FRONTIER energy

CEC Plug-Load Project Results

TAC Technical Advisory Committee
Update meeting
April 5, 2018

California Energy Commission
Edmund G. Brown Jr., Governor

Presentation by:

David Zabrowski
Mark Finck & Edward Ruan

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https://fishnick.com/cecplug/

Thank You to the Plug Load Project Sponsor

CALIFORNIA ENERGY COMMISSION

PG&E

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Beth Lorenzini	FER Magazine

CEC Plug Load Project Web Page

http://www.fishnick.com/cecplug/

Goals for Today:

1. Explain the Project
2. Base-line Appliance Results
3. Market profile / Survey
4. Appliance replacement insight
5. Get you Interested – support next goals

Plug-Load Project Team:

- Frontier Energy
  - David Zabrowski - Project Manager
  - Mark Finck - Principal Investigator
  - Edward Ruan – Site and Field – Appliance / Data Analysis
  - Denis Livchak – Data Analysis and Reporting
- Fisher Consultants
  - Don Fisher – Technical Support
- Opinion Dynamics – Customer Survey
- ADM Associates, Inc. - Measurement and Verification

What are "Plug Loads" and Why do we care?

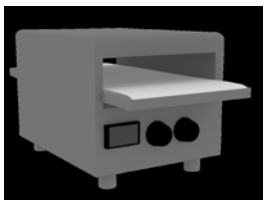
Typical Commercial kitchen Prep-line

Objective: Energy Reduction Potential of unventilated commercial plug load foodservice equipment

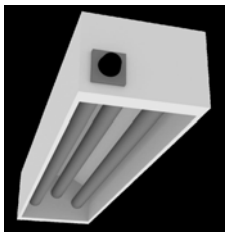
- Research and determine Plug Load appliances and determine site categories
- I*dentify top energy* using appliances with *greatest potential* to implement a *reduced* energy mode during *periods of minimal activity*
- Field monitoring at 5 target sites (currently 14 and growing)
- Demonstrate potential to *reduce* appliance's *energy consumption without hindering* overall *kitchen production*
- Can use pre-commercial appliance designs and control technologies
- Operational behavior changes
- Create a database of appliance energy info

Equipment Overview

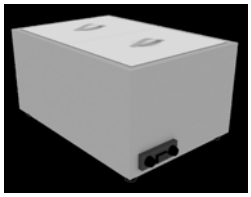
Heating



Equipment Overview

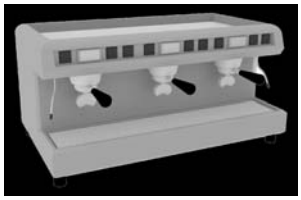


Holding



Equipment Overview

Beverage



Research and identify appliances

Table 2. Estimated CCFS Plug Load Energy Consumption and Savings Potential for Select Appliance Categories

Appliance Category	Avg. Power During Typical Use (W)	Avg. Power During Standby (W)	Est. Production Hours	Est. Standby Hours	Est. Energy Use/day (kWh)	Est. Energy Reduction/ day (kWh)	Est. Energy Reduction/ year (MWh)
Toaster Vertical	2,600	800	8	6	36	11	2.9
Toaster Conveyor Radiant	1,800	800	4	4	14	4	1.1
Food Warmers Top Heat	1,000	100	11	5	16	5	1.2
Hot Plate/btm Heat Holding	1,000	700	6	6	12	2	0.5
Rice Cooker	1,550	81	5	7	12	10	2.7
Soup Warmer	800	400	8	8	8	3	0.8
Coffee Brewers / Hot Water Dispensers	800	125	6	18	19	12	3.2
Espresso Machines	2,200	200	12	12	53	24	6.3

Table 3. Estimated CCFS Plug Load Energy Consumption and Savings Potential for Select Appliance Categories

Appliance Category	Est. Inventory in CA	Total Energy Use (GWh)	Total Power Reduction during Standby (MW)	Total Energy Reduction (GWh)	Penetration Rate (%)	Adjusted Power Reduction (MW)	Adjusted Energy Reduction (GWh)
Toaster Vertical	45,000	597.9	81.0	177.4	10%	8.1	17.7
Toaster Conveyor Radiant	38,000	199.7	38.0	55.5	15%	5.7	8.3
Food Warmers Top Heat	46,000	268.6	41.4	75.6	15%	6.2	11.3
Hot Plate/btm Heat Holding	25,000	109.5	7.5	16.4	10%	0.8	1.6
Rice Cooker	11,000	49.8	16.2	41.3	15%	2.4	6.2
Soup Warmer	43,000	125.6	17.2	50.2	15%	2.6	7.5
Coffee Brewers / Hot Water Dispensers	200,000	1,401.6	135.0	887.0	30%	40.5	266.1
Espresso Machines	50,000	963.6	100.0	438.0	10%	10.0	43.8
					TOTALS	**76.3**	**362.6**

Site / Locations

- Restaurants:
  - Fine Dining:
    - Bridges Restaurant, Danville
  - Casual:
    - SideBoard – Danville
    - SideBoard – Lafayette
    - Dabba, San Francisco
    - Lin Jia Asian Kitchen, Oakland
  - Café / Bakery:
    - Rebecca's Café, San Ramon
    - Caffe 817, Oakland
    - Chain account Café/Bakery, San Ramon
  - Quick Service
    - McDonald's
    - Togo's Sandwich
    - Chipotle
- Cafeteria Kitchen:
  - San Ramon Valley Conference Center, San Ramon
- University / College:
  - Mills College Founders Commons, Oakland
  - UC Berkeley Crossroads Dining Hall, Berkeley
- Hotel:
  - DoubleTree – Pleasanton
- Lab:
  - Food Service Technology Center

Market Assessment

- Extrapolate findings to estimate total energy savings potential
- Create business case outlining the projected benefits of implementing specific energy-saving measures

Potential For Big Savings From Small Loads?

Appliance Plug Loads can be substantial - there are approximately 100,000 commercial food service (CFS) facilities operating in California and over 1 million facilities nationwide.

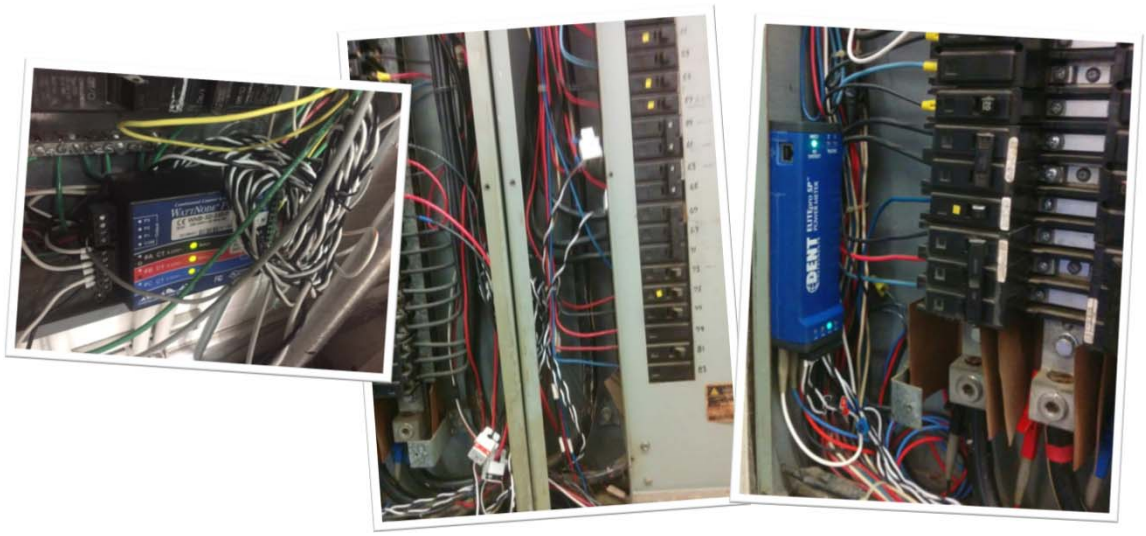
Project Status: Baselines Measured

- Assessed baseline plug load energy usage at 14 commercial foodservice facilities.
- Facilities included a large bakery/cafe chain, university dining, hotel, fine-dining, fast casual, take-out and cafes
- Sub metered from 2 to 8 appliances at each site
- Energy use for each appliance type was averaged and normalized to generate energy usage estimates

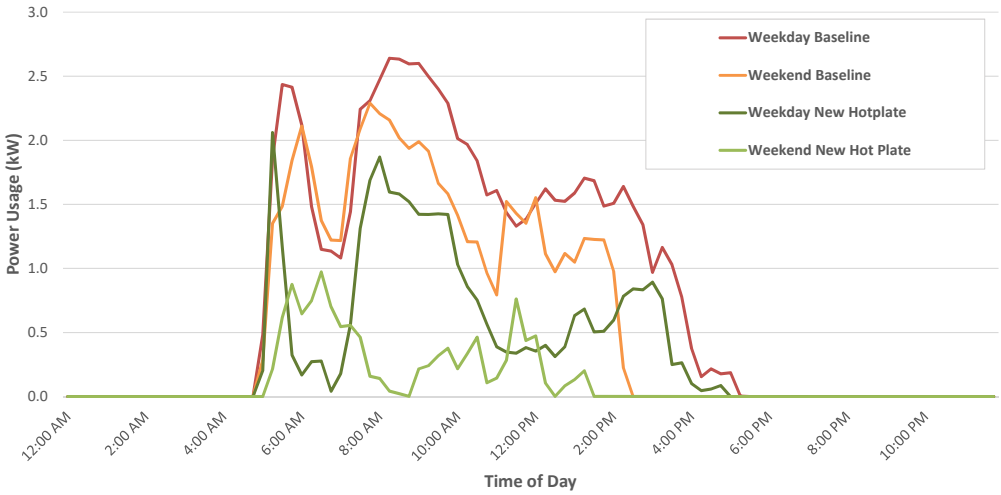
In-Line Data Collection Techniques

Custom In-Line Data Collection Boxes

In-Panel Data Collection Techniques



Metering Validation



ADM Associates, Inc. - Measurement and Verification

Project Status: Baselines Measured

- Conveyor toasters, coffee brewers, espresso machines, rice cookers, and soup wells were the most commonly metered appliances.
- The most energy intensive appliances observed were conveyor toasters.
- Appliance energy usage varied significantly by site and operation type, with hours of operation and appliance settings playing a key role
- Rice cookers, soup wells, and tea brewers used the least energy due to lower hours of operation and lower average input rates

Client Survey

FOOD SERVICE PLUG LOAD SURVEY

Food Service Plug Load Savings Potential Study

April 5th 2018

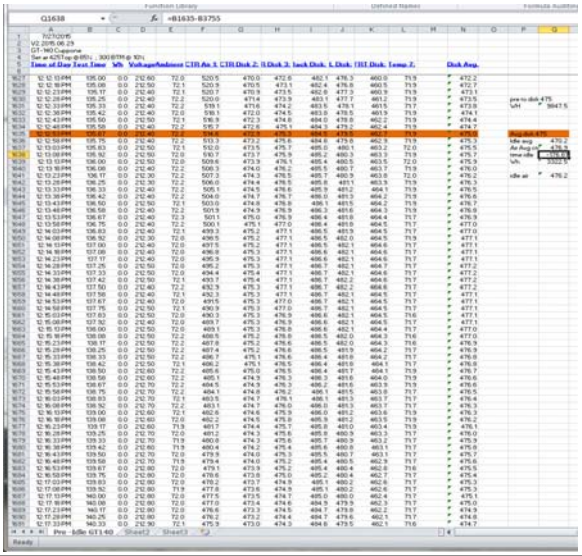
Opinion Dynamics

Let's Look at Some Data!

Data - the numbers

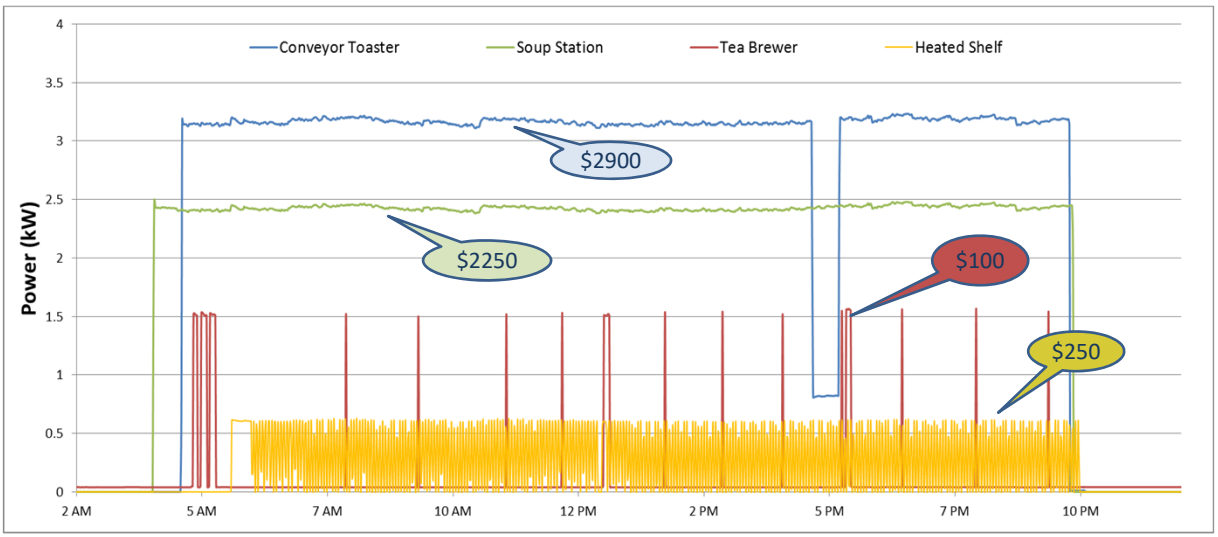
What do the numbers mean?

Make the data usable for the project



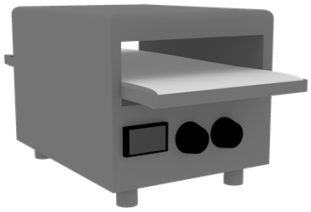
Appliance Type	Baseline			
	Number of Appliances Monitored	Total Average Daily Energy Usage (kWh/day)	Total Average Daily Hours of Operation (h/day)	Normalized Energy Usage Rate (kW)
Coffee Brewer	6	8.6	20.0	0.43
Conveyor Toaster	4	22.4	10.2	2.34
Espresso Machine	3	8.1	13.9	0.59
Heat Strip	2	13.5	18.0	0.84
Heated Shelf	1	4.2	13.7	0.31
Holding Cabinet	4	10.3	9.0	1.19
Hotplate	1	18.2	8.4	2.17
Panini Press	2	9.8	8.0	1.23
Rice Cooker	5	1.6	5.4	0.85
Soup Well	4	1.0	8.9	0.13
Tea Brewer	3	1.9	18.0	0.11
Tortilla Warmer	5	6.3	9.3	0.67
Wet Well	3	4.2	7.0	0.69

Bakery/Café: Daily profile of Plug-Load Appliances



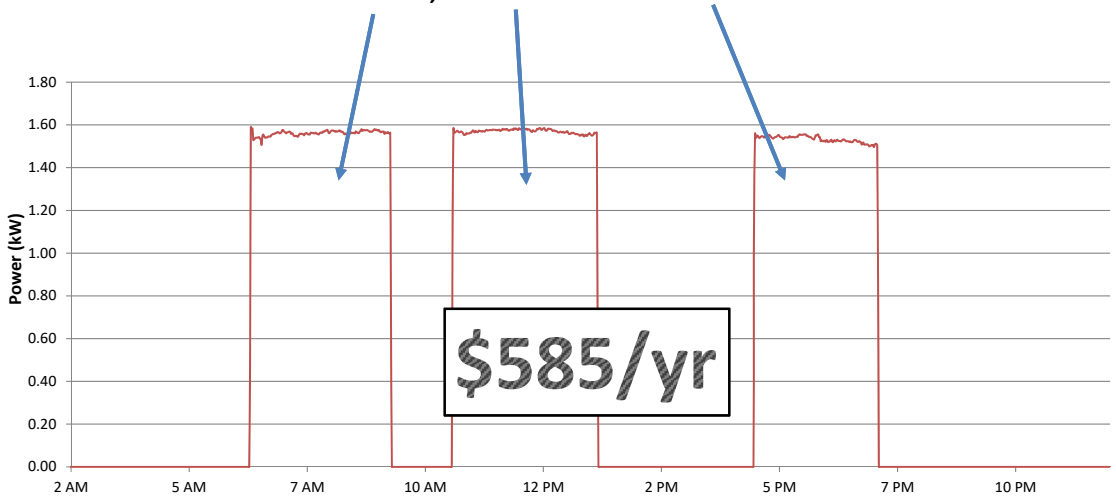
@ $0.15/kwh

Let's Start with Conveyor Toasters



Mills College (Dining Hall)

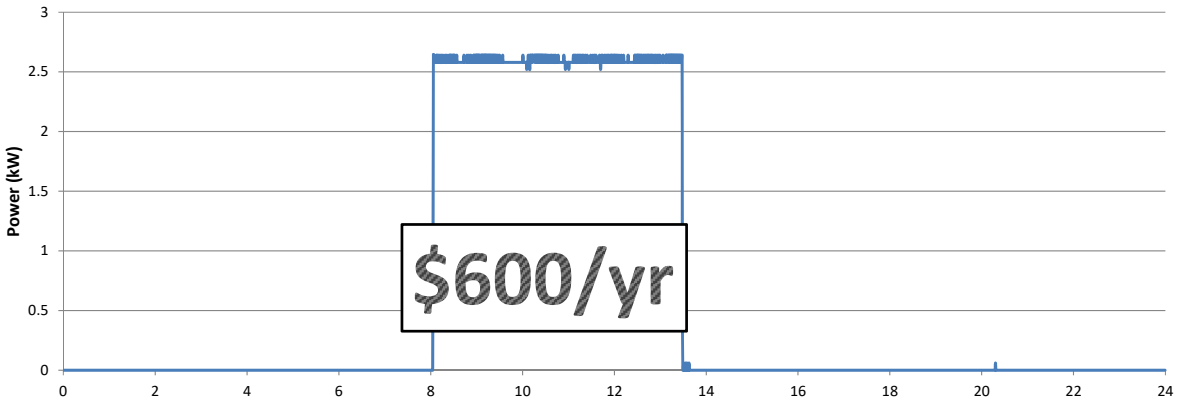
Breakfast, Lunch and Dinner service



@ $0.15/kwh

Rebecca's Cafe

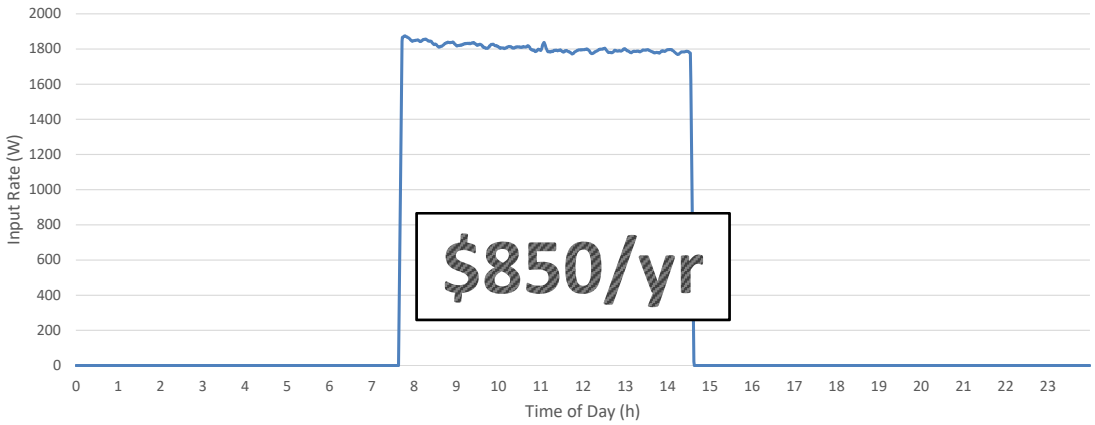
Used only in the morning/afternoon



@ $0.15/kwh

Caffe 817

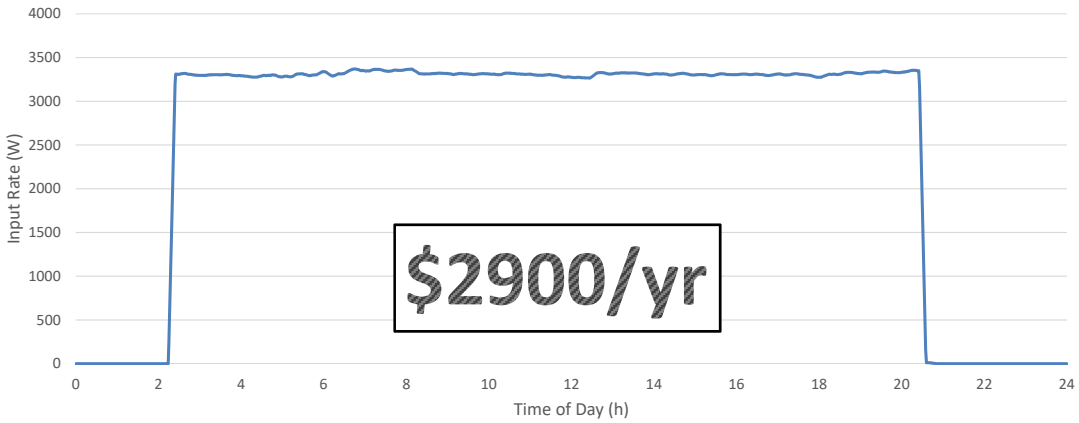
Breakfast, Lunch and Afternoon Café Service



@ $0.15/kwh

Bakery/Café: Baseline

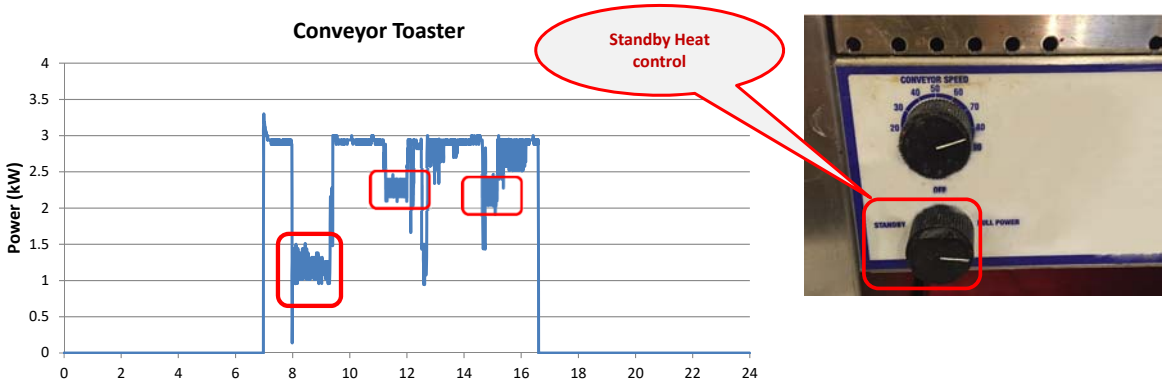
Breakfast, Lunch and Dinner – Busy All Day



@ $0.15/kwh

Conveyor Toaster with a power reduction selectable mode

Problem is this manual mode selection requires crew to be motivated to use



Phase Two: Monitor Intelligent Conveyor Toasters

Built-in sensor automatically activates the set toast cycle when a product is placed on the conveyor

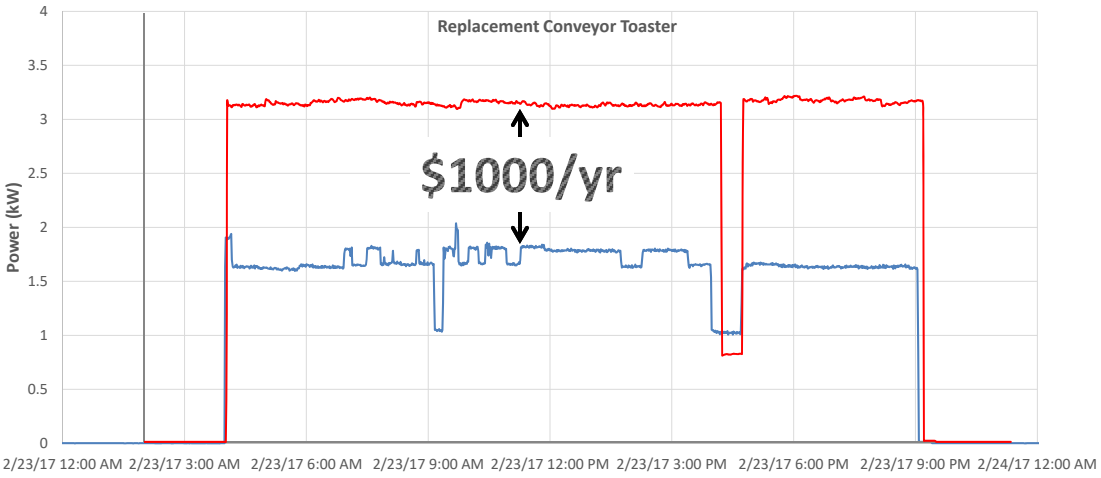
Color sensing system monitors and adjusts conveyor speed and temperature to toast food consistently

Power saver mode automatically kicks on after a set amount of time

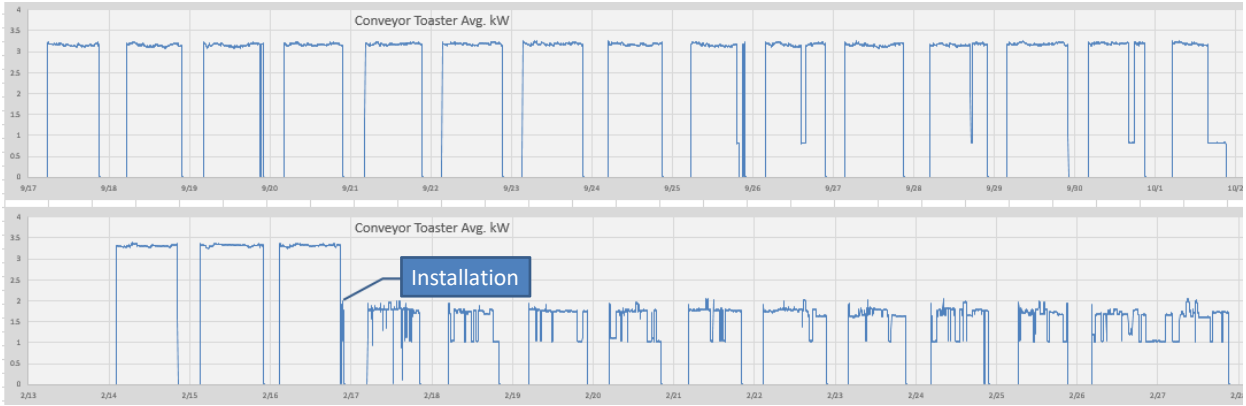
It Knows when to Doze

Bakery/Café: Replacement

Decrease from 3kW to 2kW

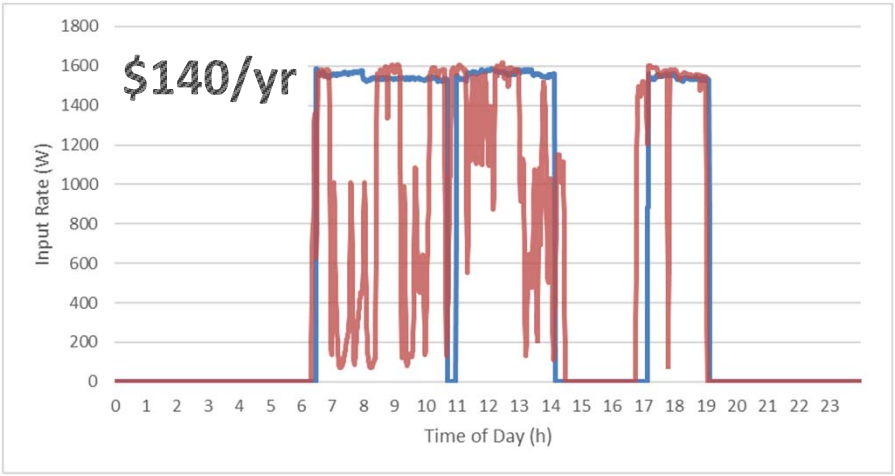


Café / Bakery energy comparison



Mills College: Replacement

Input Rate Modulation



Lab Data
Estimated Savings from Setback

Appliance	Normal Operation	Using the Setback Feature
Preheat Energy (kWh/day)	0.87	0.87
Setback Idle Energy (kWh/day)	0	9.16
Setback-to-Full Power "Recovery Energy" (kWh/day)	0	3.24
Full Power Energy (kWh/day)	62.67	23.82
Annual Energy (kWh/year)	23,127	13,501
Annual Cost ($/year)*	$3,469	$2,025

VS.

*based on $0.15/kWh

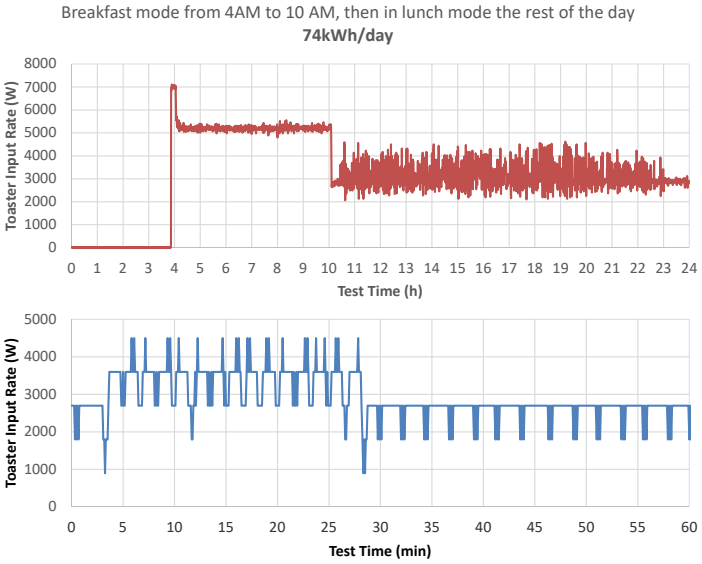
Learning More About Vertical Toasters

	Standard Heat Shield without Damper	Standard Heat Shield with a Detachable Damper Underneath	Air Channel Heat Shield with an Integrated Damper
Preheat Energy (kWh/day)	0.90	0.84	0.74
Idle Energy (kWh/day)	24.27	20.65	13.57
Cooking Energy (kWh/day)	5.56	5.54	4.39
Annual Energy (kWh/year)	11,186	9,839	6,807
Annual Cost ($/year)*	$1,119	$984	$681

VS.

*based on $0.15/kWh

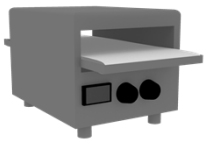
Basline Toaster Energy Savings



Horizontal Toaster Energy Savings

Configuration	Baseline			Replacement	
Operating Mode	Breakfast	Lunch	Lunch	Breakfast	Lunch
Operating Time (h)	18	12	12	18	12
Heat Transfer Type	radiant	contact	contact	radiant	contact
Energy Per Day (kWh)	85.58	35.59	10.96	44.82	18.25
Energy Cost Per Year*	$ 4,685	$ 1,948	$ 600	$ 2,454	$ 999
kWh Energy Cost per store		$ 7,234		$ 3,453	
Energy Savings (mWh)		-		25.20	
Annual Energy Savings*		-		$ 3,781	

Future Toaster Innovations?



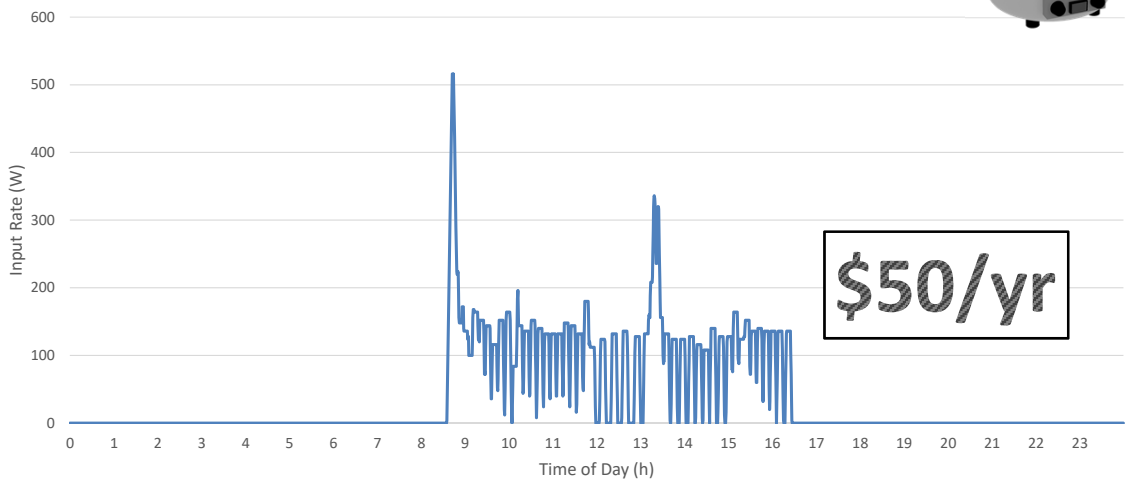
Lunch

30:00 min

How About Soup Warmers?

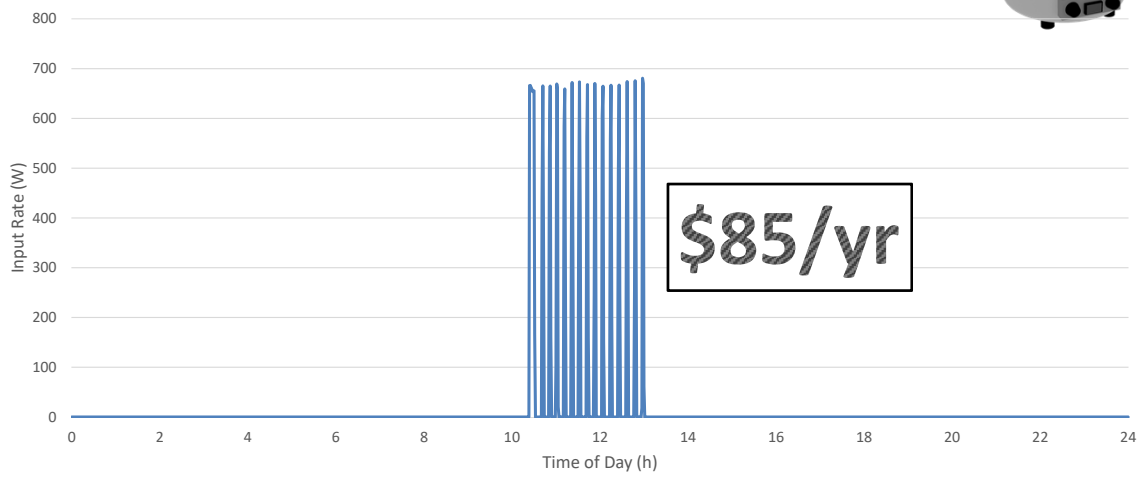
Less energy use than a conveyor toaster
but there are a lot of soup warmers out there!

Caffe 817 (7-Quart)



@ $0.15/kwh

Mills College (11-Quart)



@ $0.15/kwh

Standard Countertop Soup Warmer vs Induction Lab Testing Data

69% Energy Reduction!

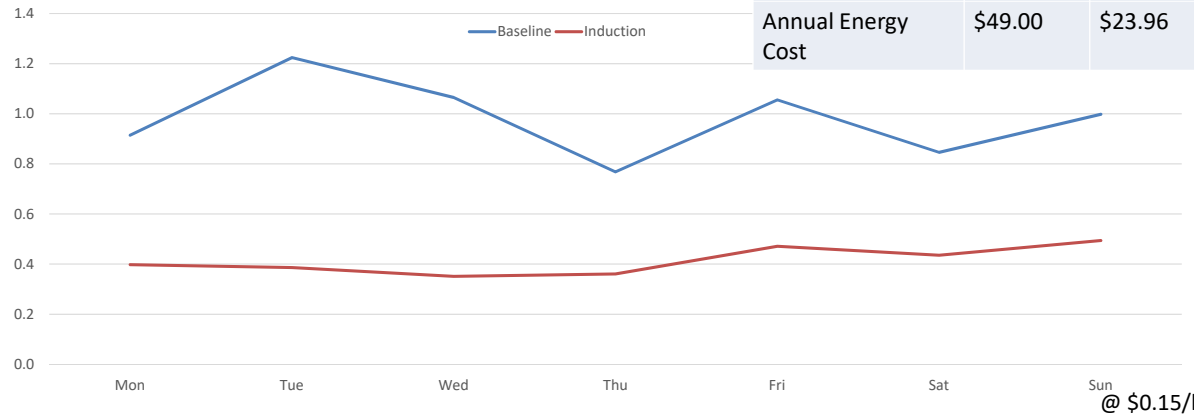
Wet Well holding rate: 339 W

Induction holding rate: 105 W

Direct Replacement Savings

- Café test site: replacement of baseline soup warmer with induction = 52% energy savings
- Client pleased with performance and noted ease of use

	Baseline	Induction
Average Daily Energy Use	0.90 kWh	0.44 kWh
Annual Energy Cost	$49.00	$23.96

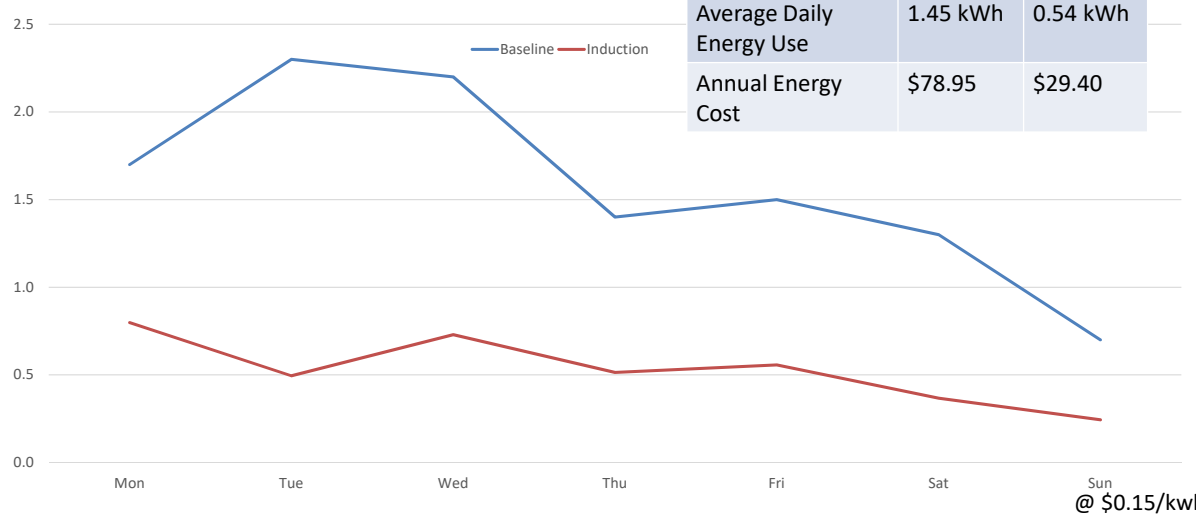


@ $0.15/kwh

Direct Replacement Savings

- College campus test site: replacement of baseline soup warmer with induction = 63% energy savings

	Baseline	Induction
Average Daily Energy Use	1.45 kWh	0.54 kWh
Annual Energy Cost	$78.95	$29.40

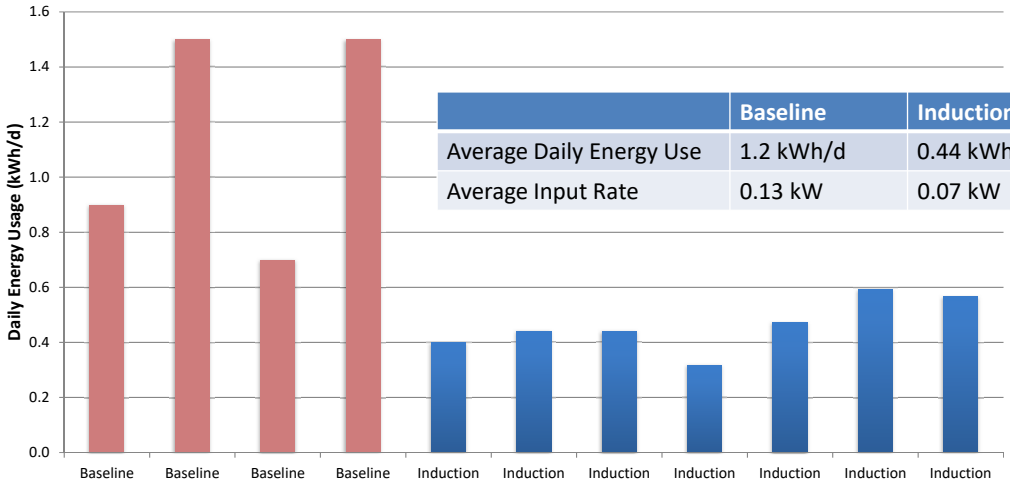


@ $0.15/kwh

Induction Potential

- Energy metering of four baseline soup warmers and seven induction soup warmers showed that induction units used 62% less energy than their wet well counterparts

	Baseline	Induction
Average Daily Energy Use	1.2 kWh/d	0.44 kWh/d
Average Input Rate	0.13 kW	0.07 kW



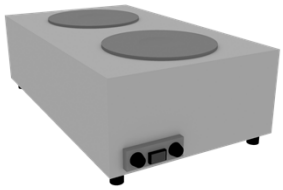
Induction Soup Warmer Savings Potential in a Fast Casual Restaurant

- **From 375 kWh/yr per soup well to 143 kWh/yr**
- **Times 12 soup wells**
- **Estimated savings = $420/yr**

@ $0.15/kwh

Other Energy Saving Alternatives?

How About Hot Plates?

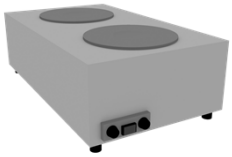


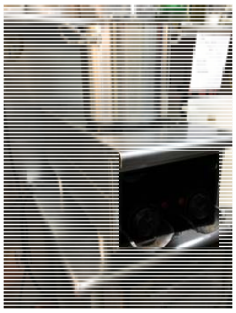
Induction in Other Applications

Café site: baseline electric hotplate to induction hotplate

- Energy use was reduced by 59%
- Estimated annual energy savings of about $600

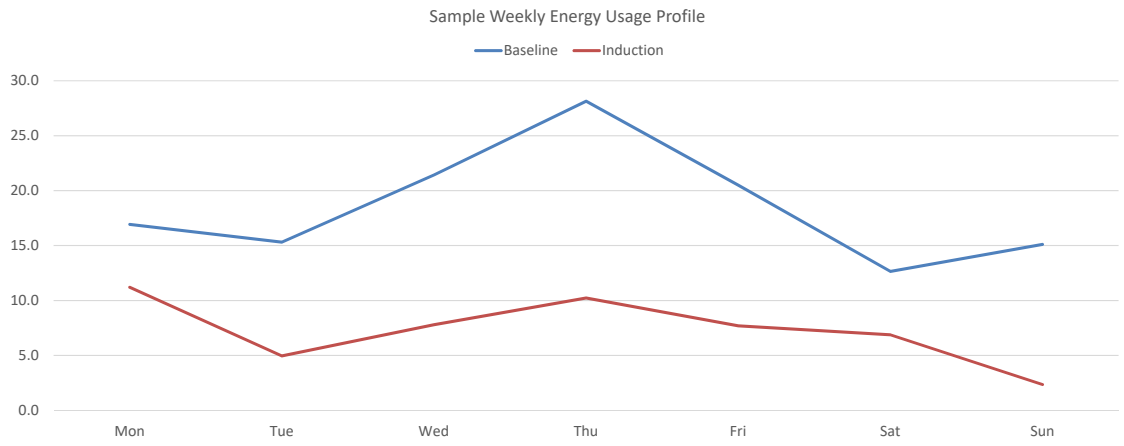
	Baseline	Induction
Average Daily Energy Use	18.2 kWh	7.4 kWh
Annual Energy Cost	$1000	$400



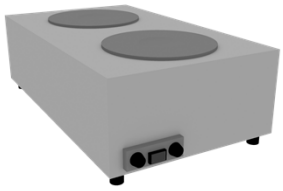


@ $0.15/kwh

Hotplate Energy Usage Comparison



Other Replacement Options

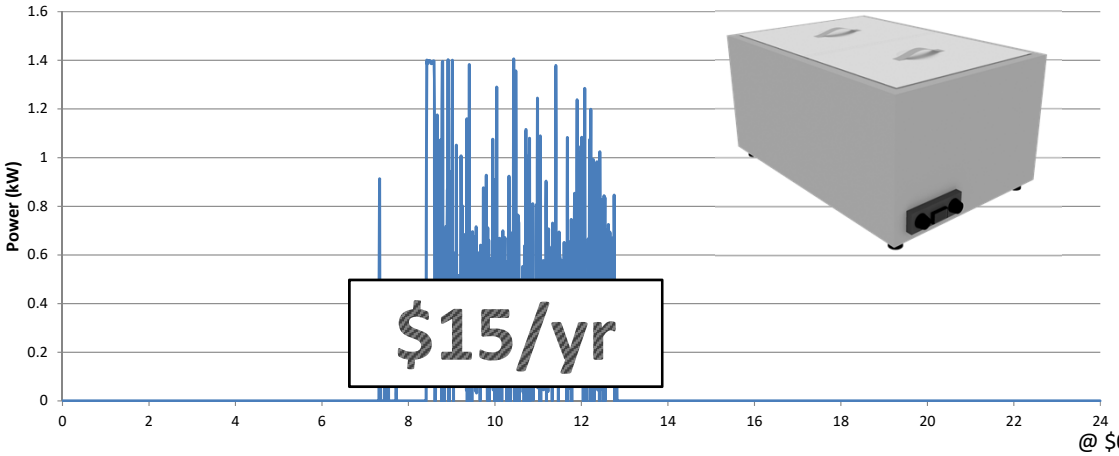


How About Wet Wells?

Big Range of Energy Use

Wet Well at Rebecca's Café

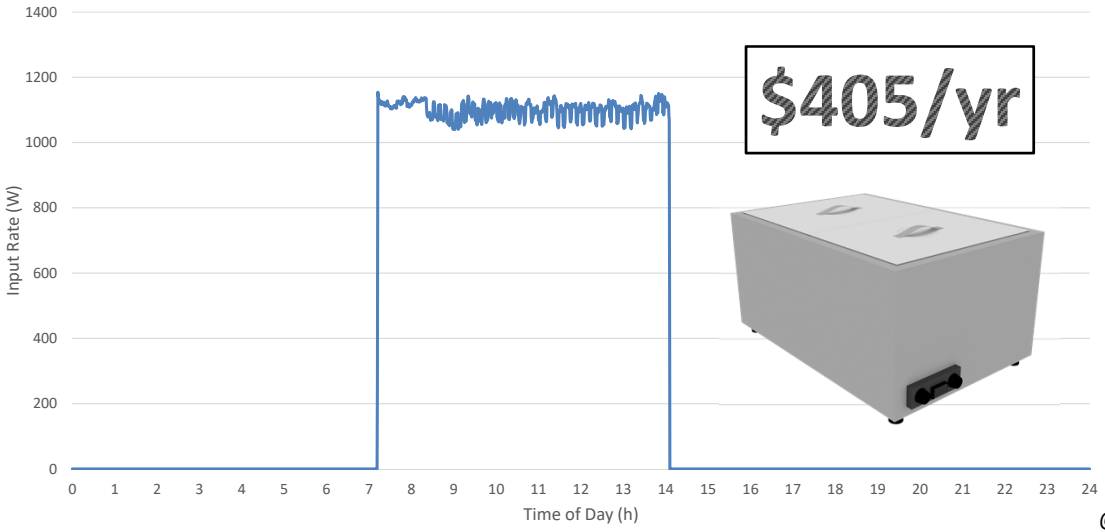
- Warmer rarely used (only 3 days out of the month monitored)
- Average energy usage of only 0.3 kWh/day across entire month



@ $0.15/kwh

Wet Well at Togo's Sandwich

- One of two 12" x 20" Warmers used every day

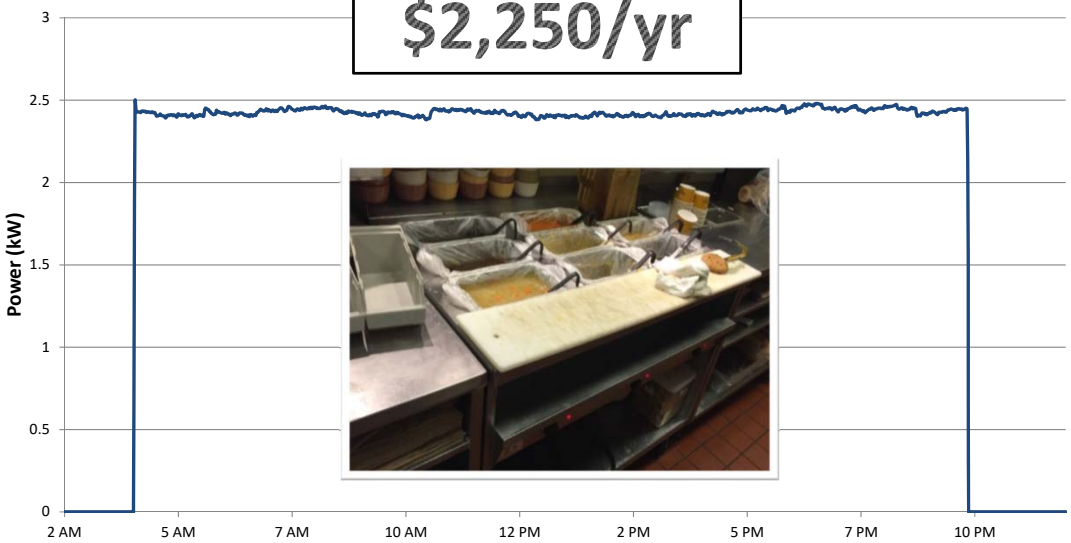


$405/yr

@ $0.15/kwh

Wet Well – Soup Station at Bakery/Café

$2,250/yr



Total for all 8 wells

@ $0.15/kwh

Dry Well: Potential Savings

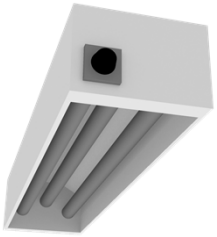
	Dry Well	Steam Well
Number of Wells	1	2
Total Product Volume (gal)	14	12
Preheat Energy (Wh/day)	570	4,156
Holding Energy (Wh/day)	13,125	25,350
Annual Energy Consumption (kWh/yr)	4,999	10,767
Annual Operating Energy Cost ($/yr)	$740	$1,615

@ $0.15/kwh

Solutions Better Than Dry Wells?

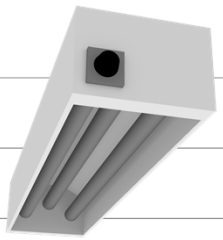
Induction Wells On The Way?

Heat Strips



Heat Strip – Over Product warming heaters

Mills College (Café)

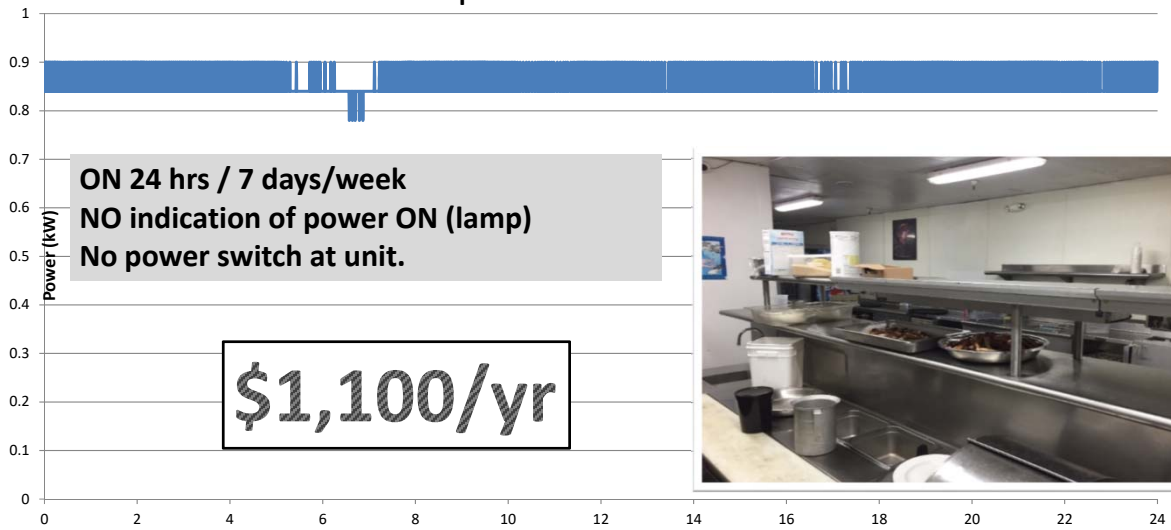


$350/yr

@ $0.15/kwh

Doubletree Hotel

4ft Heat Strip



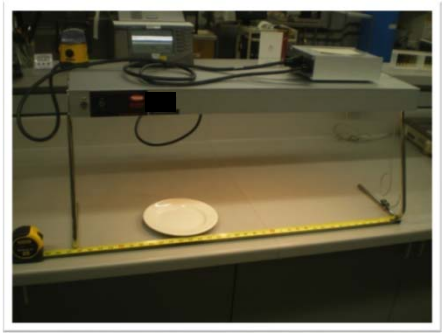
ON 24 hrs / 7 days/week
NO indication of power ON (lamp)
No power switch at unit.

$1,100/yr

@ $0.15/kwh

Replacement Options

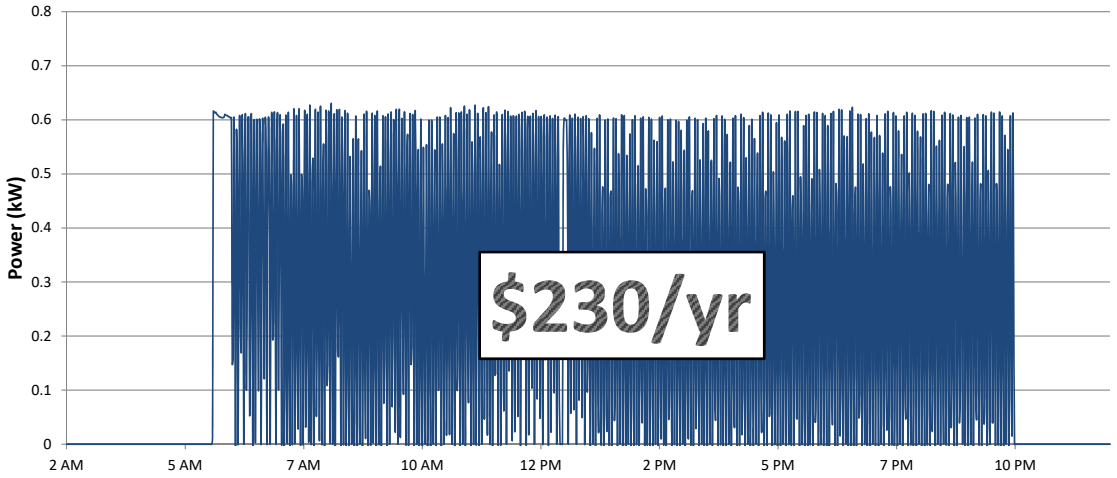
- **Behavioral changes can make a dramatic difference**
  - **(example: Doubletree)**
- **Heat strips with optical sensors**



Testing a Prototype

Bakery/Café Heated Shelf

Location	Baseline (kWh/d)	Replacement (kWh/d)
Bakery/Café	4.2	N/A

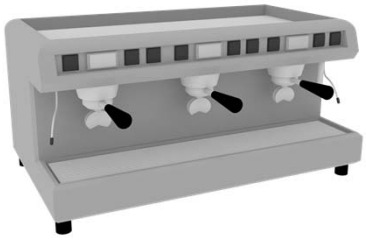


@ $0.15/kwh

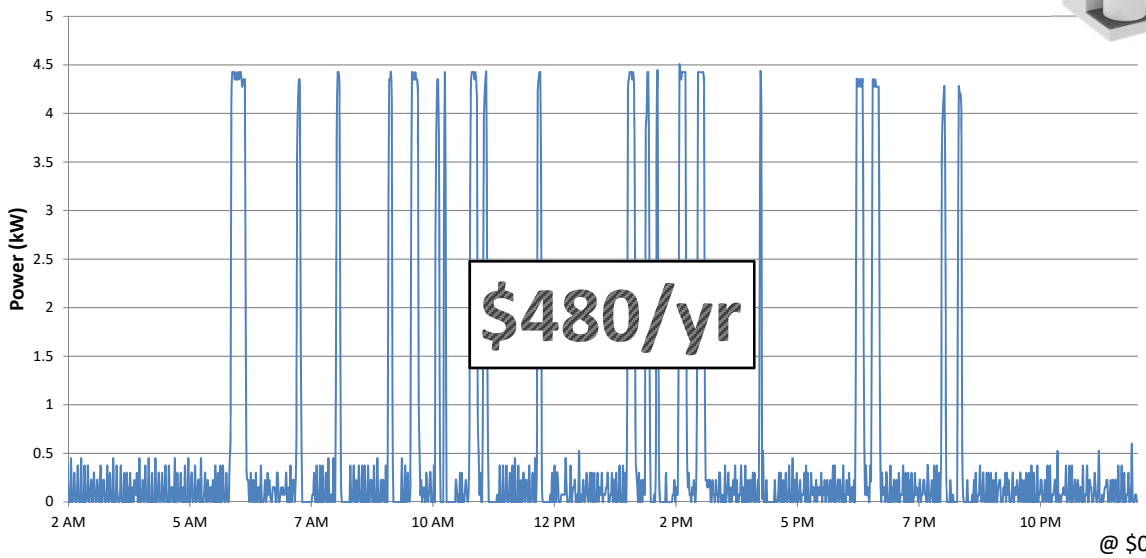
Replacement Options

Need to find options with an energy saving mode, likely using either optical or weight sensor. Suggestions?

Now, lets talk Coffee Makers

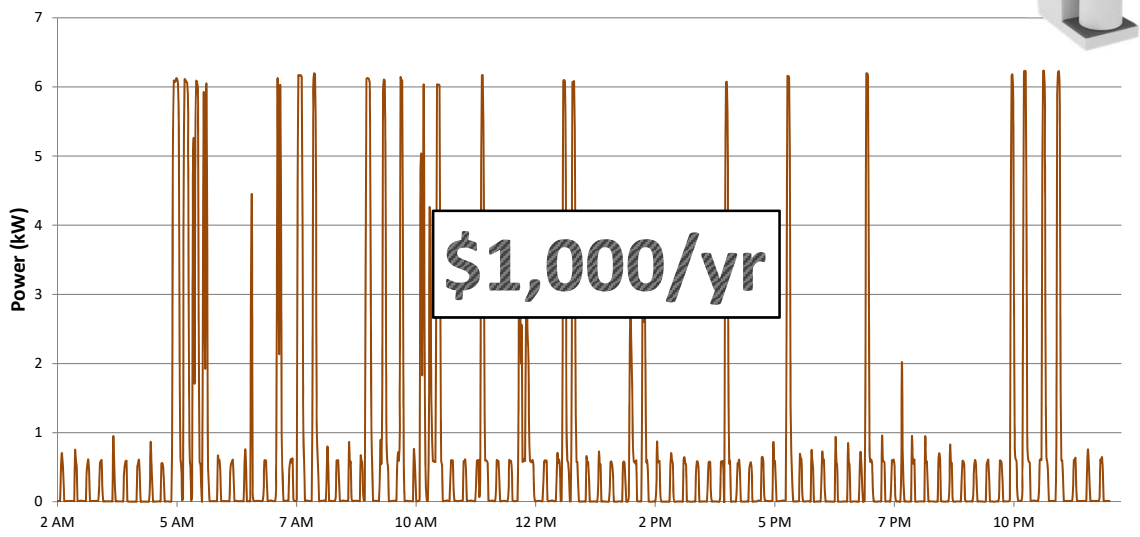


Mills College (Café)



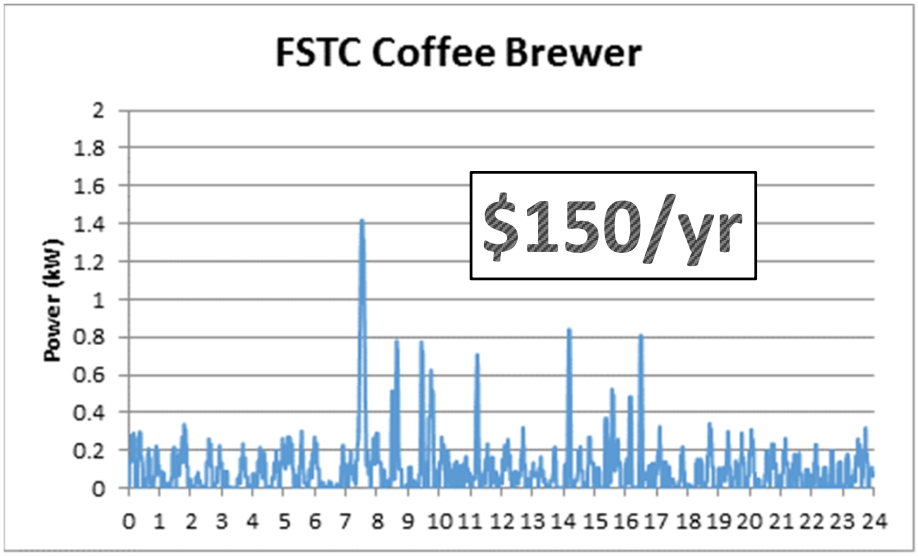
@ $0.15/kwh

Bakery/Café



@ $0.15/kwh

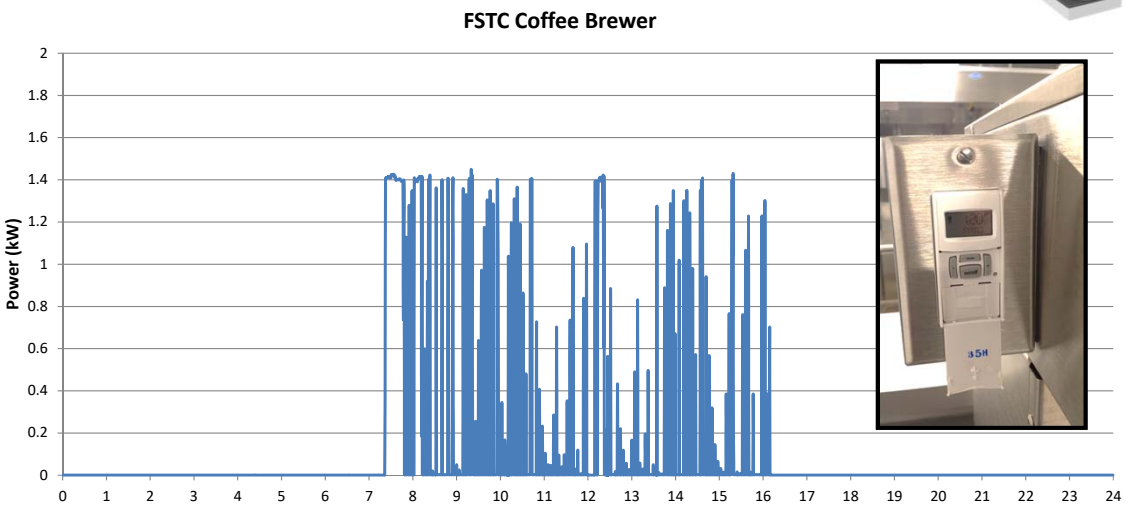
FSTC: Baseline



@ $0.15/kwh

FSTC: Replacement

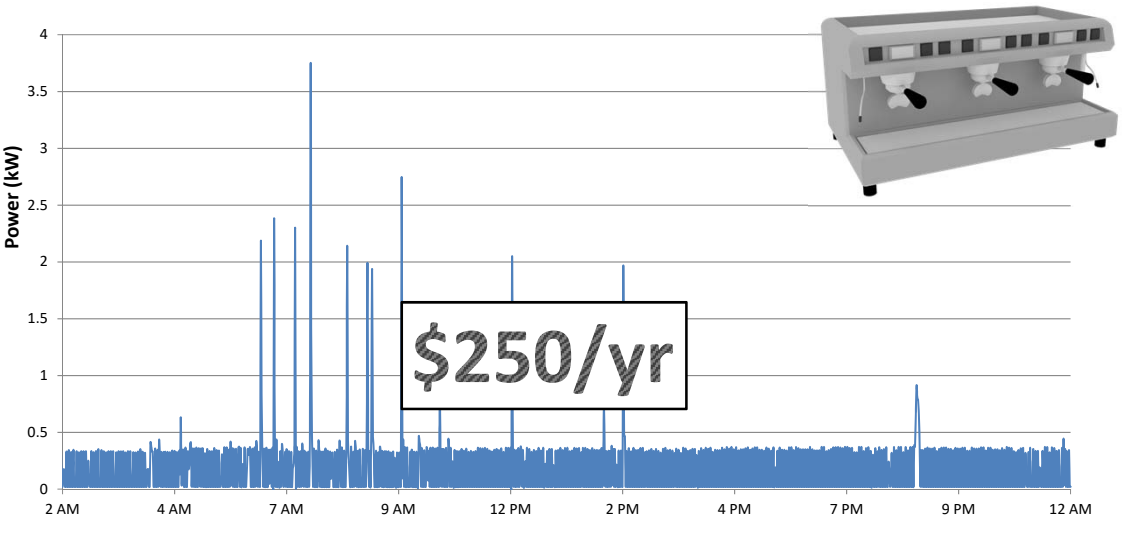
Same model, controlled with Off/On timer



Baseline vs Replacement

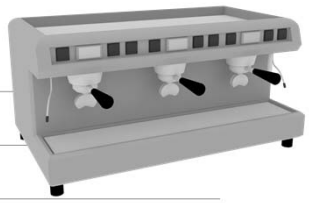
- Timer controlled On/Off resulted in idle energy savings, about 12% of the total energy usage
- Using mfg. energy savings mode there was crew dissatisfaction delay of 30 mins for first pot of ready to drink coffee.
- Controls work best with behavior-change based training

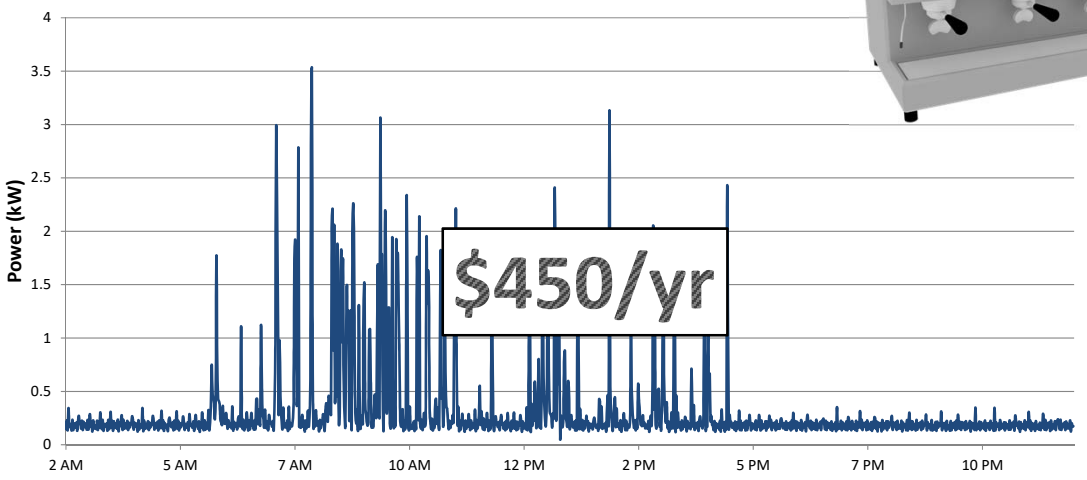
Bakery/Café



@ $0.15/kwh

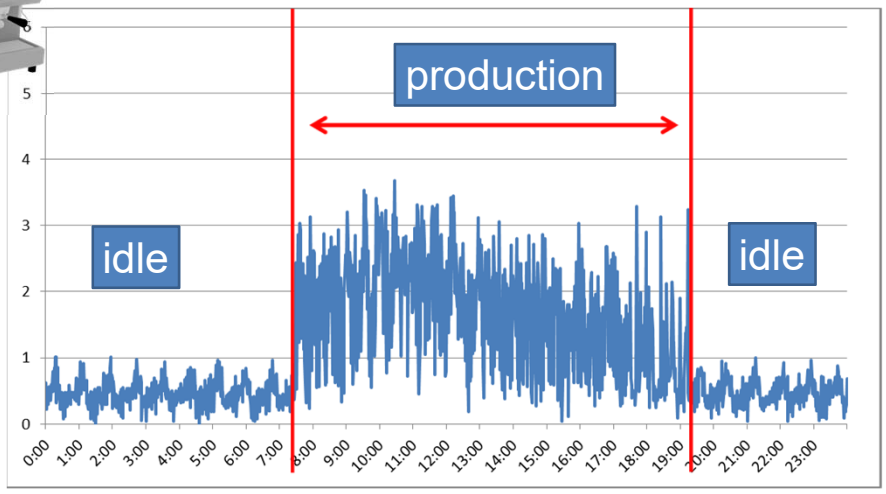
Mills College (Café)



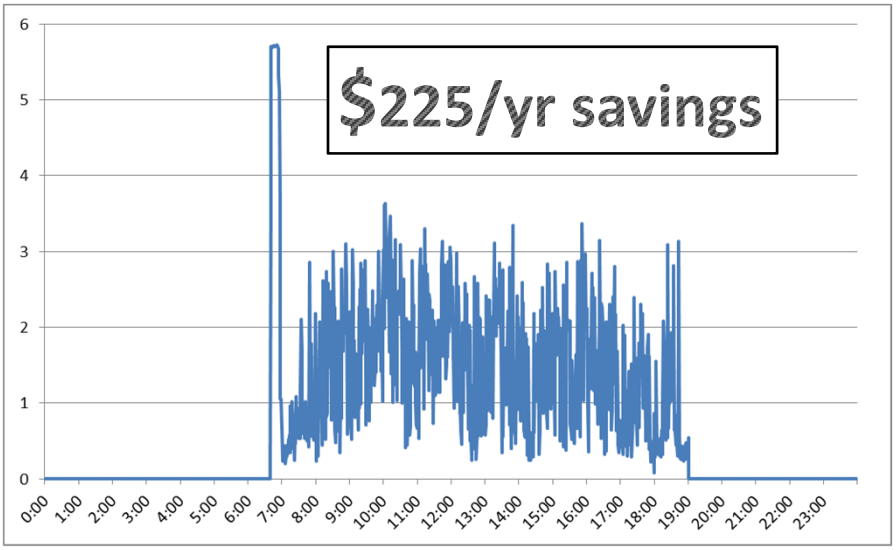


@ $0.15/kwh

Espresso Machine Challenge – Always ON

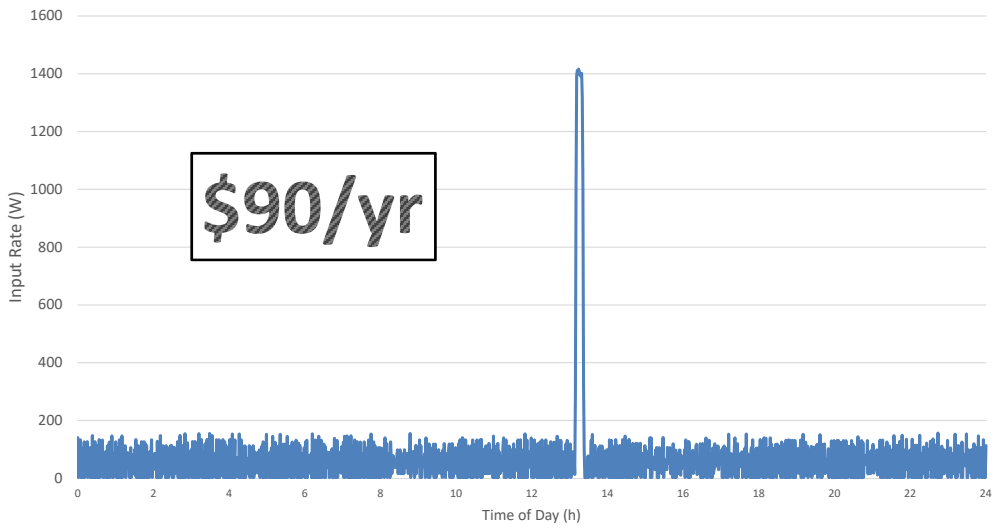


Espresso Machine Controlled with Internal Timer
Cut Energy Cost by 33%



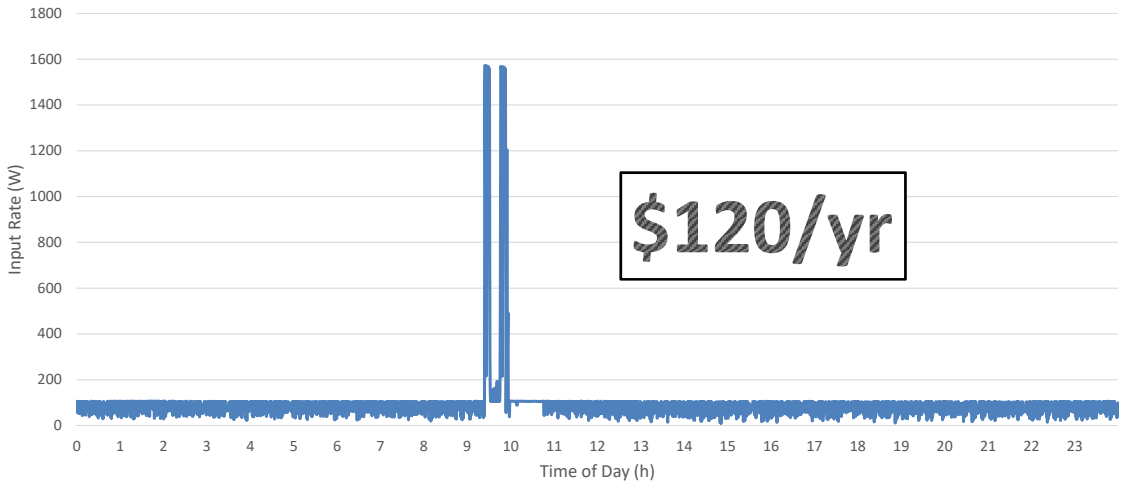
Tea Brewers on the other hand…

Mills College (Café)



@ $0.15/kwh

Togo's Sandwich

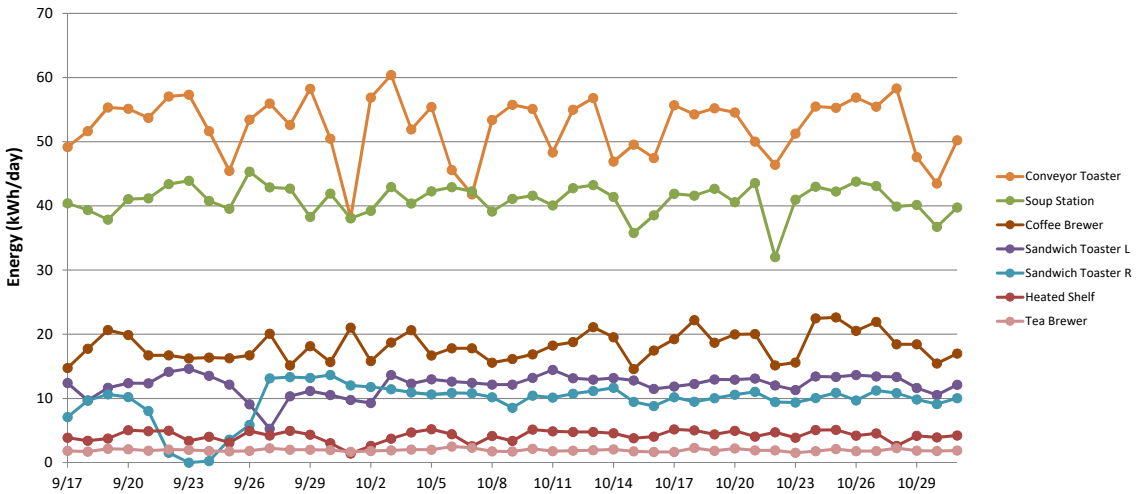


@ $0.15/kwh

Options Besides Timer or Energy Save Mode?

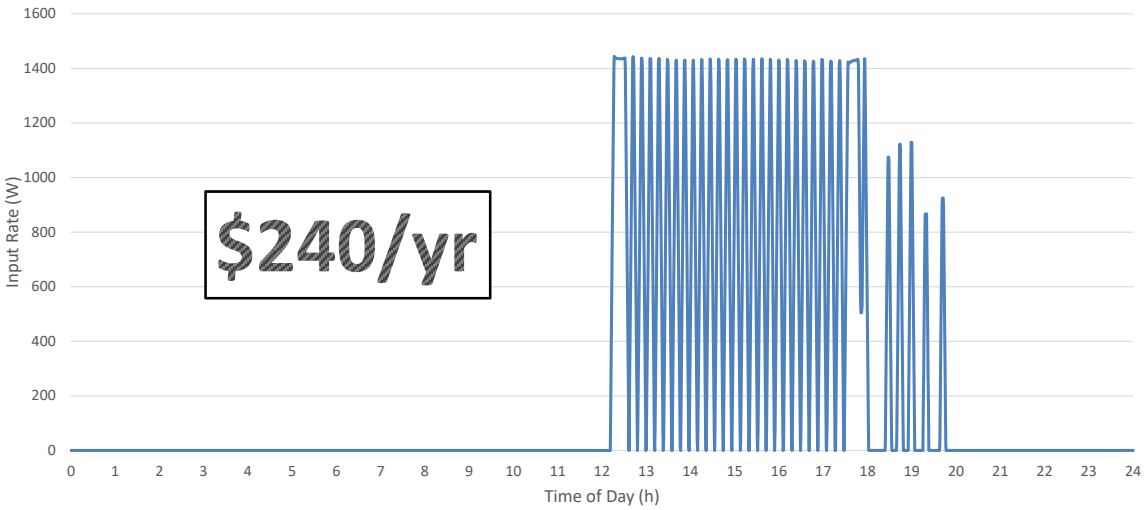
Relative Appliance Energy Usage

- At Bakery/Café



Panini Grills

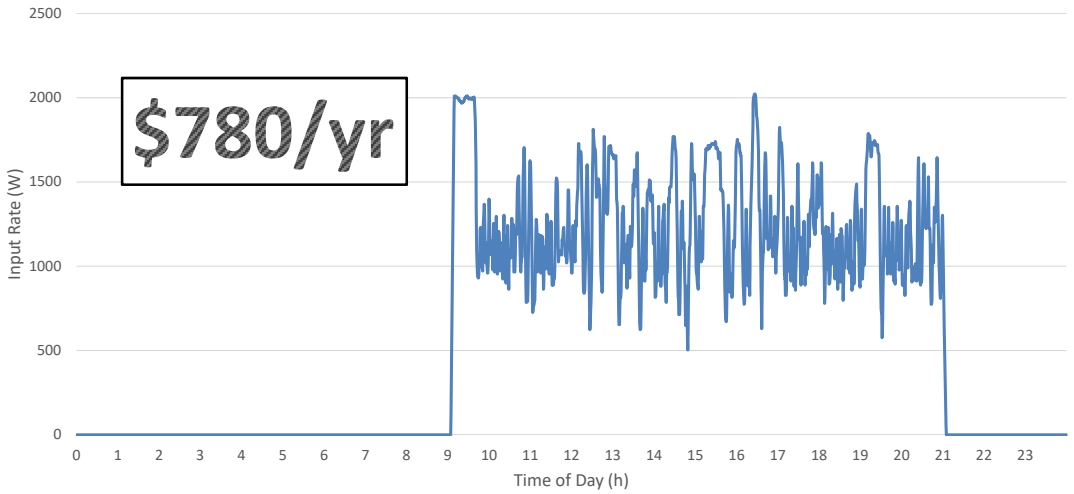
UC Berkeley



$240/yr

@ $0.15/kwh

Togo's Sandwich

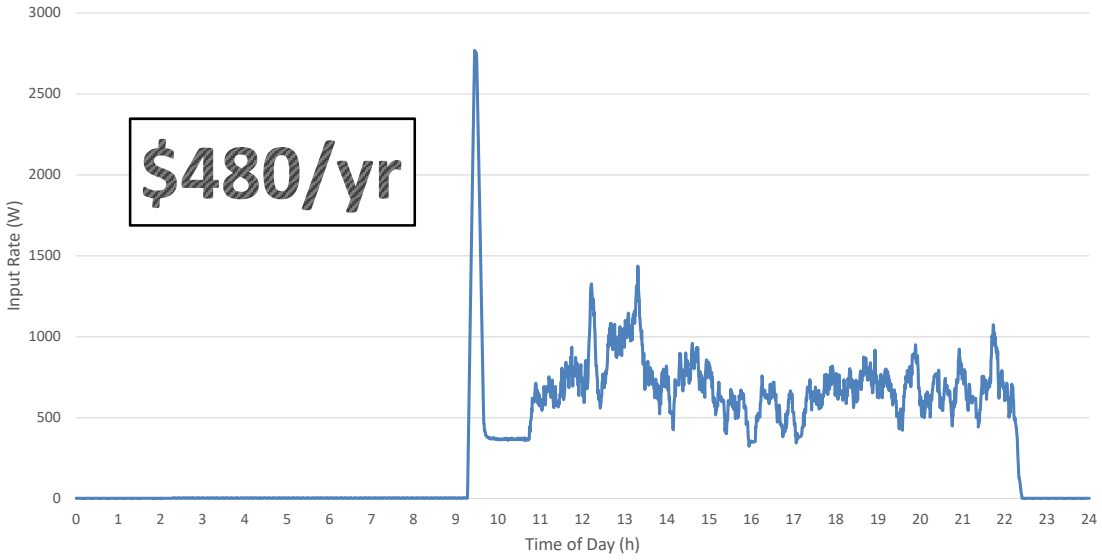


@ $0.15/kwh

What Does a Efficient Panini Grill Look Like?

Tortilla Warmers

Chipotle

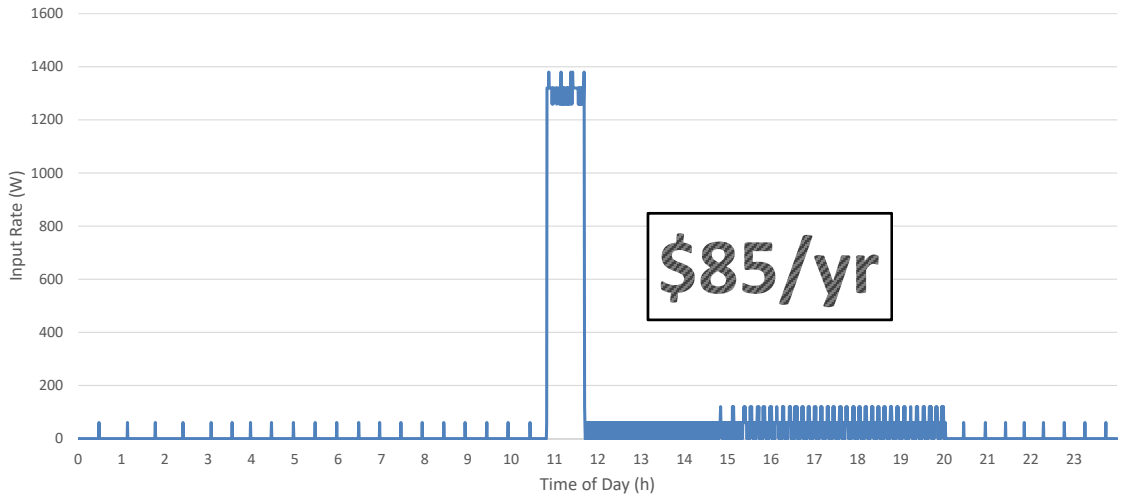


@ $0.15/kwh

Efficient Tortilla Warmers?

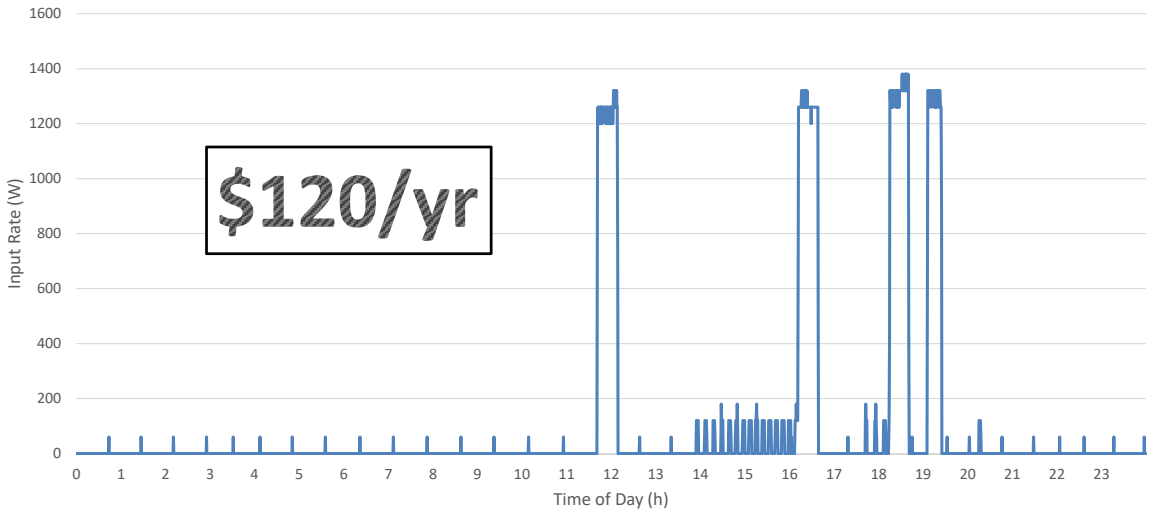
Rice Cookers

Lin Jia Asian Kitchen



@ $0.15/kwh

Lin Jia Asian Kitchen



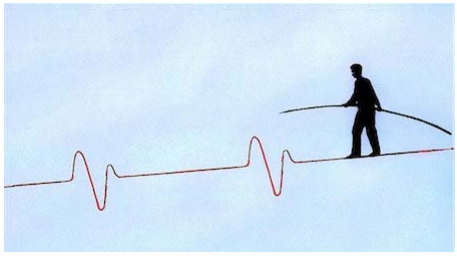
@ $0.15/kwh

Innovative Technologies?

And a Few Replacements Made!

Appliance Type	Number of Units Replaced /Modified	Baseline		Replacement		Savings from Direct Replacement
		Total Average Daily Energy Usage (kWh/day)	Normalized Energy Usage Rate (kW)	Total Average Daily Energy Usage (kWh/day)	Normalized Energy Usage Rate (kW)	
Coffee Brewer	2	2.0	0.25	1.0	0.18	50%
Conveyor Toaster	2	31.6	2.43	18.3	1.80	42%
Hotplate	1	18.2	2.17	7.4	1.54	59%
Soup Well	2	1.2	0.15	0.5	0.08	58%

Project Challenges



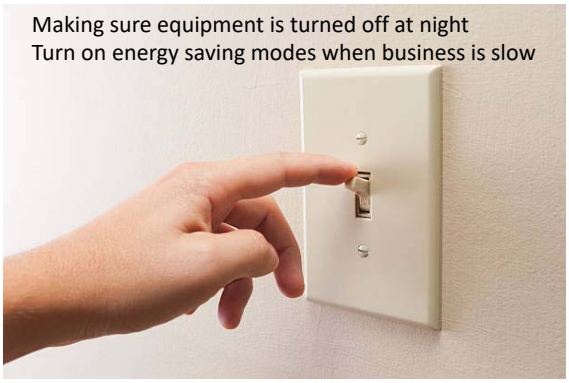
- Difficult to change operator usage
- Savings per appliance relatively small - owner/operator looking for BIG dollar savings.
- Finding equipment technology to reduce idle (non-production) energy and without affecting speed of service – limited options!
- Kitchen management systems difficult to implement for small stores

Current Project Status

- Completed Field M&V validation at five sites
- Installed replacement toasters, soup wells, and hot plates
- Continue working with equipment manufacturers to acquire replacement appliances
- Expanding baseline locations
- Project continues until 2020

Behavioral Changes

Behavior can have a significant impact on plug load energy use – next study?



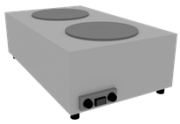
notes

- Could add panini grills and tortilla warmers
- Have holding cabs for baselines but no replacements yet –
- See the findings/conclusions section
- See sidebar with list of different appliances – all the ones they have already looked at.

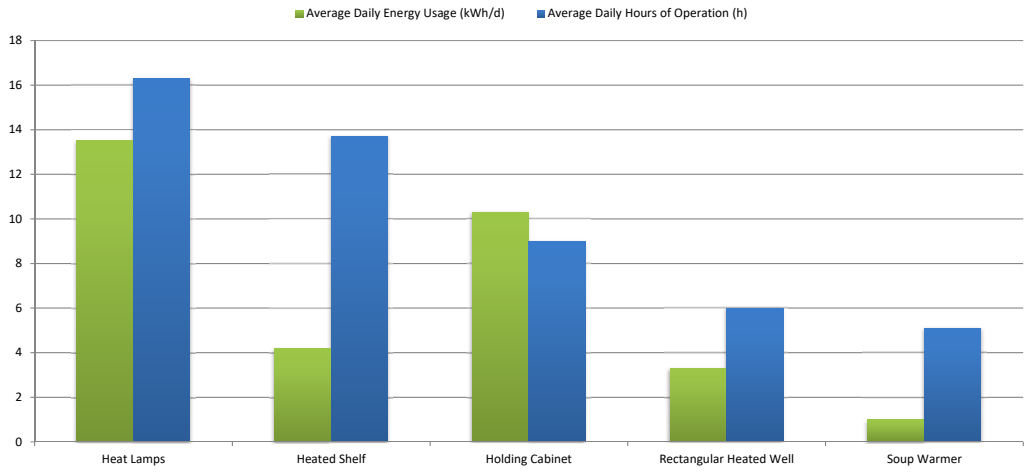
notes

- Look at plug load ops – different for dif places. Cost can be big relative to cost of equipment
- Add some costs to the energy profile slides
- Add espresso idle cost savings slide
- Turn on and off with controls could be big as many are left on 24/7 – IoT?
- Discussion?
- Ask for equipment and locations – study wraps in 2020 - looking for dry wells, holding cab, heated shelves, heat strips, new tech
- Change from kwh/day/year to kwh/day or kwh/y

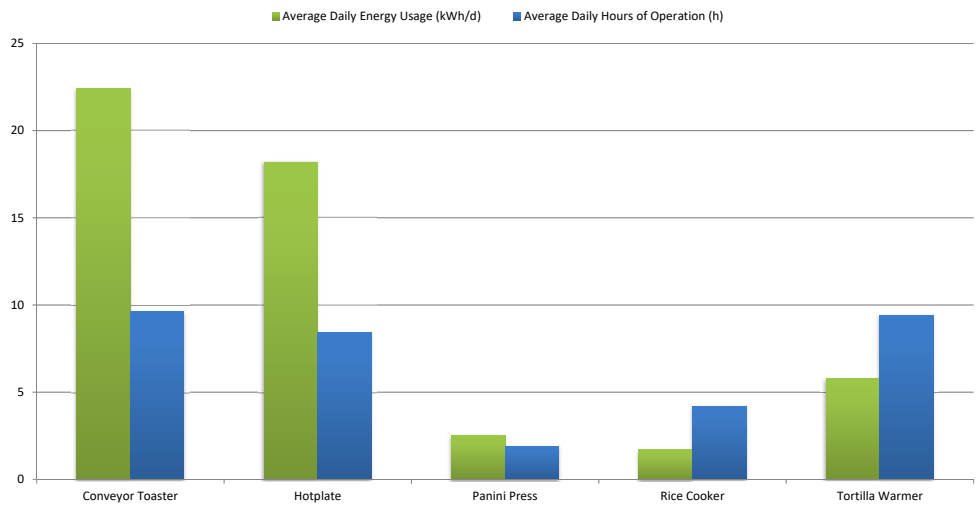





Energy Use Comparison of Holding Equipment



Energy Usage Comparison of CFS Heating Equipment



Energy Usage Comparison of CFS Beverage Equipment