they are wasting energy.

Table 1 Range Energy Use and Time of Operation

	Energy Use	Operation Time
Werewolf	3.1 therms/day	7.2 hours/day
Airline Catering (with salamander)	4.7 therms/day	12.8 hours/day
Doubletree 1 (with salamander)	5.0 therms/day	19 hours/day
Doubletree 2	2.8 therms/day	16 hours/day
Doubletree 3	1.9 therms/day	11 hours/day
Average	**3.5 therms/day**	**13.2 hours/day**

No ranges were replaced; this study was able to characterize range energy usage at three sites. Two of the ranges had a built in salamander that was used for melting cheese for nachos. The ranges with salamanders used almost twice the energy, but the salamander was not submetered. Compared to other ranges with no salamander, it is estimated that salamanders account for 2 therms per day energy consumption. Ranges without the salamander used an average of 2.6 therms per day. Energy efficient cookware with integrated heatsinks is estimated to reduce that energy by 30-40% as documented in this report: http://www.fishnick.com/publications/appliancereports/rangetops/Eneron_Pot_Testing.pdf

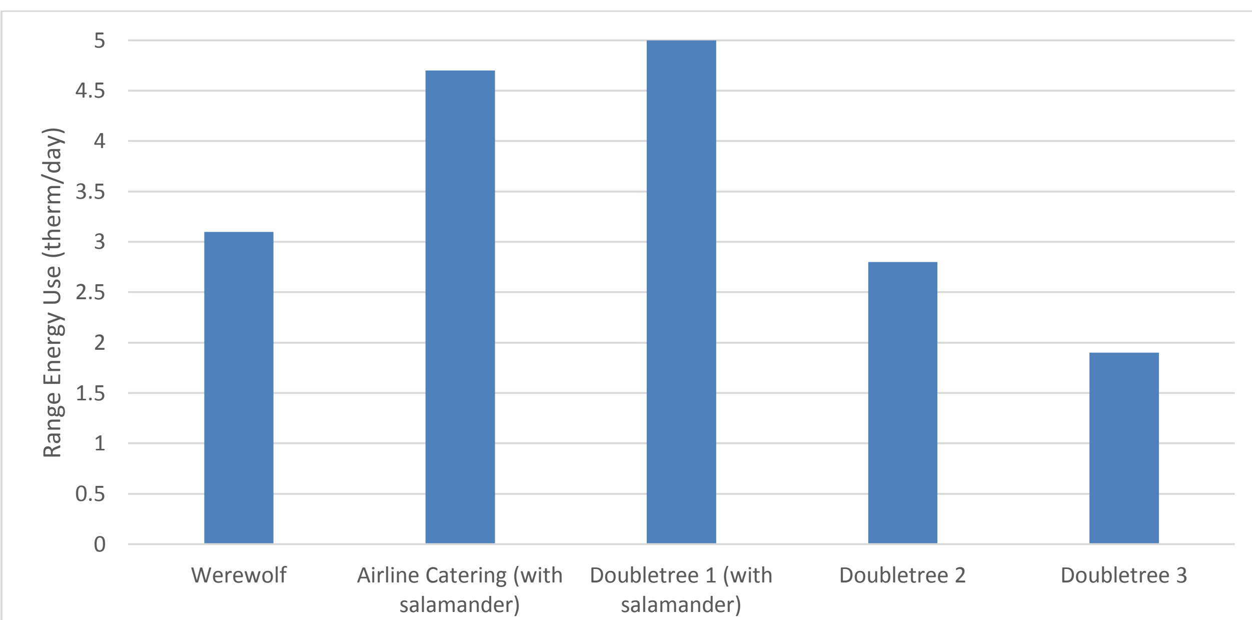

Figure 5 Standard Range Energy Use per Site

Ovens and Steamers

There are several different types of ovens on the market including convection ovens, pizza ovens, combi ovens, steamers and rack ovens. Convection ovens are one of the most popular appliance types with the ability to cook a plethora of different foods. Foodservice manufacturers have been improving oven designs for decades producing different oven types which vary in price and energy efficiency.

Figure 6 Baseline Convection Oven

Figure 7 Replacement Combi Oven

Most advanced ovens are combi ovens which combine convection and moisture cooking. Combi ovens can replace a convection oven and a steamer. Combis inject steam in the cooking cavity either by using an internal pressurized boiler or by spraying a controlled amount of water on a hot fan wheel which vaporizes the water. Power burners, better door seals and fan modulation make combi ovens more efficient and more expensive than convection ovens. Combi ovens allow the operator to maximize the use of space in the kitchen while expanding their menu. Aside from convection ovens, combis can replace steamers and rotisserie ovens. Rotisserie ovens are some of the most inefficient appliances in the kitchen that do not have a sealed cavity causing a lot of the heat to escape which makes them a great potential combi oven replacement.

Figure 8 Oliver's Market Combi Replacement

Figure 9 Oliver's Market Baseline Rotisserie

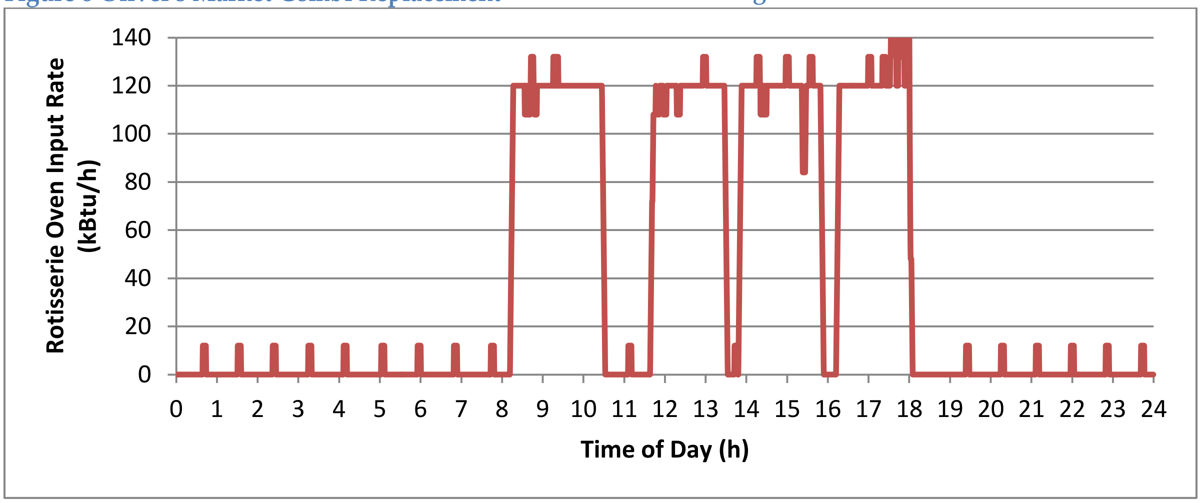

Figure 10 Rotisserie Oven Energy Profile Oliver's Market Cotati

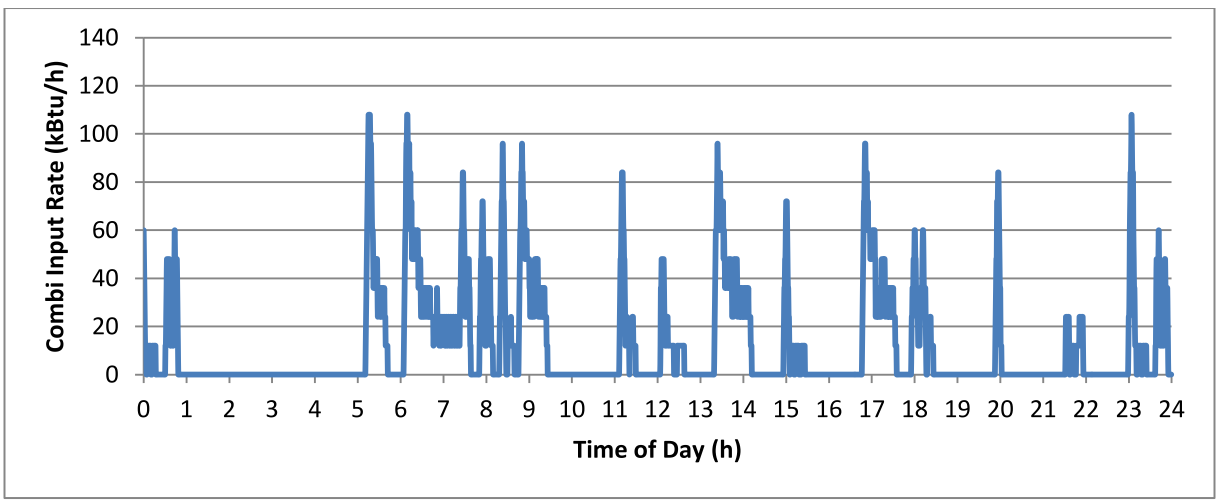

Figure 11 Combi Oven Energy Profile Oliver's Market Windsor

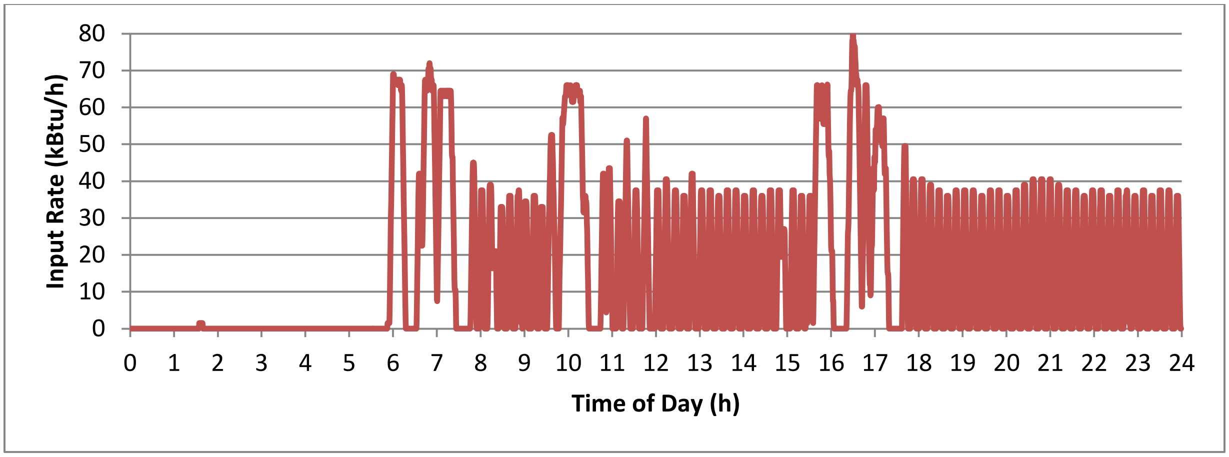

Figure 12 Convection Oven Average Hourly Input Rate

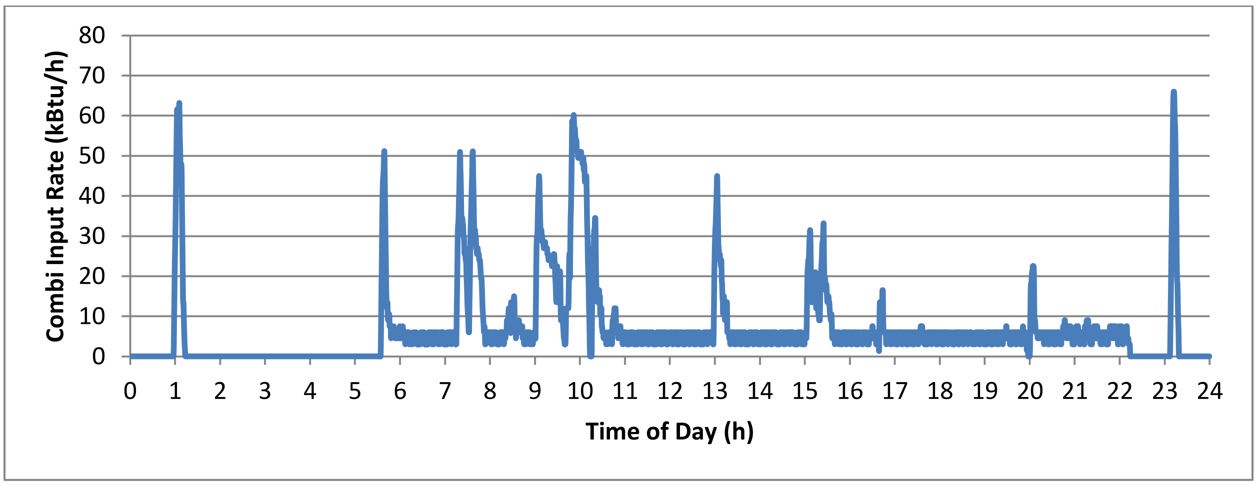

Figure 13 Combi Oven Replacement Average Hourly Input Rate

Standard convection ovens come in single and double stack configurations, based on gas monitoring, a single cavity consumes between 3 to 6 therms of gas per day, a doublestack cavity uses between 5 and 9 therms per day. Energy efficient convection ovens are characterized by utilizing insulation, thermostatic control optimization and efficient gas flue design. Doublestack convection ovens that were replaced at UCSF reduced energy consumption from 15.5 to 7.2 which is over 3000 therms saved per year.

Table 2 Oven Energy Use and Operation Time

	Convection Oven Energy Use (therms/day)	Replacement (therms/day)	Operation Time
Doubletree 1 (dual)	4.2	1.4	19.2
Doubletree 2 (dual)	5.6	N/A	19.1
UCSF 1 (dual)	7.0	3.8	14.0
UCSF 2 (dual)	8.5	3.4	16.2
Airline Catering	5.9	N/A	17.6
Werewolf (single cavity)	3.5	1.7 (combi)	19

The convection oven is the most commonly replaced appliance by a combi oven. The single convection oven at the Airline Catering Company and the Restaurant Bar used 4.2 and 3.5 therms per day. The replacement combi oven at the Restaurant / Bar reduced the energy consumption by more than half and expanded their menu through moisture cooking. The biggest energy savings were achieved by replacing a rotisserie oven with a large combi oven resulting in 68% savings. The Doubletree hotel had three steamers with one of them replaced by a combi oven and the other two were replaced with an energy efficient steamer which reduced idle energy and consumed significantly less water.

Table 3 Combi Oven Replacement Results

Site	Baseline Appliance	Baseline Energy	Replacement Appliance	Replacement Energy	Energy Savings (therms/day)
Doubletree Hotel	Doublestack Steamer	80 kWh/day	10 half Pan Combi	0.4 Therms/day	80 kWh/day
Airline Catering	Convection Oven	4.2 therms/day	Doublestack 6 full Pan Combi	2 therms/day (est)	2 therms/day (est)
Restaurant / Bar (Werewolf)	Convection Oven	3.5 therms/day	10 half Pan Combi	1.7 therms/day	1.8 therms/day
Grocery Store	Rotisserie	7.8 therms/day	10 full Pan Combi	2.5 therms/day	5.3 therms/day

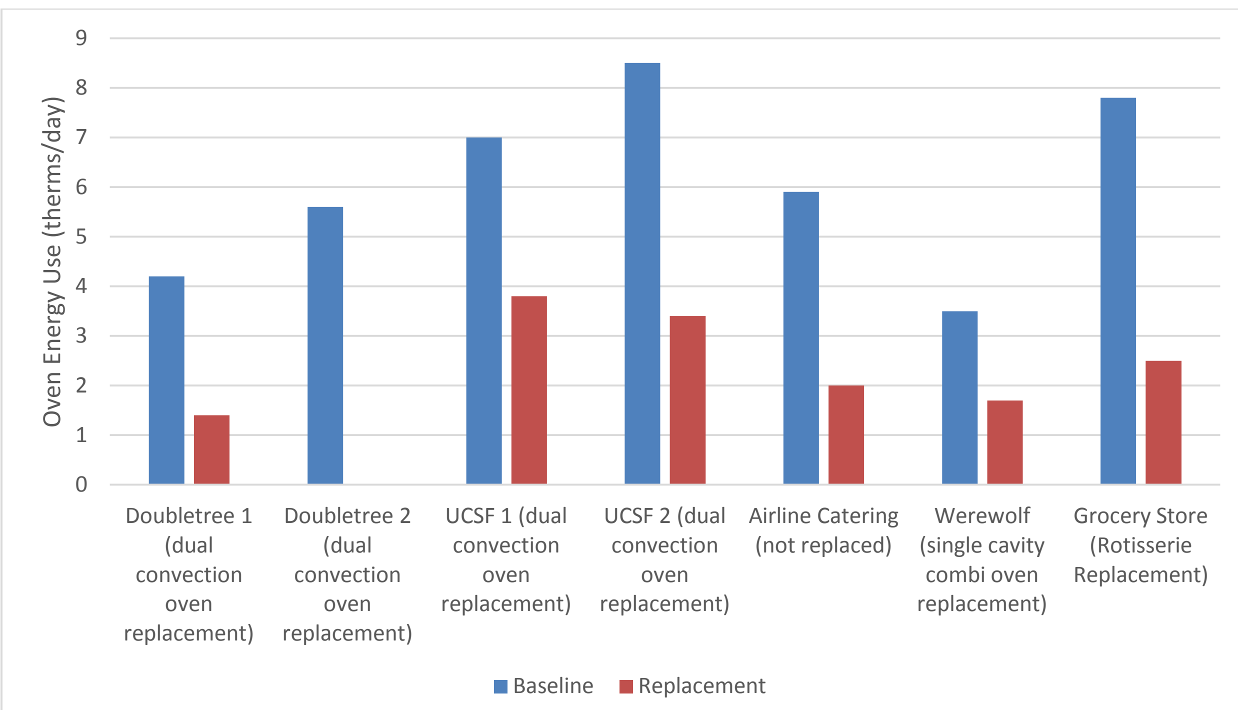

Figure 14 Oven Energy Savings per Site

Fryers

Fried food has been America's favorite food for centuries and fryers have become the centerpiece of quick service restaurants. They are able to produce delicious inexpensive food which often results in the highest profits for the restauranteur.

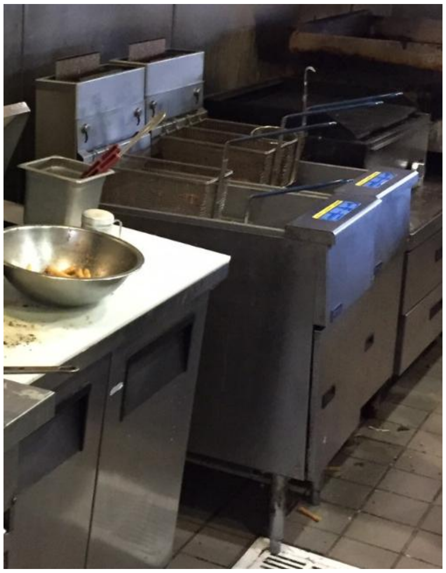

Figure 15 Low Cost Energy Efficient Fryer at Werewolf

Figure 16 High End Energy Efficient Fryer at Werewolf

A fryer is essentially a pot of oil that is heated. 14" wide fryers are the most popular and range in cost from $1 to 5k depending on their design. Inexpensive baseline fryers have tube burners underneath the square frypot for heating, the exhaust gases are then routed the back of the fryer. More advanced designs utilize a power burner that feeds a controlled mixture of gas and air into the burner. The burners can utilize either jet nozzles or be infrared burners which are generally more efficient. Flue gases can also be routed through a heat exchanger which maximizes heat transfer to the cooking oil.

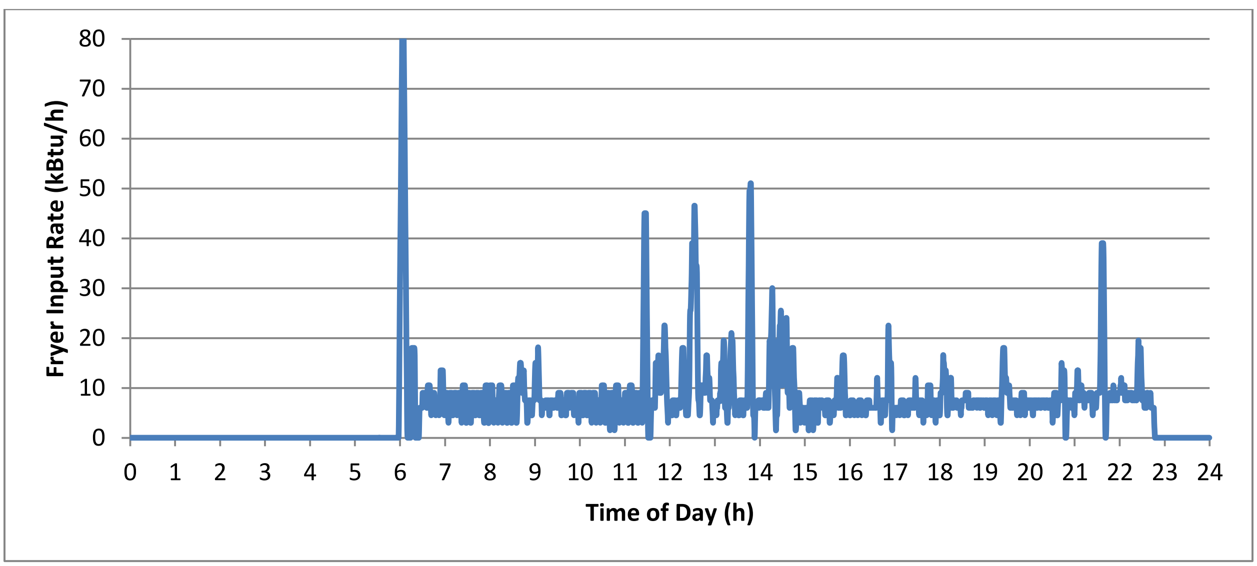

Figure 17 Typical Fryer Daily Energy Profile

14" fryers range between 30 and 60% in efficiency when cooking French fries with more efficient models having higher production capacity. Fryers were submetered at four sites and three standard fryers were replaced with energy efficient fryers. Replacement fryers resulted in 40-50% energy savings while increasing the restaurant's production capacity. Fryer replacement yielded in at least one therm per day per vat savings.

Table 4 Fryer Energy Savings

	Baseline (therms/day)	Replacement (therms/day)	Operation Time (h)
Doubletree (dual)	3.7	1.3+1.0	15
UCSF (18" wide)	3.3	N/A	16.5
Airline Catering	3.4	2.4	16.7
Werewolf 1	2.7	1.8	11.0
Werewolf 2	2.5	N/A	18.6
Average	**3.1**	**1.6**	**16**

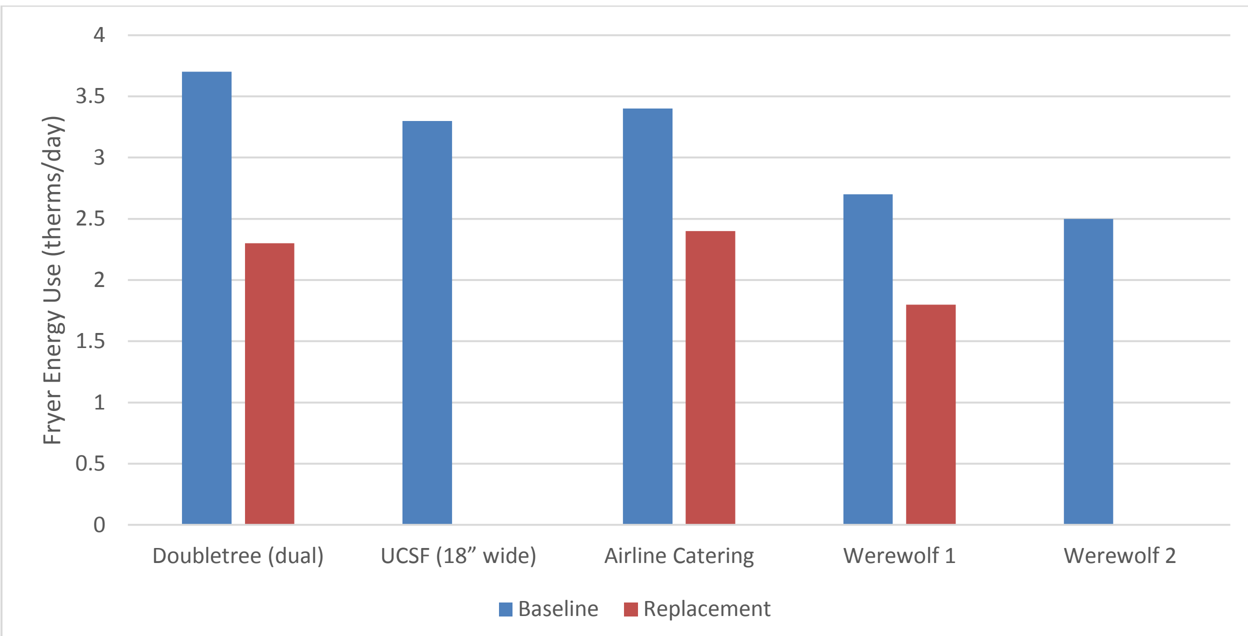

Figure 18 Fryer Replacement Energy Reduction

Griddle

Griddles or Flattops are used in a variety of restaurants to cook proteins by searing the outer surface. Burgers are one of the most common items cooked on the griddle, other items include eggs and vegetables that are not cooked in a pan.

Figure 19 Doubletree Non-thermostatic Griddle

Figure 20 Doubletree Replacement Thermostatic Griddle

Griddles are essentially a flat sheet of metal that is heated underneath. Conventional griddles use a ¼" stainless steel plate with tube burners underneath. 3ft wide griddles are most popular and each linear foot has its own controls. There are two types of controls: manual where the knob position is directly proportional to the flame underneath the griddle plate, and thermostatic where the flame turns on and off automatically based on the temperature setting. Most food is cooked between 325 and 375F on the griddle surface. Non-thermostatic griddle efficiency depends heavily on the operator who can waste a lot of energy by forgetting to turn down the burners after an item has been cooked. Thermostatic controls eliminate this problem and often have an indicator showing that the griddle is up to temperature.

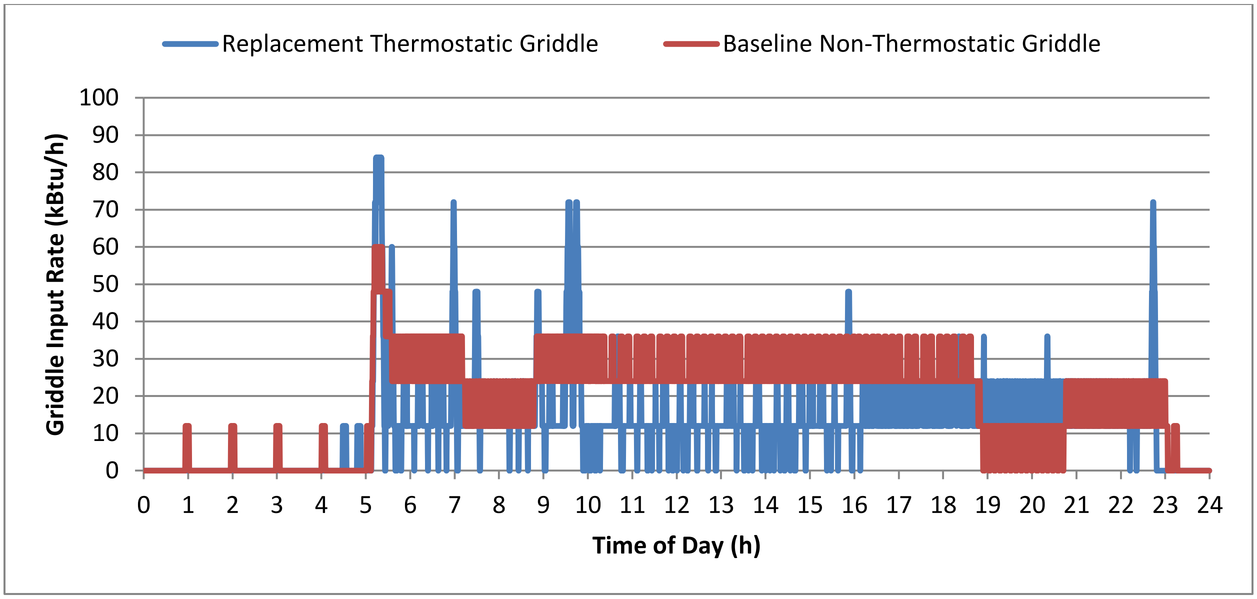

Figure 21 Thermostatic Griddle Replacement Energy Profiles

Energy efficient griddles use thermostatic controls and infrared burners. The griddle top thickness and surface material also makes a difference in energy consumption. Two griddles were monitored consuming an average of 4.5 therms per day. Baseline griddle replacement resulted in 1 therm per day energy savings with energy efficient thermostatic griddles.

Table 5 Griddle Replacement Results

	Baseline Energy Use (therms/day)	Replacement (therms/day)	Operation Time (h)
Doubletree	4.1	3.1	11.9
Werewolf 1	4.9	3.7	17.5
Average	4.5	3.4	14.7

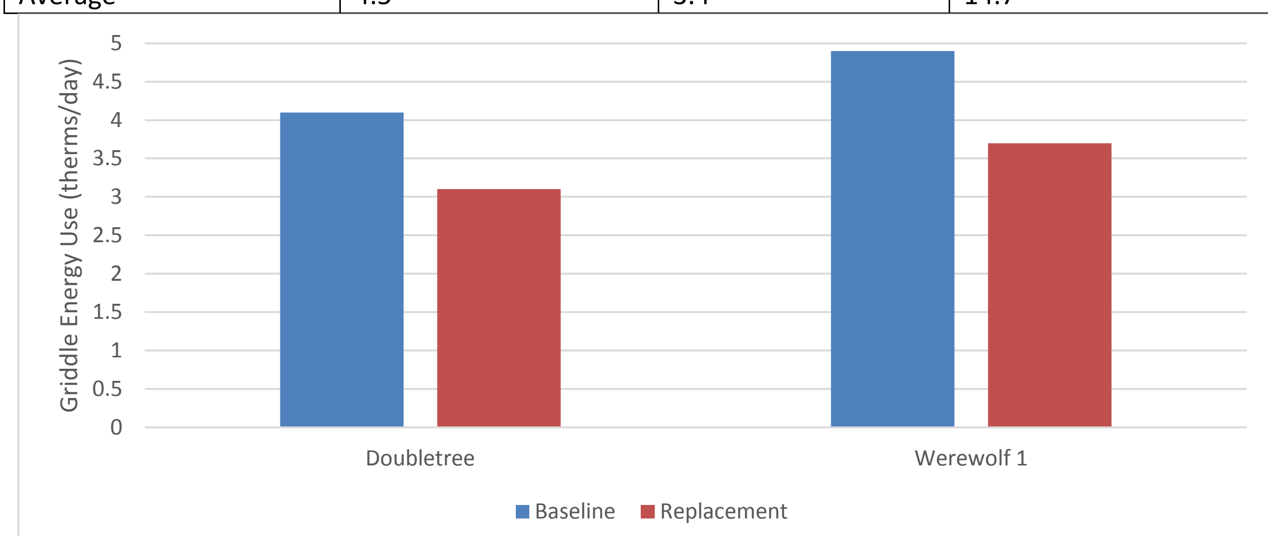

Figure 22 Griddle Replacement Results

Broiler

Broilers are some of the most energy intensive appliances in foodservice. Most establishments that serve alcohol have a broiler which is used to cook burgers and chicken producing the signature sear marks on the surface. Broilers operate between 500 to 600F requiring large amounts of heat which often escapes into the kitchen and requires high ventilation rates. Broilers use more than twice the energy of griddles and are non-thermostatic with each half linear foot having a gas input rate knob.

Figure 23 IR Plate Charbroiler

Figure 24 Baseline Underfired Charbroiler

Based on the broiler energy profiles below, these appliances are turned off in the morning and not adjusted much throughout the day. Energy efficient broilers utilize infrared burners that are more expensive than the standard cast iron tube burners. The infrared heat is spread more evenly across the broiler surface resulting in lower overall input rate compared to the standard broilers.

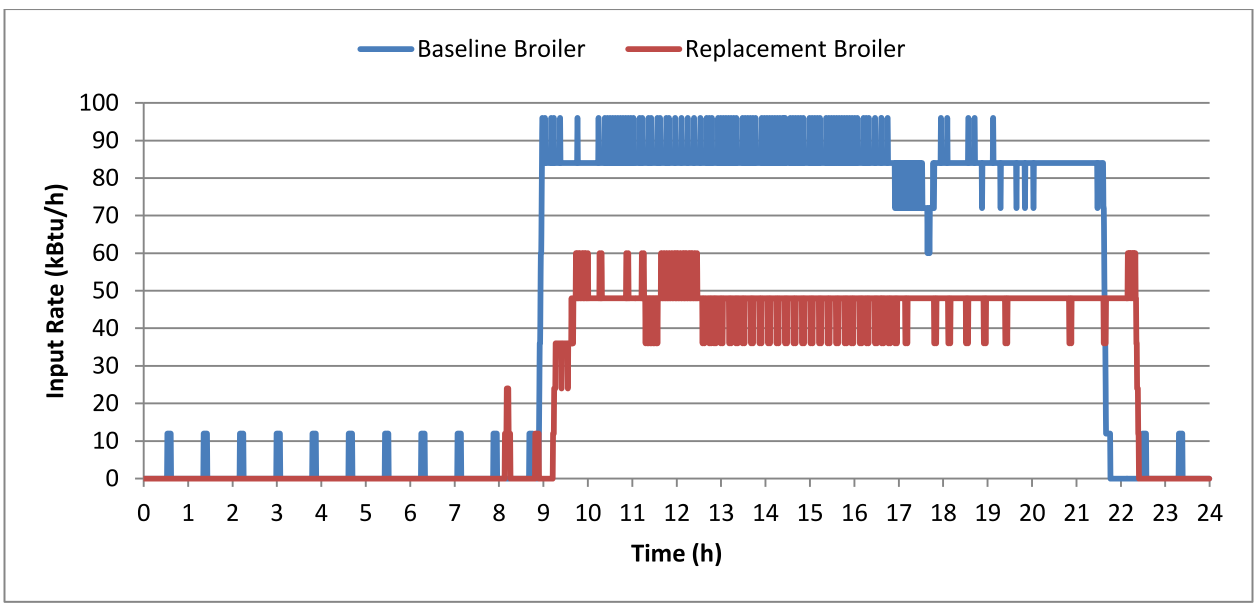

Figure 25 Broiler Replacement Typical Daily Energy Profile

Table 6 Broiler Replacement Results

Site	Broiler Width	Broiler Hours Operation	Baseline Broiler Energy Usage	Replacement Broiler Energy Usage	Replacement Broiler Type
Norm's	4	12.0	12.5	12.8	No Pilot
Firehouse 37	4	12.9	12.0	11.6	No Pilot
Yalla Mediterranean	conveyor	14.9	38.4	5.9	Conveyor Broiler
Sideboard Lafayette	3	12.0	7.5	NA	Not replaced
Hometown Buffet	3	5.2	3.4	NA	Not replaced
Doubletree	3	15.4	11.6	7.9	IR Burner
Werewolf	2	18.9	5.3	4.9	IR Plate
Airline Catering	4	20.4	18.0	15.7	Conveyor Broiler
Bridges	4	11.3	10.4	6.8	IR Plate
Esin	3	12.9	11.0	6.3	IR Plate
Revel	3	8.8	7.0	4.0	IR Plate
Average		**13.2**	**9.7**	**8.4**	

Baseline undefired broilers were replaced at multiple sites with the IR plate and IR burner broilers resulting in the highest energy savings of 30%. Conveyor broilers at Yalla and Airline Catering used the most energy and their energy efficient replacements resulted in the highest savings. Radiant reflector broilers with electronic ignition were analyzed, due to their energy savings claims, however they did not yield any actual energy savings at Norms and Firehouse. IR plate broilers had some problems with the plates warping after heat-stress caused by wet product.

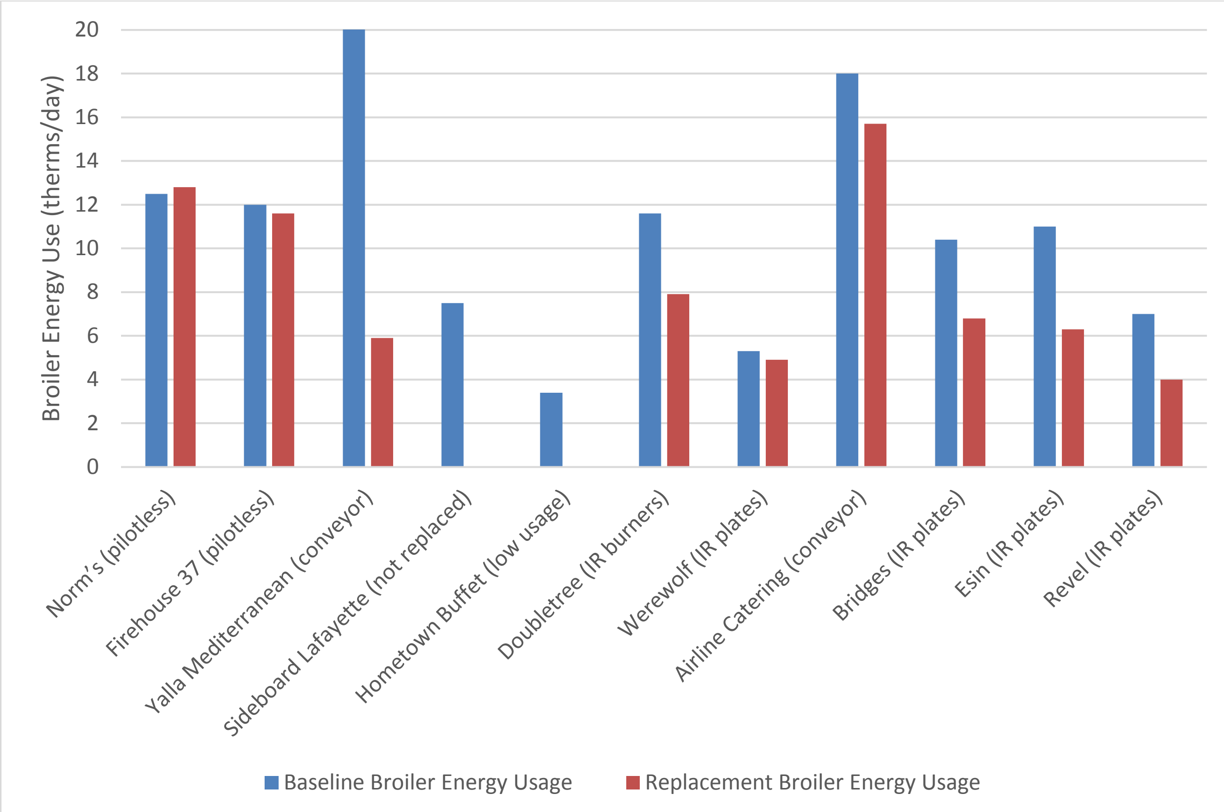

Figure 26 Broiler Replacement Energy

For the typical 3ft standard radiant broiler, the average energy use was about 72 kBtu/h. Given a restaurant that operates daily for an average of 10 hours a day, this would be equivalent to 262.8 MBtu annually. For a restaurant operating in California, where the average utility cost is $0.88 per therm for natural gas, that would equate to approximately $2313 in gas costs from the broiler alone. Assuming the average 25% energy savings from broiler replacement resulting in about $578 in energy savings every year. Separate estimates for each category can be found listed in the table below, with the plate warping issues previously mentioned about the IR Plate broilers.

Table 7 Average Field Broiler Energy Use and Savings

Site	IR Plate	IR Burner	Radiant Reflector Pilotless	Lidded Thermostatic
Baseline (kBtu/h/ft)	22.992	22.355	24.568	25.143
Replacement (kBtu/h/ft)	14.859	16.990	24.916	18.427
Percent Savings	35%	24%	N/A	27%
Estimated Annual Energy Cost Savings	$818.22	$554.88	N/A	$634.17

Ventilation

The 1500 square foot Werewolf restaurant with its 50 seat capacity and mixed-duty appliance line was a very good candidate for a Demand-Controlled Kitchen Ventilation (DCKV) system as an addition to the restaurant's HVAC system. A DCKV system refers to any engineered, automated method of modulating (i.e., variable reduction) the amount of air exhausted for a specific cooking operation in response to a full-load, part-load or no-load cooking condition (i.e., such as by duct temperature, effluent opacity or appliance surface temperatures). In conjunction with this, the amount of makeup air is also modulated to maintain the same relative air ratios, airflow patterns, and pressurizations. Complete capture and containment of all smoke and greasy vapor must be maintained when an exhaust system equipped with DCKV is operated at less than 100% of design airflow. Selection of all components, and design of the DCKV system, must be such that stable operation can be maintained at all modulated and full-flow conditions.

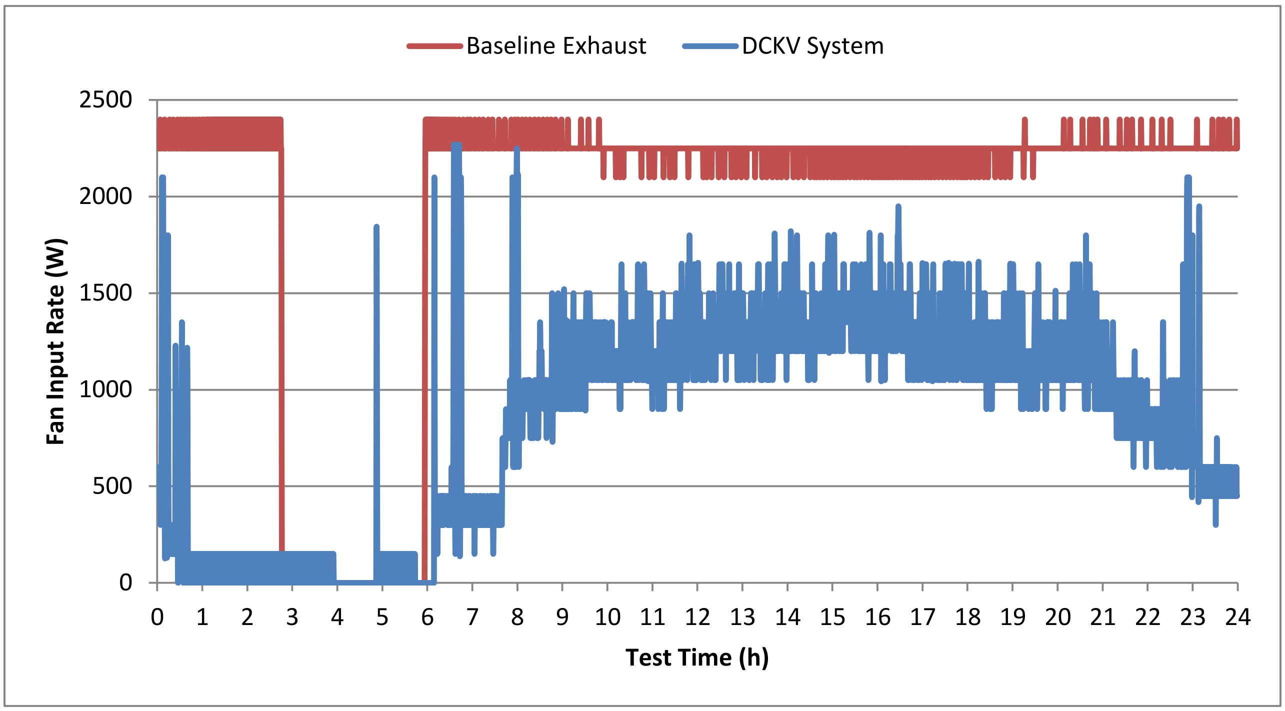

Figure 27 Commercial Kitchen Ventilation System Daily Energy Profile

The energy and utility savings are based on a reduction of fan energy due to reductions in air flows on both the exhaust and makeup air sides. There are additional savings based on reductions of cooling and heating energy due to a reduction in supply air flow rates. The type of system, appliance line, amount of exhaust air flow, weather conditions, and other factor affect the amount of savings.

The DCKV system chosen for the Werewolf restaurant was the Melink system. This system modulates both exhaust and supply fans based on duct temperature along with an opacity sensor that detects smoke rising from the appliance. The opacity sensor allows for a quick fan speed increase response that maintains capture and containment during heavy effluent cooking which does not rapidly increase duct temperature. Because of this rapid optical response, the minimum airflow threshold can be lowered during times of light cooking or appliance idling. Maximizing the airflow range based on cooking conditions reduces the average fan speed which reduces energy use both from the supply and exhaust fans as well as makeup-air conditioning costs.

The Werewolf restaurant kitchen used a mixed duty appliance line including a range, combi, two fryers, small broiler and two griddles. It was a good candidate for the DCKV system. A Melink Intelli-Hood® 3 DCKV system was chosen and retrofitted to a dual section 18 ft hood with optical and temperature sensors over the main appliance line. The DCKV modulated the exhaust and supply fan between 20 and 80% power for three quarters of the time depending on exhaust temperature and effluent generated by the cooking process. The baseline energy consumption of the exhaust and makeup air fans was 72.1 kWh. After the retrofit, the energy consumption was reduced to 39.0 kWh. This represents a 33.1 kWh savings or a 46% reduction in fan energy. The temperate San Diego climate resulted in no cooling savings and the gas heating savings of 1,200 therms per year were calculated for makeup-air conditioning.

Table 8 Commercial Kitchen Ventilation System Energy Savings

	Pre-DCKV	Post-DCKV Retrofit	Savings
Exhaust Fan	48.6 kWh/day	26.0 kWh/day	22.6 kWh/day
Supply Fan	23.5 kWh/day	13.0 kWh/day	10.5 kWh/day
Heating	N/A	N/A	1,200 therms/yr
Cooling	No Cooling	No Cooling	0
Total Savings			**12,081 kWh/yr** **1,200 therms/yr**

Appliance energy reduction opportunities

Gas and electric usage for the monitored foodservice facilities is shown in the table below. Daily gas consumption ranged between 22 and 115 therms per day which is between $8k and $42k in gas bills annually. Commercial kitchen ventilation systems were analyzed at all four sites; however, only two of them could potentially be optimized due to the facilities regulations. An energy consumption feedback system could be implemented at all but one site, informing the operators of their energy use so that they can make behavioral changes to reduce their consumption.

Table 9 Energy Usage at Different Sites

Site	Appliances Monitored	Optimized Ventilation Potential	Energy Information System Potential	Daily Energy Usage (therms/day)	Daily Energy Usage (kWh/day)
Hotel	12	Yes	Yes	39	293
University Hospital	4	No	Yes	32	N/A
Airline Catering	12	No	No	115	N/A
Restaurant / Bar	8	Yes	Yes	22	64

The Airline Catering Company had the highest total energy usage out of all sites because of its long operating hours and several cook lines. The Restaurant/Bar had the least energy usage because of its small appliance line, however, it has the greatest energy reduction potential because of the outdated appliances. The Hotel had the greatest electric load because of the three electric steamers, large ventilation system, and a comparatively low gas load. The annual electric cost to run the steamers and the ventilation system was over $16k. The University Hospital cookline had only two ovens that were candidates for replacement, these appliances used the most energy providing a great opportunity for targeted selective replacement.

Table 10 Average Operating Hours for Different Appliances (hours/day)

Site / Appliance	Fryer	Broiler	Griddle	Oven	Range
Hotel	15	17	12	19	15
University Hospital	17	N/A	N/A	15	N/A
Airline Catering	17	18	N/A	18	N/A
Restaurant / Bar	15	19	18	19	7
Average – All Sites	16	18	15	18	11

The monitored foodservice facilities had long operating hours with the most common appliances being on between 15 and 19 hours per day. Fryers, broilers, griddles, and ovens were usually turned on when the staff arrived in the morning and turned off after the dining room closed. The range was the only appliance that was turned on and off during service because range burners are manually adjusted when necessary by the operator resulting in shorter operating hours. Ranges were also the only appliances where the cooking flame was visible to the operator, while other appliances such as ovens and broilers were left on longer and not turned down between lunch and dinner services.

Table 11 Average Energy Usage for Different Appliances (therms/day)

Site / Appliance	Fryer	Broiler	Griddle	Oven	Range
Hotel	3.7	11.9	4.1	5.1	3.2
University Hospital	3.3	N/A	N/A	7.8	N/A
Airline Catering	3.4	18.0	N/A	4.8	5.6
Restaurant / Bar	2.6	5.3	4.9	3.5	3.1
Average – All Sites	3.2	11.7	4.5	5.3	4.0

Broilers used the most energy followed by ovens and griddles. Griddles used half the energy of broilers. A fractional reduction in broiler energy could overshadow higher percentage reductions in other appliances. Ovens had the most energy variation, making the higher consumers great potential replacement candidates. Range energy usage depended greatly on restaurant menu items and availability of breakfast service. Fryers had the most consistent energy usage due to standard oil vat size and temperature set points. The next phase of the project will analyze energy reduction of each appliance type at the different foodservice facilities.

Realized appliance energy reduction

Gas energy was measured for entire cooklines at four sites and for a single rotisserie at a grocery store with a deli. After energy efficient appliance replacement, the entire cookline gas energy reduction ranged between 19 and 27%. The airline catering company had the highest energy usage with most of the savings coming from the steam kettle replacement with energy efficient dual compartment steamers. The University Hospital benefited from oven replacement which resulted in 55% oven energy savings, however the rest of the cookline was not eligible for replacement resulting in 27% overall savings. The restaurant / bar benefited from the whole cookline replacement which resulted in 19% savings. The hotel appliance replacement resulted in 20% savings mostly due to broiler replacement.

Table 12 Cookline Gas Energy Reduction (therms/day)

Site	Pre Gas Consumption	Post Gas Consumption	Gas Savings	Gas Savings
Hotel	39.2	31.2	8.0	20%
University Hospital	31.8	23.3	8.5	27%
Airline Catering	115.3	88.2	27.1	23%
Restaurant / Bar	21.9	17.6	4.3	19%
Grocery Store	7.8	2.5	5.3	68%
Total – All Sites	215.9	162.8	53.1	25%

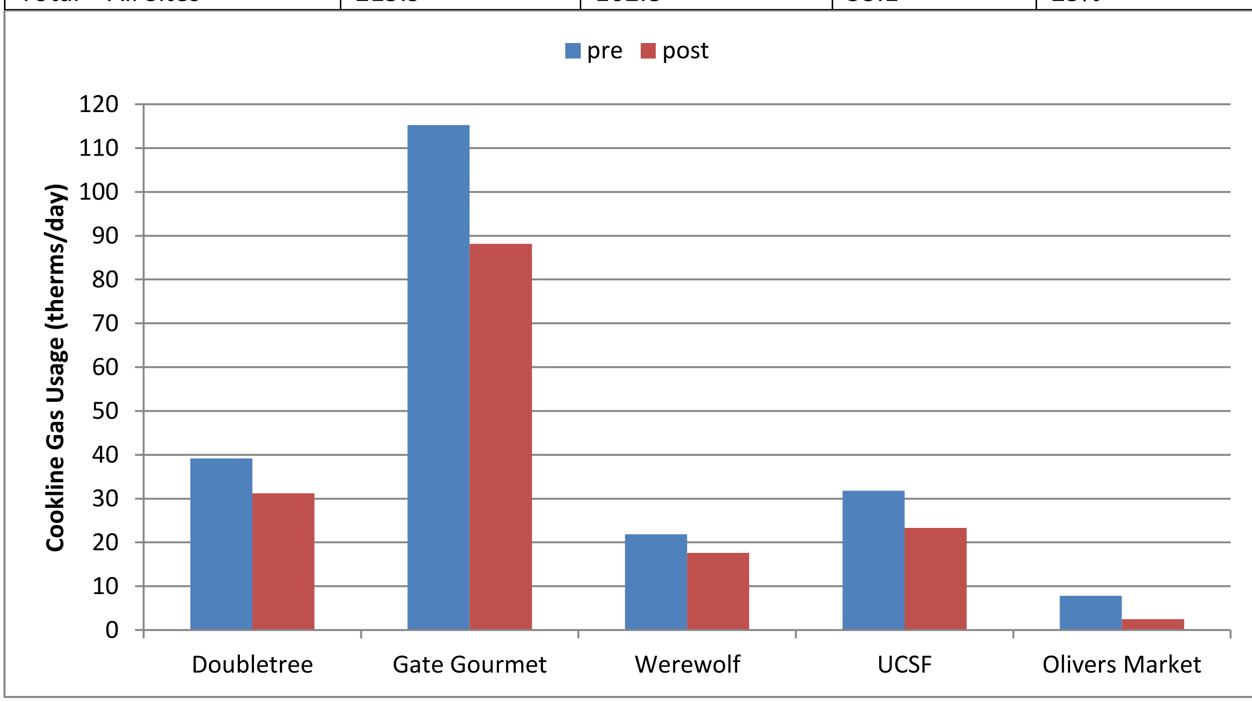

Figure 28 Cookline Gas Energy Reduction

The grocery store only had one appliance replaced. The rotisserie oven was replaced by a combi oven resulting in 68% savings. Based on the large savings and easier cleaning, the grocery store is planning to replace their rotisserie ovens with combi ovens at their other locations.

Electrical energy was monitored at two sites. The hotel had three electric dual compartment steamers which got replaced by a gas steamer, gas combi and an electric steamer. The steamer replacement resulted in over 200 kWh reduction and the two gas appliances only added two therms per day to the gas load. The restaurant / bar had two kitchen ventilation hoods which got consolidated into one by moving the oven from the prep line to the main cook line. The main line hood had a demand control ventilation system installed which resulted in additional 30% savings.

Table 13 Cookline Electric Energy Reduction (kWh/day)

Site	pre electric	post electric	electric savings	electric savings
Hotel	293.0	85.0	208.0	71%
Restaurant / Bar	64.0	32.3	31.7	49%
Total – All Sites	357.0	117.3	239.7	67%

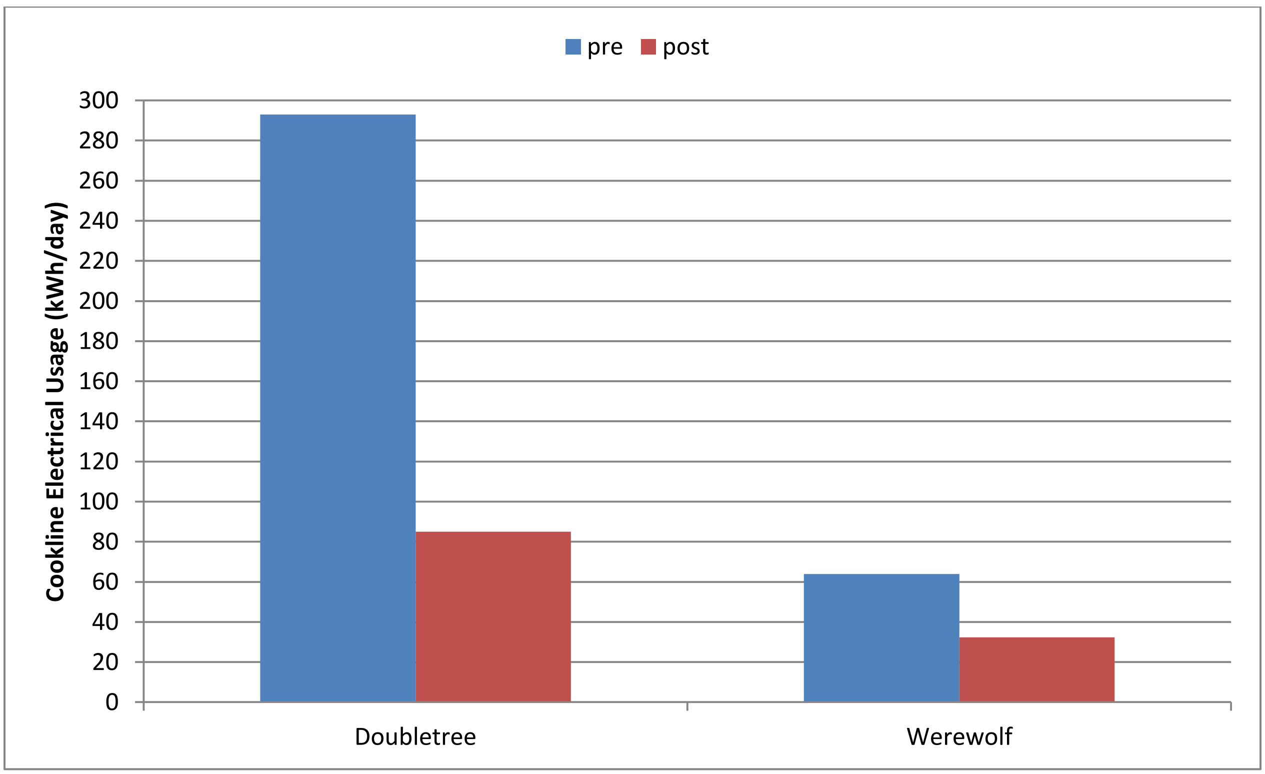

Figure 29 Cookline Electric Energy Reduction

Impact on the industry

As energy becomes costlier and more people are becoming aware of their carbon footprint, it is more important to identify energy reduction opportunities in different commercial sectors. Historically, foodservice has been a slow to adapt industry where speed is valued more than efficiency. In order to reduce the carbon footprint of restaurants and institutional kitchens, change can come either from the cooking equipment providers, the restaurant operators or the consumers themselves.

Appliance Energy and Carbon Footprint

As the consumers become more aware of the sustainable practices of the restaurant from the food sourcing perspective, they should start scrutinizing the amount of energy it takes to prepare the food. A sustainably sourced chicken that has been roasted in an open rotisserie that consumes 10 therms per day is no longer a sustainable product once it ends up on the plate. Authentic Italian pizza with ingredients flown in from Italy and cooked in a 1000F oven that is on 24/7 has some of the highest carbon footprints per pound of food served.

Sustainable material evaluation involves cradle to grave analysis starting from material sourcing and ending with the material recycling at its end of life. The cradle to grave analysis of our food is incomplete, because the overall energy impact of food is not complete once the animal is killed, it is complete once it is consumed by people. There is abundant data of the greenhouse gases emitted during production and transportation of different foods as shown in the figure below, but the cooking energy impact is often overlooked.

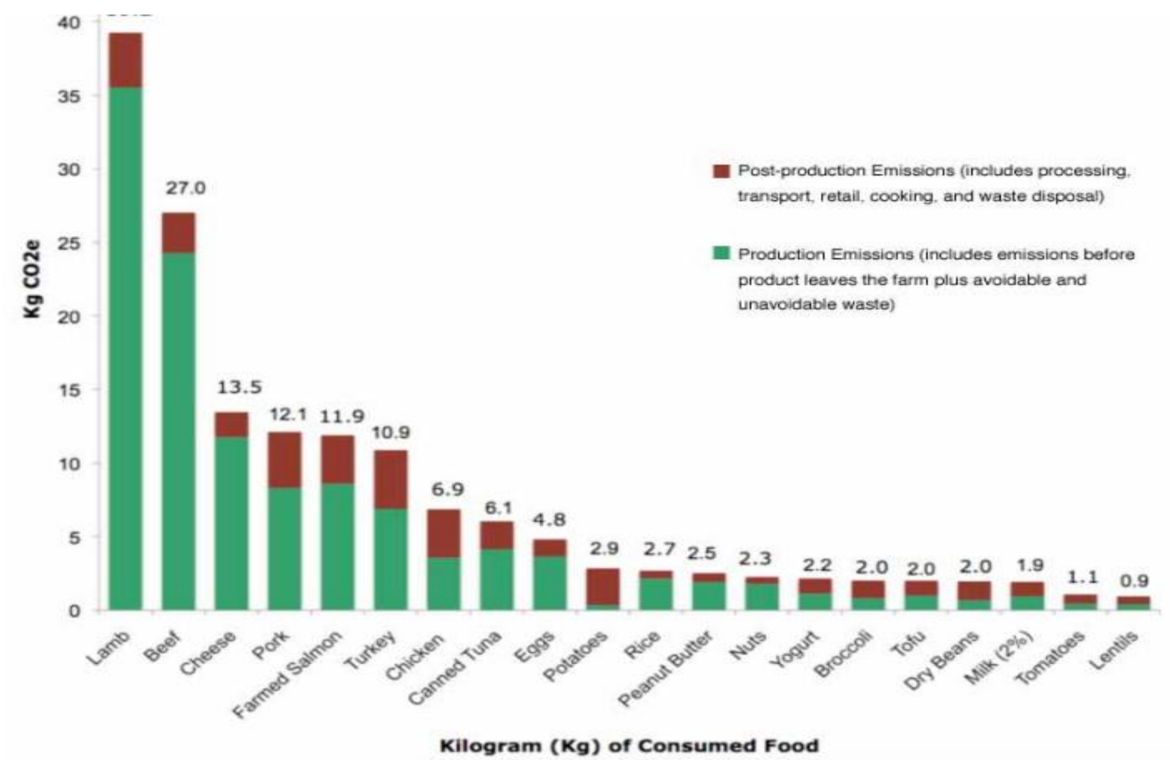

Figure 30 Food Product Greenhouse Gas Emissions (Environmental Working Group Meat Eaters Guide: Methodology 2011)

Even when craving for a hamburger, a consumer can have a decision of their carbon foot print impact: to go to a restaurant that uses a flat top griddle or a flamed char broiler that uses three times the energy. Quick Service Restaurants have been criticized for their use of food additives and unsustainably harvested products which may lead to higher production emissions, however most quick service restaurants utilize energy efficient appliances that result in lower post production emissions. Chain restaurants often have engineers that specify energy efficient equipment in order to streamline the cooking process and save costs on energy, therefore reducing their carbon emissions for the cooking process. High end cook to order restaurants may use very energy inefficient appliances to cook individual portions of food that have been sustainably sourced. This results in a lower food production emission and a higher post production emission. The chart below shows the energy consumption of each appliance which is used to cook food. The carbon emissions are proportionate to the energy consumption.

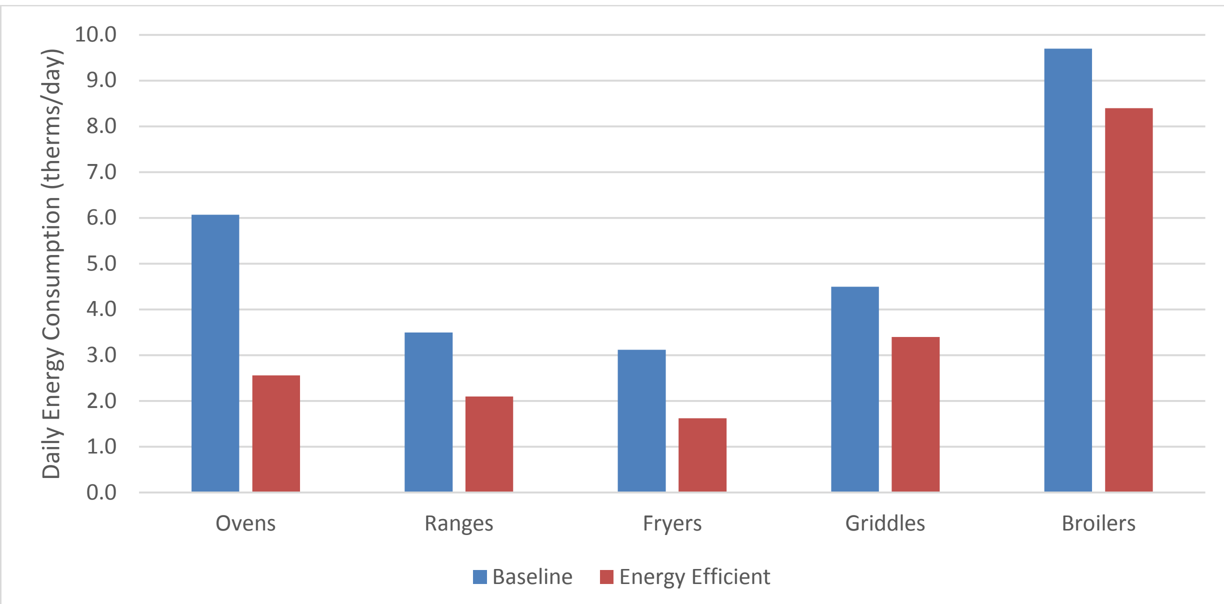

Figure 31 Energy Consumption Per Appliance Type

Energy consumption can initially be reduced by choosing less energy intensive appliance types, and then further reduced by specifying energy efficient appliances. Using the carbon footprint assumptions for PG&E territory, the annual carbon footprint of each appliance can be calculated.

Table 14 Carbon Emissions Per Energy Source in PG&E Territory (Pacific Gas and Electric Company Carbon Footprint Calculator Assumptions)

	Carbon Emissions (lbs)	Unit
Electric Appliance	0.524	Per kWh
Gas Appliance	13.446	Per therm

Table 15 Commercial Kitchen Appliance Carbon Footprint

Cooking Appliance	Baseline Emissions (tons CO2 per year)	Energy Efficient Emissions (tons CO2 per year)
Ovens (2 Cavity)	29.8	12.6
Ranges (6 Burner)	17.2	10.3
Fryers (one 14in vat)	15.3	8.0
Griddles (3ft wide)	22.1	16.7
Broilers (3ft wide)	47.6	41.2

Broilers have the highest CO_2 emissions with the ovens having the second highest emissions. In order to reduce the broiler carbon emissions, the operator can either replace it with an energy efficient broiler or switch to a griddle which would result in even greater reduction. Ovens are quite versatile and can cook a variety of products which means their carbon emissions per item cooked can be much lower if the food is cooked in large batches. Energy efficient ovens are readily available and are relatively inexpensive way to reduce the carbon footprint. Fryers seem to have the lowest footprint, however the reported numbers are per fryer vat and larger restaurants have several vats. Besides switching to energy efficient fryers, the operator can use fresh product instead of frozen which will reduce the overall cooking energy. A restaurant with one of each appliance type can reduce their carbon footprint by 43 tons of CO_2 per year if the operator was to replace their inefficient appliances, or efficient appliances were specified in the first place.

Appliance Costs and Utility Rebates

Commercial cooking appliances are much more expensive than their residential counterparts. These appliances are mostly made of stainless steel and use very few plastic pieces which results in higher cost. Furthermore, the appliance production numbers are lower for the commercial market than residential which drives the design and certification costs up compared to the units sold. The typical appliance costs for each type are shown in a table below. The most energy intensive appliances are some of the cheapest.

Table 16 Typical Appliance Costs

Cooking Appliance	Baseline Efficiency Appliance Retail Cost
Convection Oven (Per Cavity)	$4,000
Steamer (Per Cavity)	$5,000
Combi Oven (Per Cavity)	$10,000
Range (6 Burner)	$3,000

Fryers (one 14in vat)	$2,000
Griddles (3ft wide)	$3,000
Broilers (3ft wide)	$2,500

Appliances typically last anywhere from 6 to 20 years with an average effective useful life of 12 years. Ovens and steamers often require the most repairs with many components prone to failure such as thermostats, fans, igniters and door hinges. Broilers and ranges have less components that can fail, so the operators are less likely to replace those appliances. Once an appliance fails, and cannot be repaired, it is often hastily replaced by whatever appliance is available at the local foodservice retailer. Very little attention is paid to the appliance's energy efficiency.

Energy efficient appliances often cost 10-30% more than their baseline counterparts. Energy efficient appliances often have higher production capacities and additional features such as programmable timers. Energy efficient appliances also have low end and high end models, with the high end models often costing two to three times the baseline cost. Budget efficient appliances may cost almost the same as their inefficient counterparts. Higher initial appliance costs of energy efficient appliances can often be justified by energy savings and higher sales volumes for busy restaurants.

Energy efficient appliance cost premium is sometimes subsidized by the energy utility company in order to reduce the energy demand. California utilities estimate their rebates based on the first year energy savings of energy efficient appliances. Some competing utilities outside of California use rebates in order to convince the customer to switch fuel sources between gas an electric. Energy efficiency rebates often provide the appliance manufacturers competitive advantage, which persuades the manufacturers to reengineer their designs in order to make their product more energy efficient. Sometimes the rebates are given to the equipment sales people instead of the customers themselves in order to drive up the sales of energy efficient equipment. Overall, utility rebates justified by verified data are a great way to move the foodservice industry forward and reduce its carbon footprint.

Behavioral Changes

Restaurant designers have the biggest influence over the restaurant's future energy consumption. Restaurant designers use foodservice consultants to specify appliances. Foodservice consultants are sometimes loyal to a certain appliance brand and may specify inefficient appliances. Foodservice consultants should be educated about the benefits of energy efficiency and have an arsenal of energy efficient appliances that they can specify for new restaurant designs and remodels.

The restaurant operator has the second most influence over the restaurant's carbon footprint. They get to decide what appliance gets replaced with what model and how much to spend. Often during restaurant construction, an unexpected change causes the project to go over budget and leaves it up to the operator to decide where to save costs. Restaurants are more likely to cut costs in the kitchen rather than the dining room, during cost cutting, specified energy efficient appliances are in danger of being replaced by cheaper inefficient appliances. It is important to teach the restaurant operators and managers how energy efficient equipment can save them operating costs in the long term despite their initial higher costs.

The appliance operators are the line cooks and sous-chefs which are the lowest paid employees in the restaurant. They often do not have any idea how much energy a restaurant uses and what the restaurant energy bills are. They also do not have any financial incentive to reduce energy, however they are ultimately the ones that have the most control over energy consumption once an appliance is installed. There is a tremendous amount of energy that is wasted due to carelessness and poor planning.

Restaurant staff comes in early in the morning before the restaurant opens in order to prep food for service. Appliances are often turned on during that time even if no cooking is taking place. A typical appliance takes 10 to 20 minutes to preheat, turning on appliances half an hour before service can save 1-4 hours of wasted energy. Restaurants that serve breakfast, lunch and dinner may use certain appliances only for one of the three services, appliances need to be turned on for that service period only. Restaurants serving lunch and dinner often have a quiet period between those two services, most appliances can be turned off or turned down in between. Restaurant managers should educate their cooks and provide financial incentives for behavioral energy reduction. Feedback on how much energy a restaurant uses can be obtained through smart meters used by many utilities around the country. Additional gas or electric sub metering services can be available through local consulting companies.

Information Dissemination

The foodservice industry is not fully aware of its overall impact on the global energy consumption and the greenhouse emissions associated with it. Operator training and information dissemination is crucial in order to achieve energy reduction goals in this commercial sector. This report will be posted on a publically accessible website and will be referenced for future energy studies. The information in this report will be used in presentations to foodservice operators, utility program managers, restaurant designers and restaurant equipment manufacturers.

The California utilities provide free training programs for their customers and employees that are involved in the commercial foodservice industry. Education and training will increase the awareness of energy waste and will trickle down to the operators and consumers that are ultimately responsible for it. Fortunately, energy use and energy cost are related to each other and most people are more likely to care about their carbon footprint if there are financial incentives to do so. Saving the operator money and saving energy go hand in hand. Utilities worldwide should continue providing financial incentives directly and indirectly to the operators to reduce their energy consumption and educate those who do not yet understand the value of it.