

ElectriSense

Using EMI for Electrical Energy
Disaggregation in the Home

Sidhant Gupta





Electrical energy disaggregation in the home using a single sensor



SAFeway

SAVE MORE AT SAFEWAY

GROCERY

SFWY PRZLE STICK		1.50 B
ResPrice 1.79	CardSav .29	3.79 B
BLKBERY PRES		2.39 B
SFY CANDLA OIL		3.69 B
CEREAL PNT BUTTER		3.29 B
CHILI SAUCE SWT		3.79 B
CHF-B PIZZA		3.29 B
LK GRCL SCE		

REFRIG/FROZEN

LUC CHEESE		4.99 B
ResPrice 6.79	CardSav 1.80	2.50 B
SPINACH ARTICHOKE		
ResPrice 3.79	CardSav 1.29	2.50 B
35 CRVN VEG RSTD		
ResPrice 3.79	CardSav 1.29	5.00 B
282.50 SFVY SEL MEDALL FC		
ResPrice 7.58	CardSav 2.58	2.89 B
MARGARINE		

GEN MERCHANDISE

SFWY BENEHIST TAB		7.99 T
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BAKED GOODS

LD COSMIC BROWNIES		1.29 B
OROWEAT RYE		3.14 B
CUSTARD PIE 9IN		4.99 B
ResPrice 5.99	CardSav 1.00	4.99 B
CHOC CREAM PIE		
ResPrice 5.99	CardSav 1.00	

**** TAX	6.26	RAL	144.25
VF MC XXXXXXXXX			144.25

CHANGE		.00
TOTAL SAVINGS	16.97	
NUMBER OF ITEMS	35	



SAFeway

SAVE MORE AT SAFEWAY

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MARGARINE	

GEY

RSFY BENEHIST TAB

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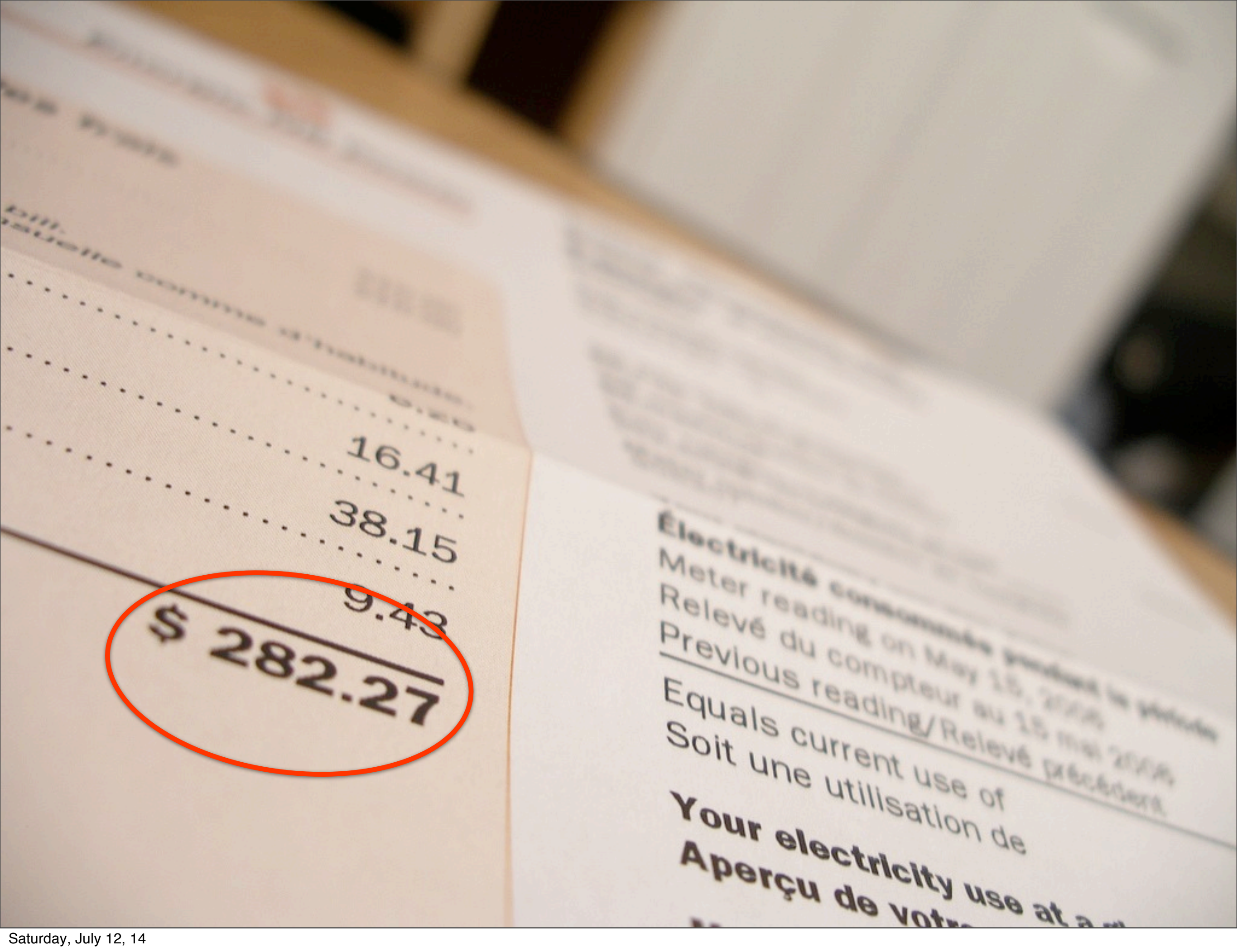
SAVE MORE AT SAFEWAY

Month: April 2006

Total Food Units: 1527

Total Price:

\$527



\$ 282.27

Électricité consommée pendant la période
Meter reading on May 15, 2024
Relevé du compteur au 15 mai 2024
Previous reading/Relevé précédent
Equals current use of
Soit une utilisation de
Your electricity use at a glance
Aperçu de votre

The background is a close-up, slightly blurred photograph of a vintage energy meter. It features several circular dials with numbers, some of which are clearly visible (e.g., 109, 90, 8, 7, 6, 5, 4, 3, 2, 1). Below the dials is a label with technical specifications: "CL 200 240V 3W" and "TYPE JSC". At the bottom, a large number "DE 435462" is visible. The overall tone is sepia or aged black and white.

Energy usage is
vastly misunderstood



Overestimate '**visible**' energy

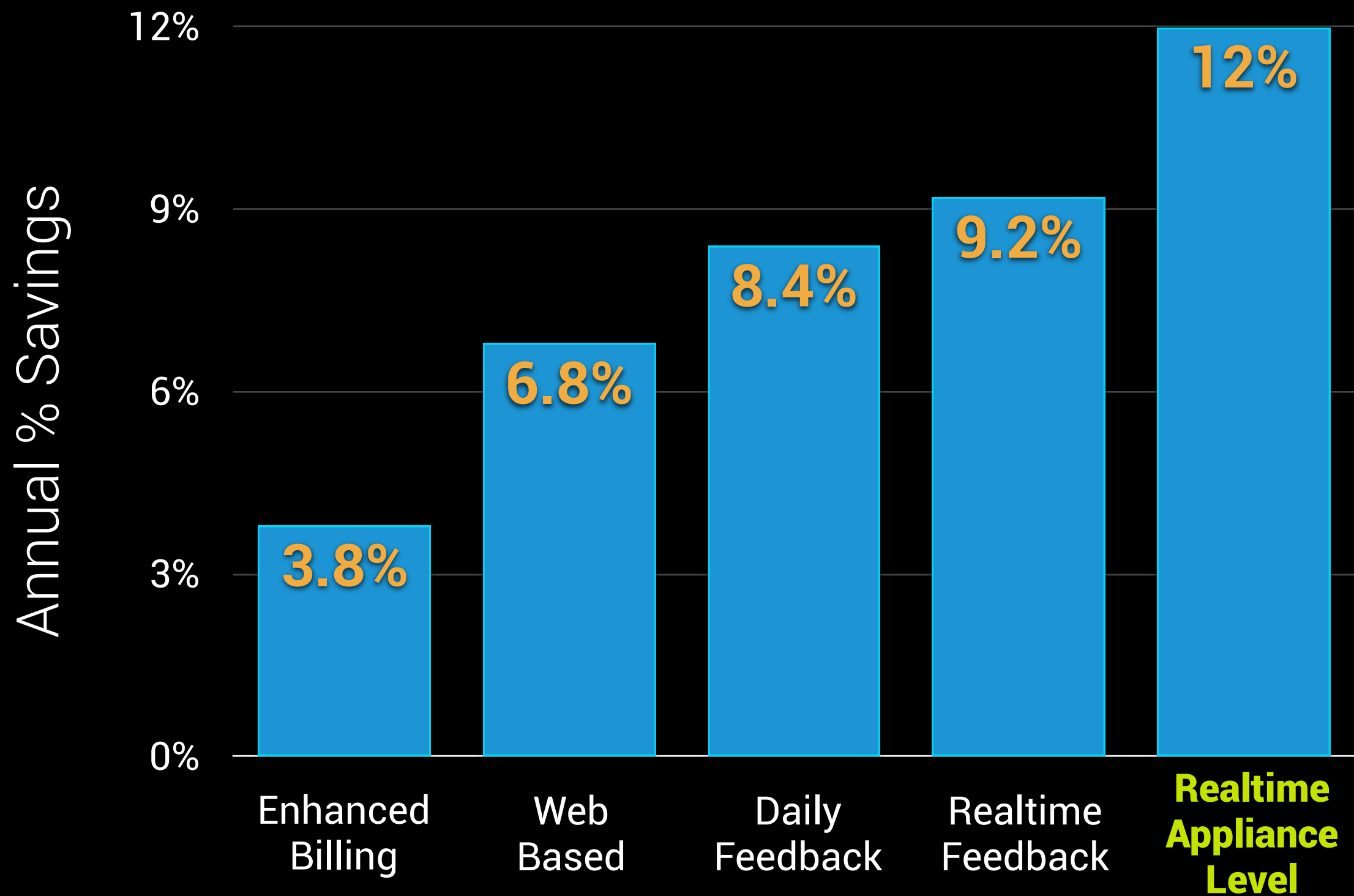


Consumers **incorrectly believed** they could save 2X more energy by reducing **lighting** rather than **hot water** usage

400 homes survey by *Kempton et al.*



Lack of appropriate feedback



Based on 36 studies between 1995-2010. Summarized by *Ehrhardt-Matinez et al.*

Aggregate Energy Usage



Aggregate Energy Usage

\$264

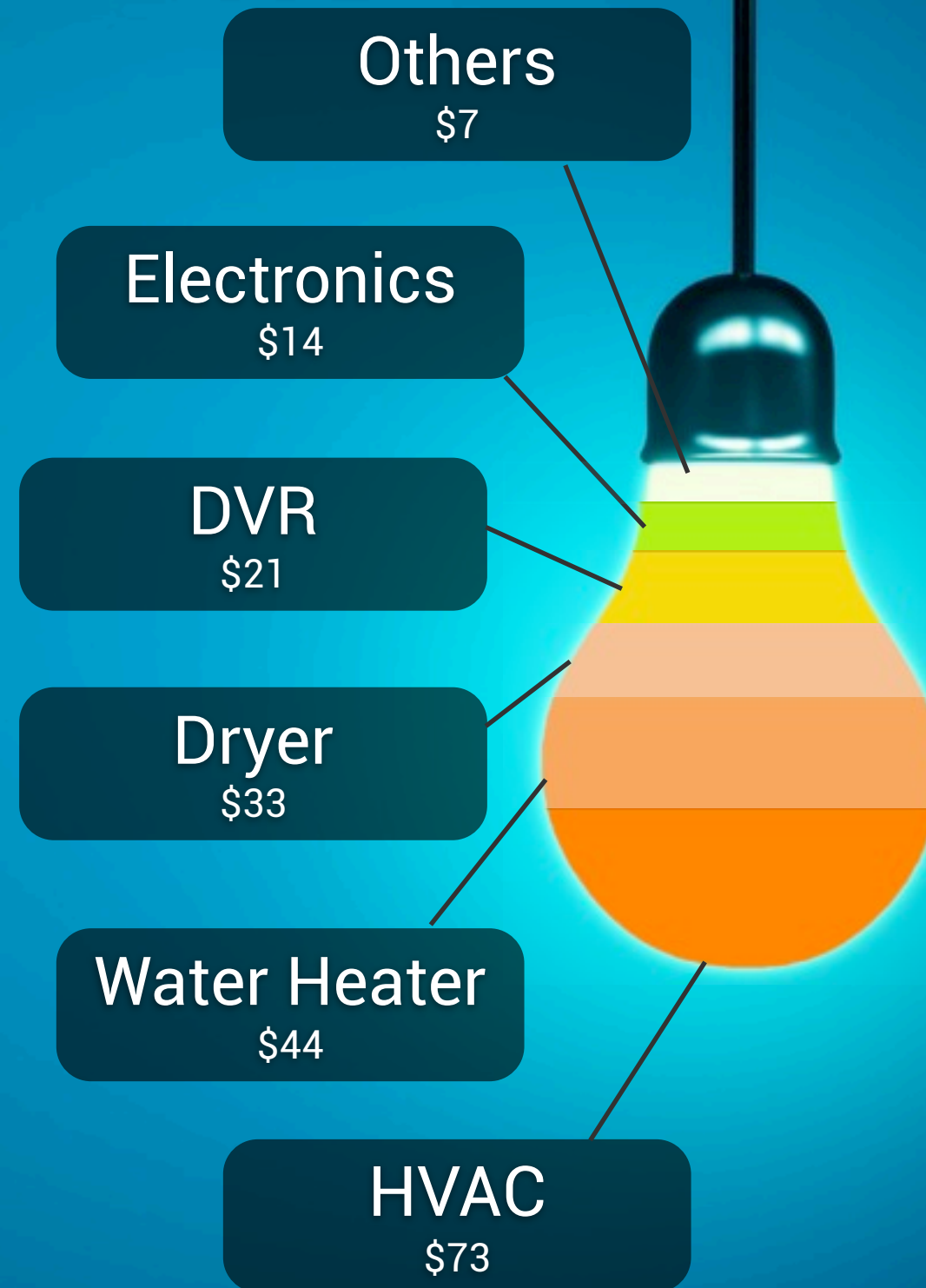




Disaggregated Energy Usage



Disaggregated Energy Usage





**not just 'visible'
energy uses**



Electricity

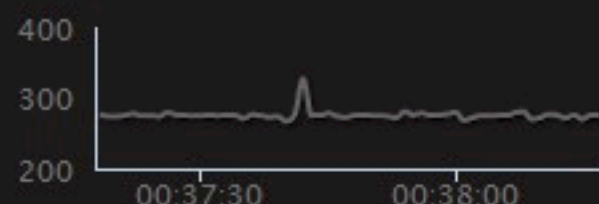
Saturday February 2 | 0:38

\$319.18 / **1081.3** kWh used this month

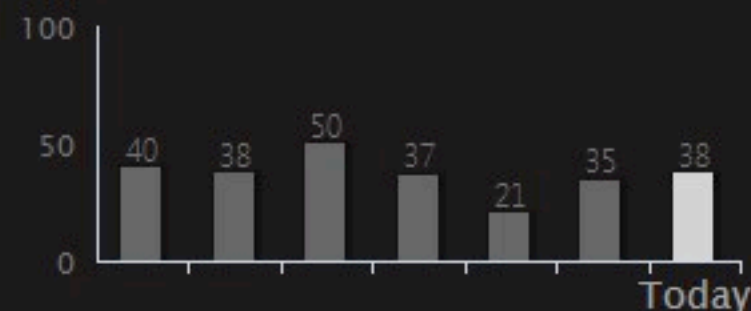
Currently
Using

270 W

Usage in
Past 1 Min

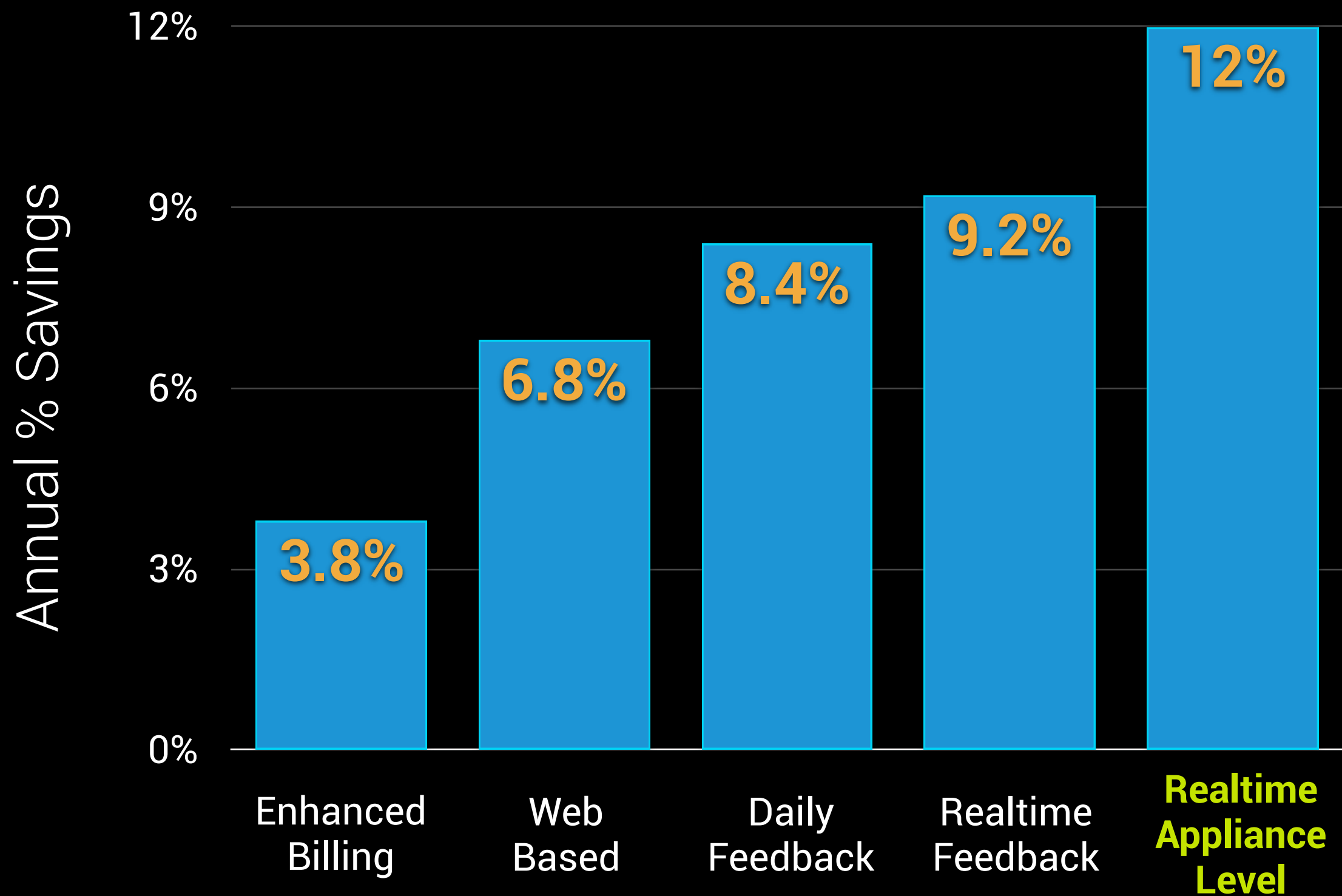


Usage Over
Last 7 Days
(kWh)

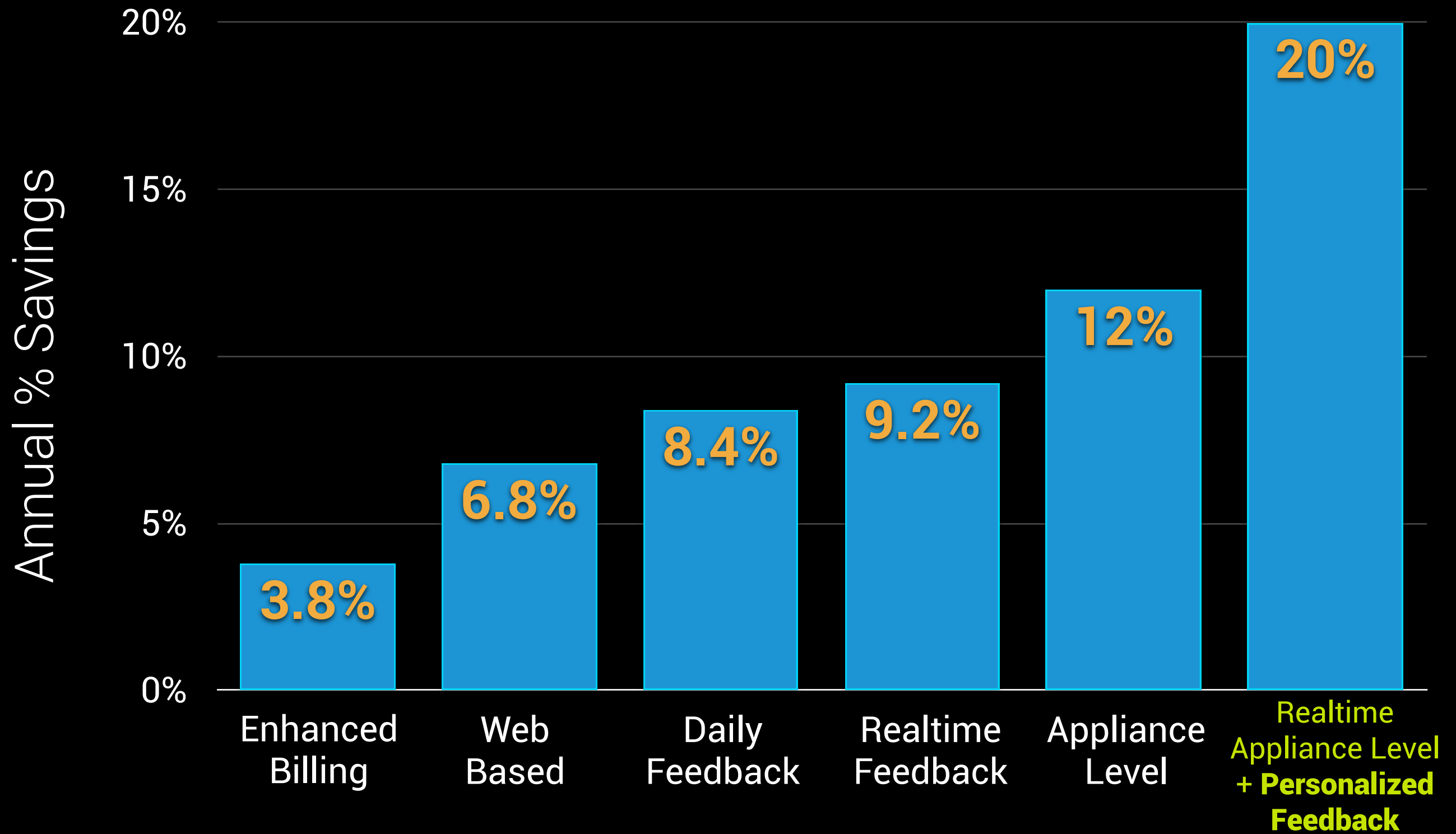


Usage Details

Pool Pump	<input type="radio"/>	32%	Master Bedroom Lights	<input type="radio"/>	5%
DVR	<input type="radio"/>	11%	HVAC Fan	<input type="radio"/>	5%
Kitchen Fridge	<input checked="" type="radio"/>	7%	Living Room TV	<input checked="" type="radio"/>	3%
Kitchen Light	<input type="radio"/>	6%	Dish Washer	<input type="radio"/>	3%
Master Bedroom TV	<input type="radio"/>	5%	Sy's Laptop	<input type="radio"/>	3%
Garage Fridge	<input type="radio"/>	5%	Living Room PC	<input type="radio"/>	2%
Varsa's PC	<input type="radio"/>	5%	Others	<input checked="" type="radio"/>	8%



Based on 36 studies between 1995-2010. Summarized by *Ehrhardt-Matinez et al.*



>20% reduction: *Gardner et al. (2008) and Laitner et al. (2009)*

Your Energy Efficiency Report



In partnership with
Belkin International, Inc.
PO Box 88888888
Cityname, ST 88888-8888

This report tells you specifically how your electricity was used last month, and suggests ways to save.

CHAD SINGER
2216 S. BENTLEY AVE #9
LOS ANGELES, CA 90064

Your billing period	Total Cost	Compared to last bill	Compared to Similar neighbors*
Sep 1 - Sep 28, 2011	\$161.68	↓ \$56.98 less (26%)	Similar



You reduced the amount of power used for air conditioning by 76% last month!

- That's 33% lower than that of similar neighbors!*
- If you maintain this level of usage, you'll save an estimated \$271 this year.



Your dishwasher used 53% more energy this month than your neighbors'.

- You could save up to \$180 a year by upgrading to an efficient dishwasher.
- If you find you often want to run the dishwasher before it is full, try the rinse-only feature common on newer models.

Your top energy consumers	Estimated Cost**	Compared to last bill	Compared to similar neighbors*
Electric Water Heater	\$31.50	↑ \$8.12 (26%)	similar
★ Air Conditioner	\$29.82	↓ \$48.23 (76%)	😊 33% lower
Refrigerator	\$22.66	similar	11% higher
Lighting	\$13.90	↓ \$14.06 (53%)	😊 21% lower
⚠ Dishwasher	\$11.55	similar	⚠ 53% higher
Stove	\$10.01	↑ \$0.61 (5%)	6% lower
Dryer	\$7.56	↑ \$0.63 (11%)	similar
Clothes Washer	\$3.66	↓ \$0.09 (4%)	similar

THINGS YOU CAN DO RIGHT NOW TO IMPROVE YOUR EFFICIENCY

Target 68°

Save more on heating costs this winter. Setting your thermostat a few degrees lower will really add to your savings.

Insulate your water heater

Adding an insulating blanket to your water heater can reduce standby heat losses and save water heating costs.

Courtesy: Belkin, Inc.

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THINGS YOU CAN DO RIGHT NOW TO IMPROVE YOUR EFFICIENCY

Courtesy: Belkin, Inc.

Real-time Appliance Level Personalized Feedback

How to Sense Appliance Level Energy Usage?





microwave





refrigerator



microwave



*coffee
maker*



refrigerator



microwave



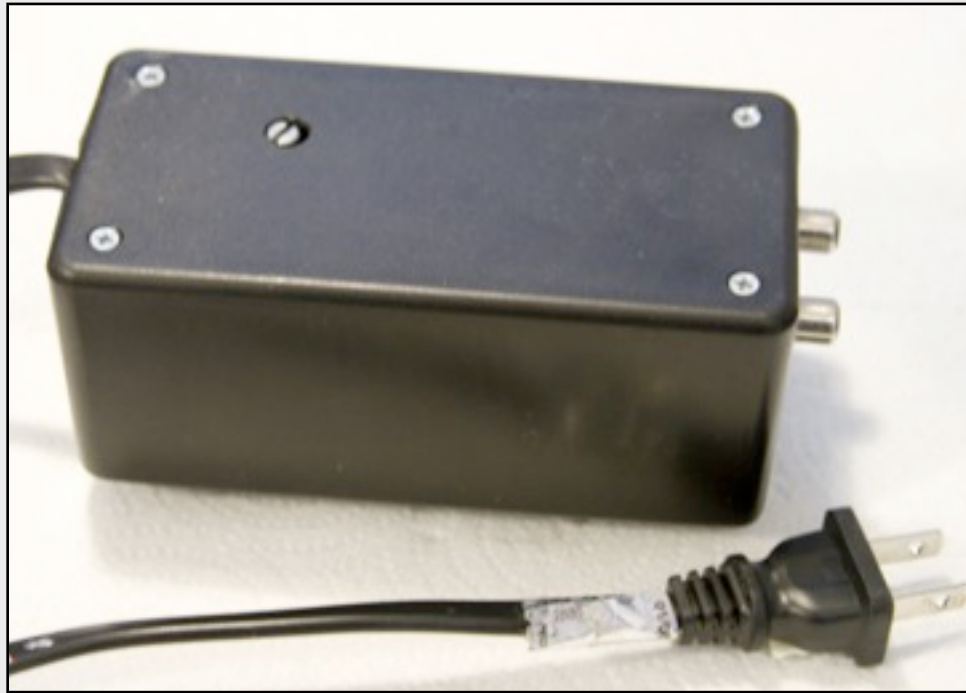


*coffee
maker*

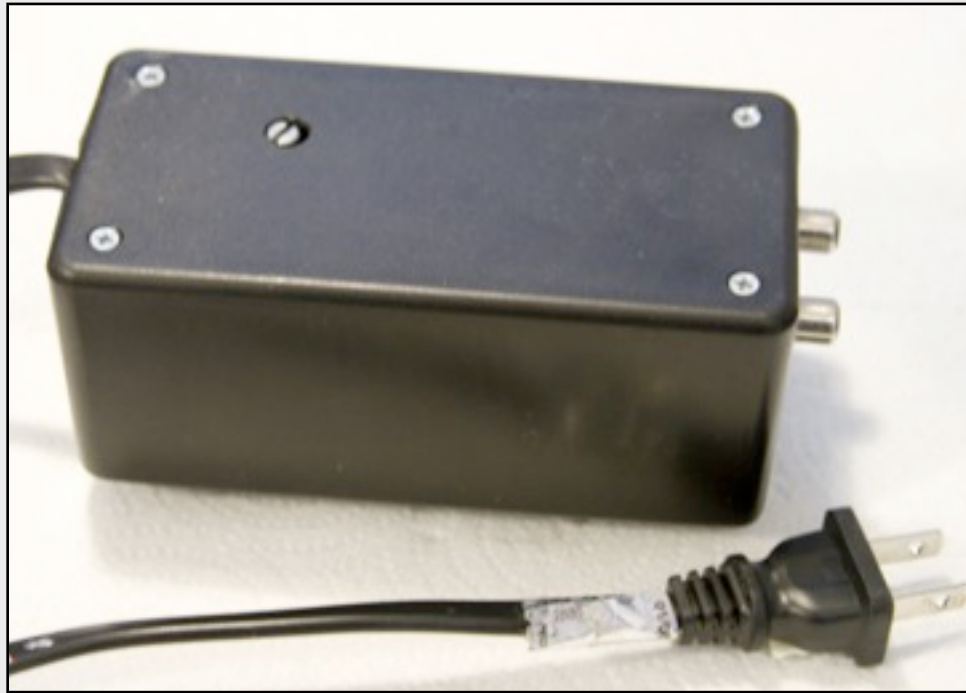
refrigerator

microwave

ElectriSense: Single Sensor



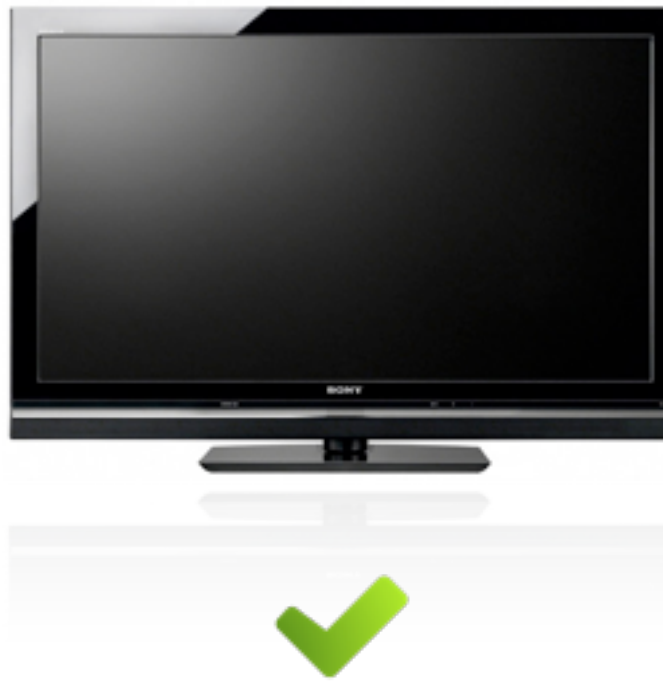
ElectriSense: Single Sensor

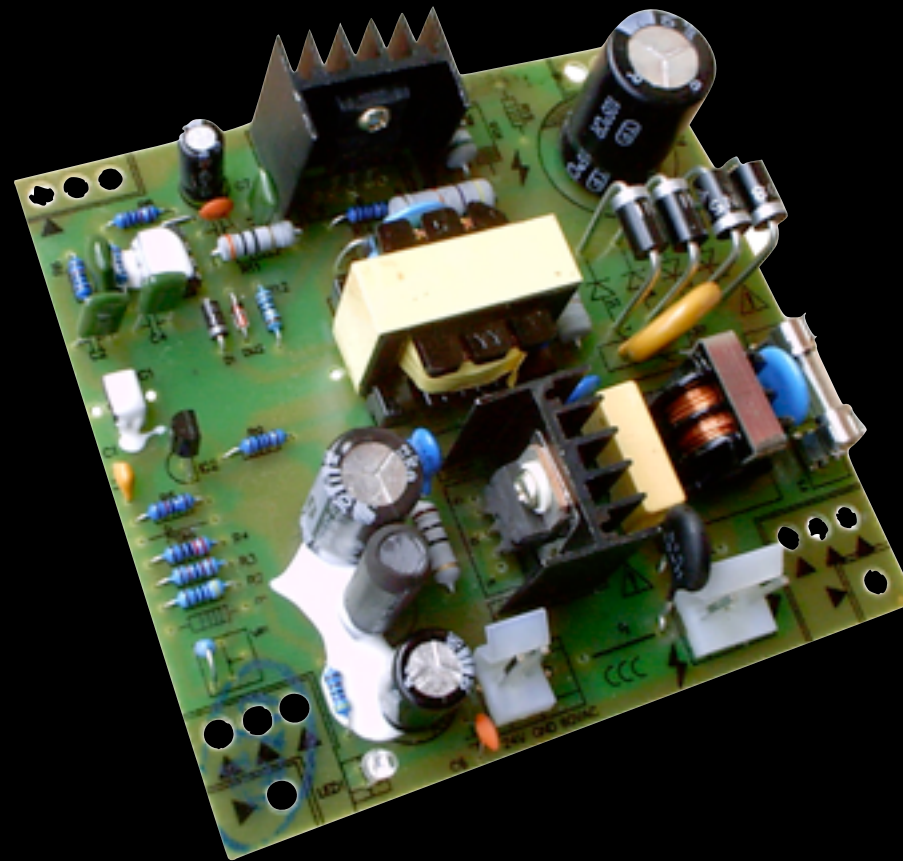


Leverage Noise From Electrical Appliances

Switched Mode Power Supply

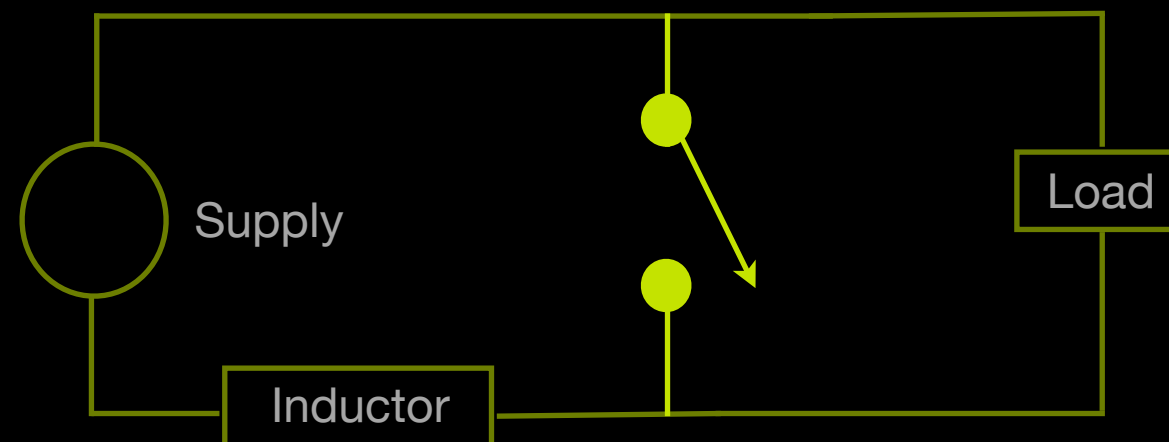
SMPS based appliances are becoming
increasingly prevalent



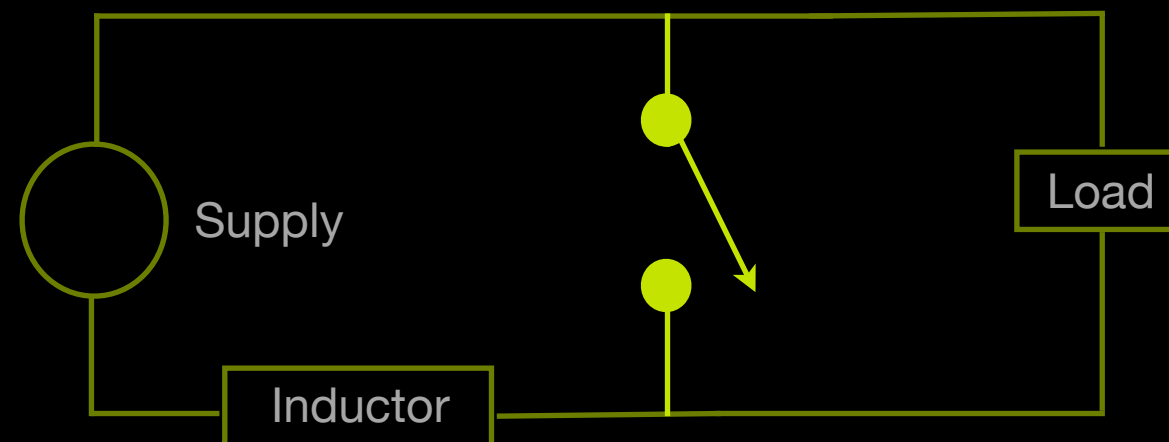


Efficient and small in size

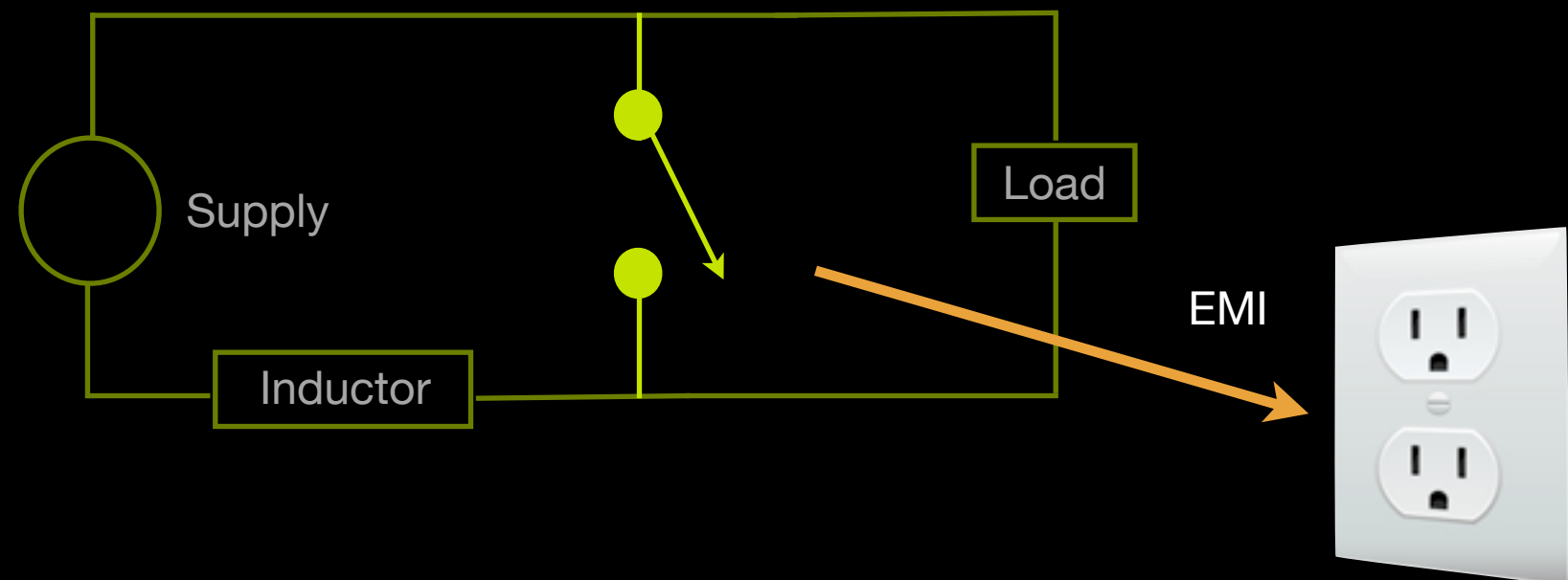
Switching Operation generates high frequency
Electro-Magnetic Interference (EMI)

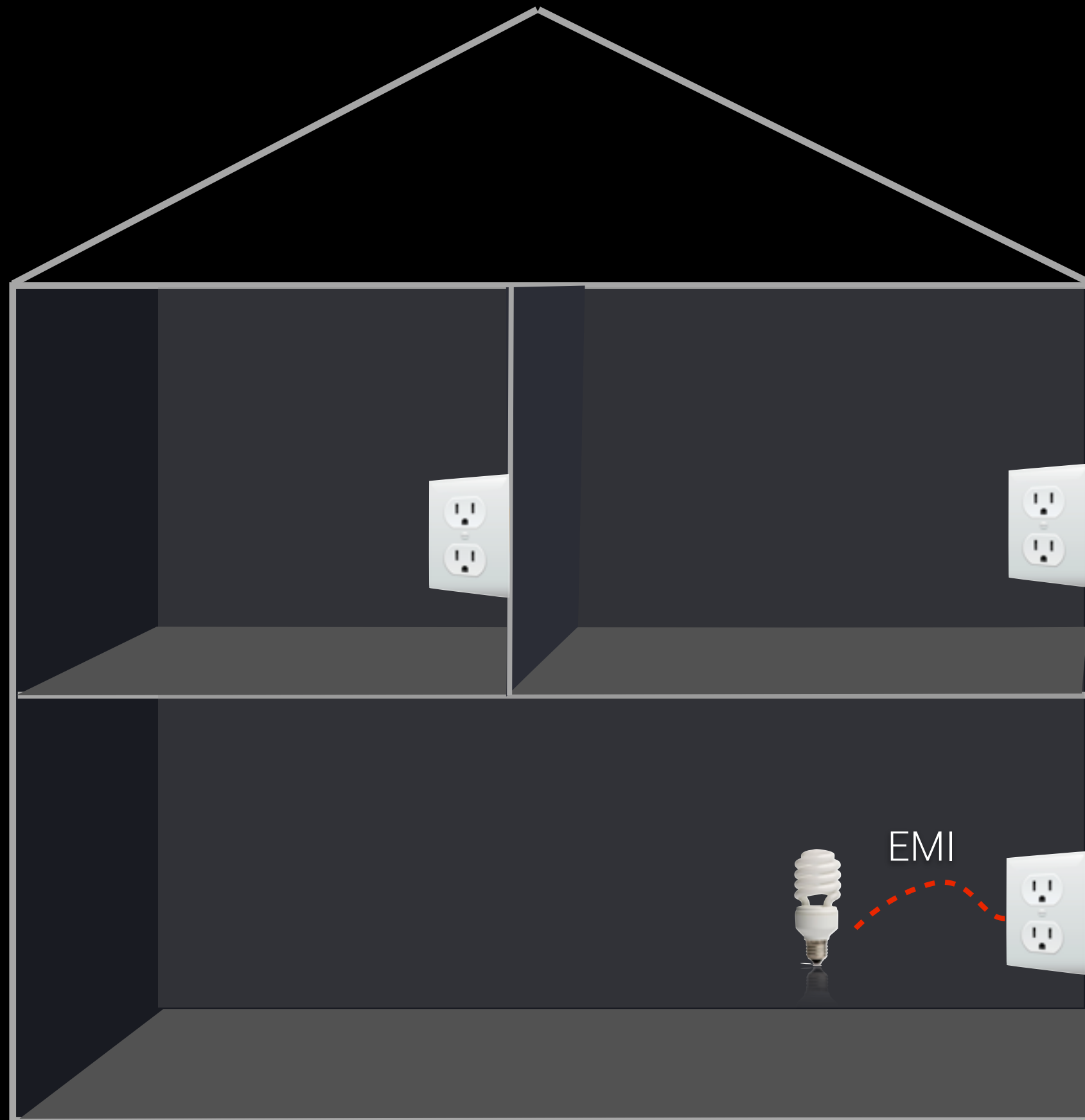


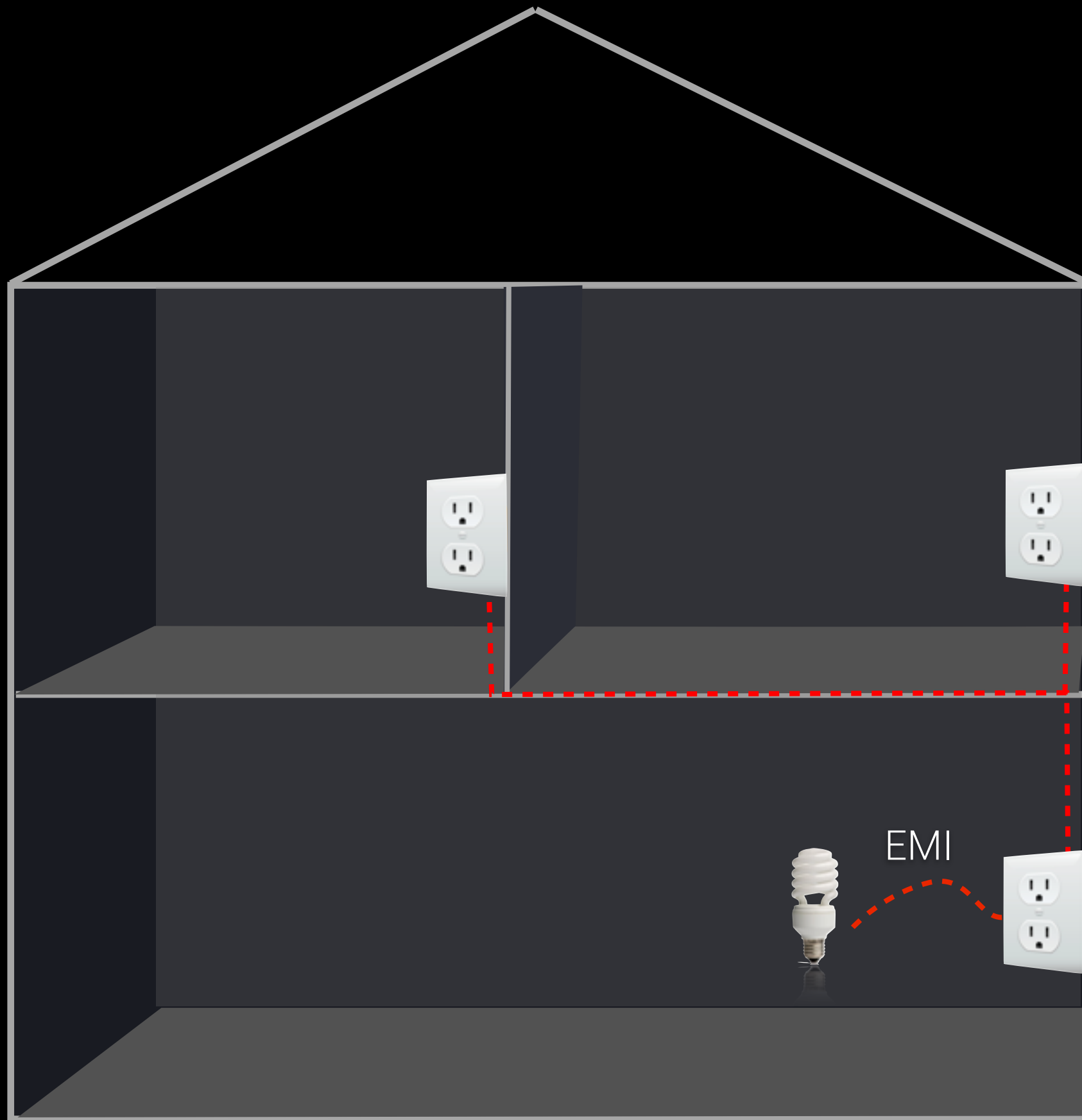
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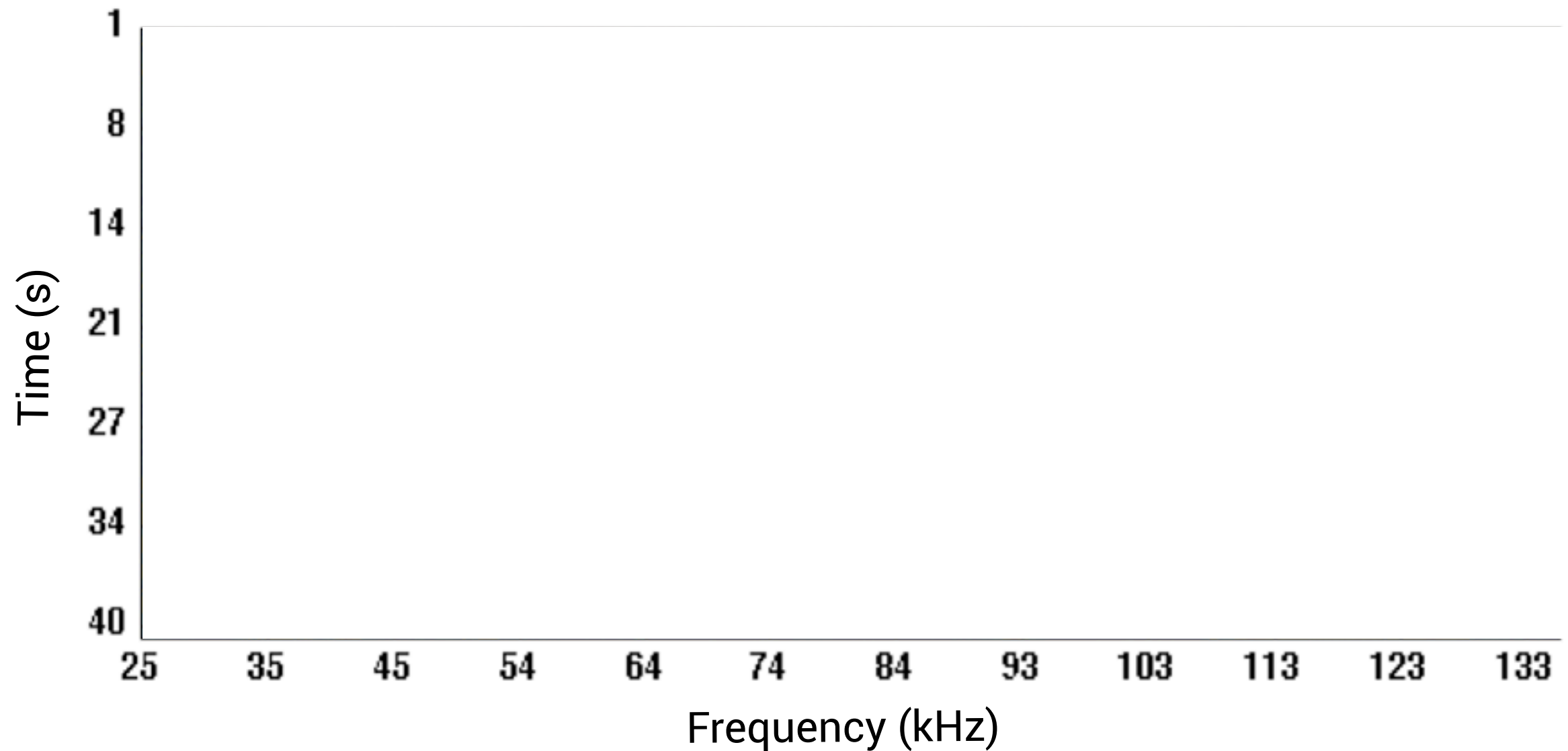




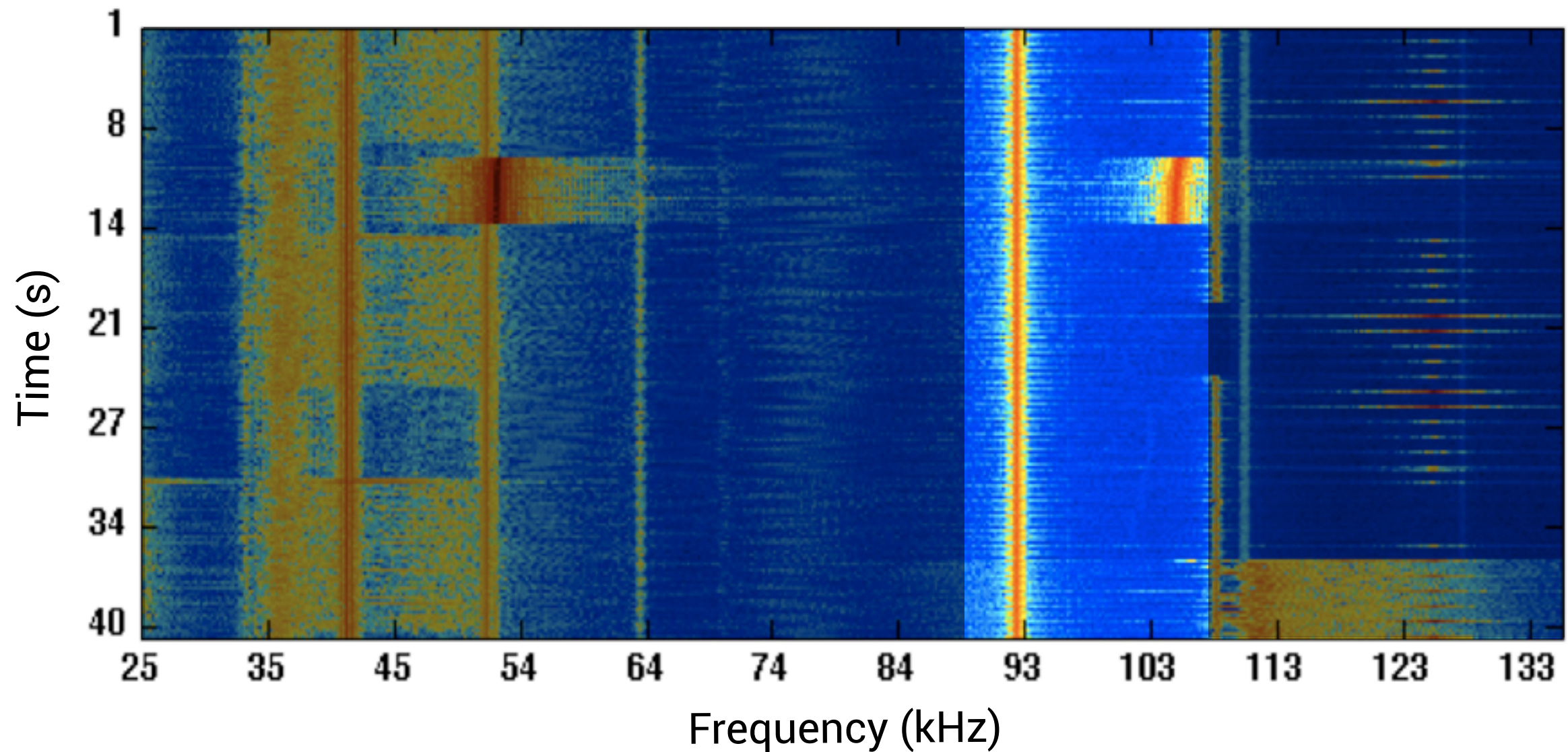




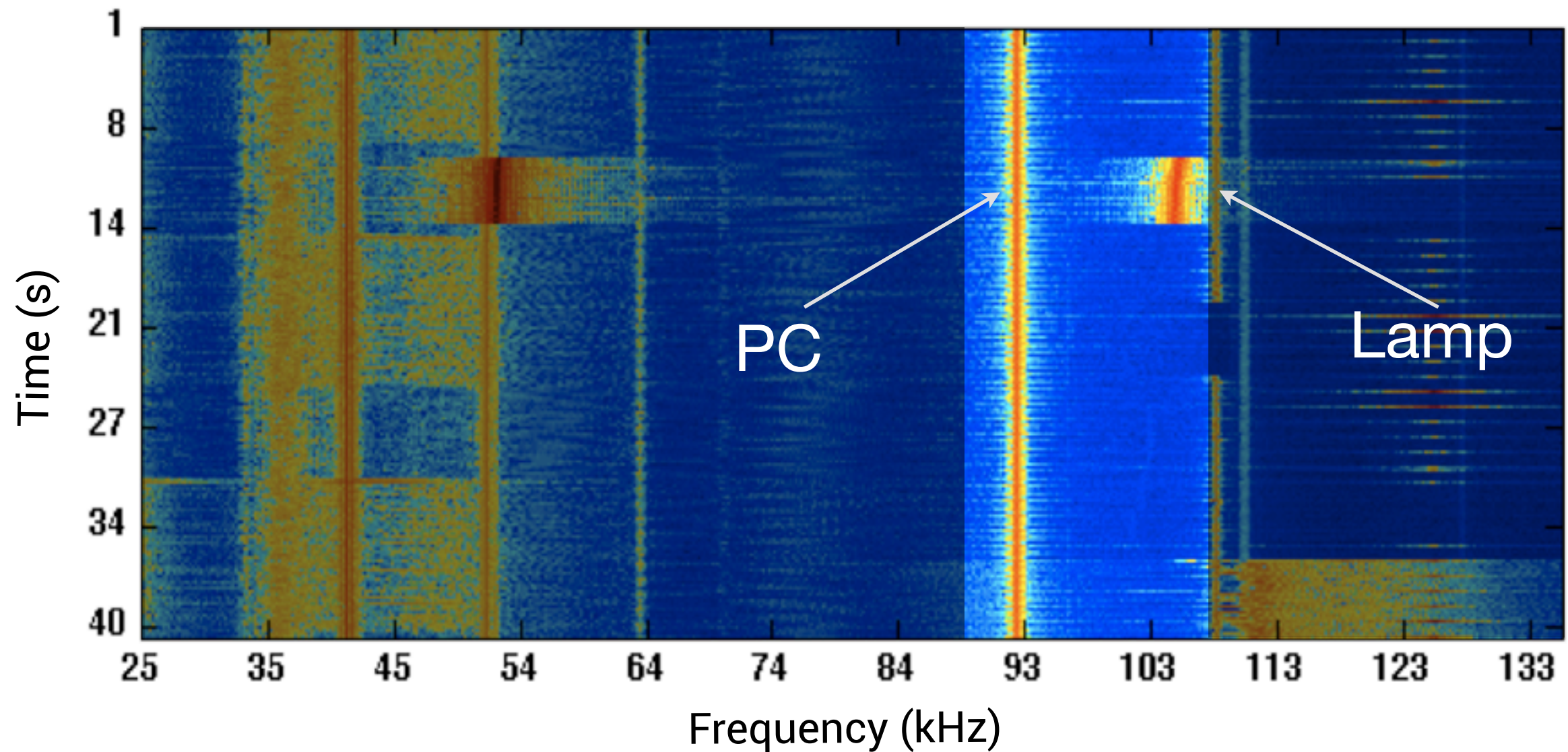
What EMI on power line looks like



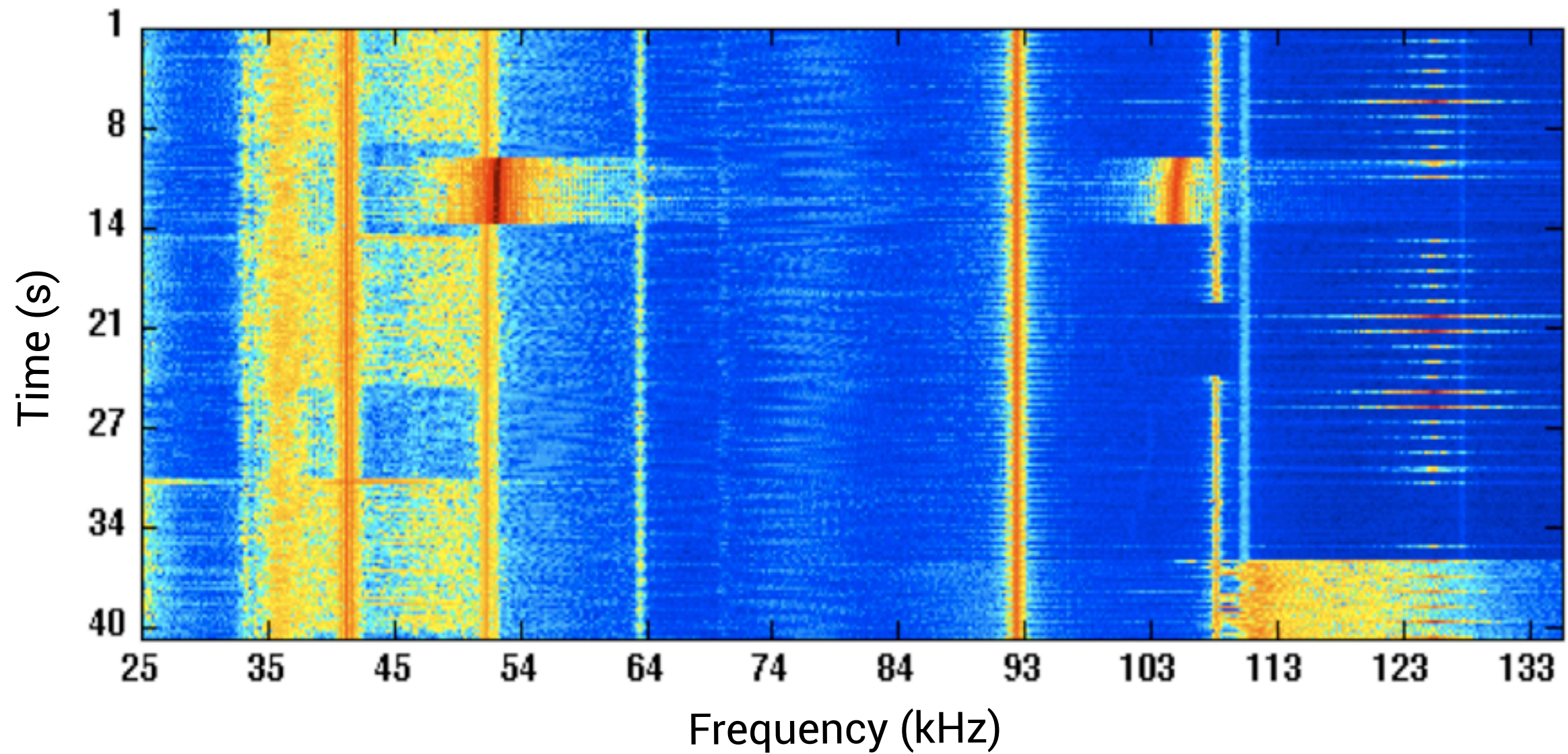
What EMI on power line looks like



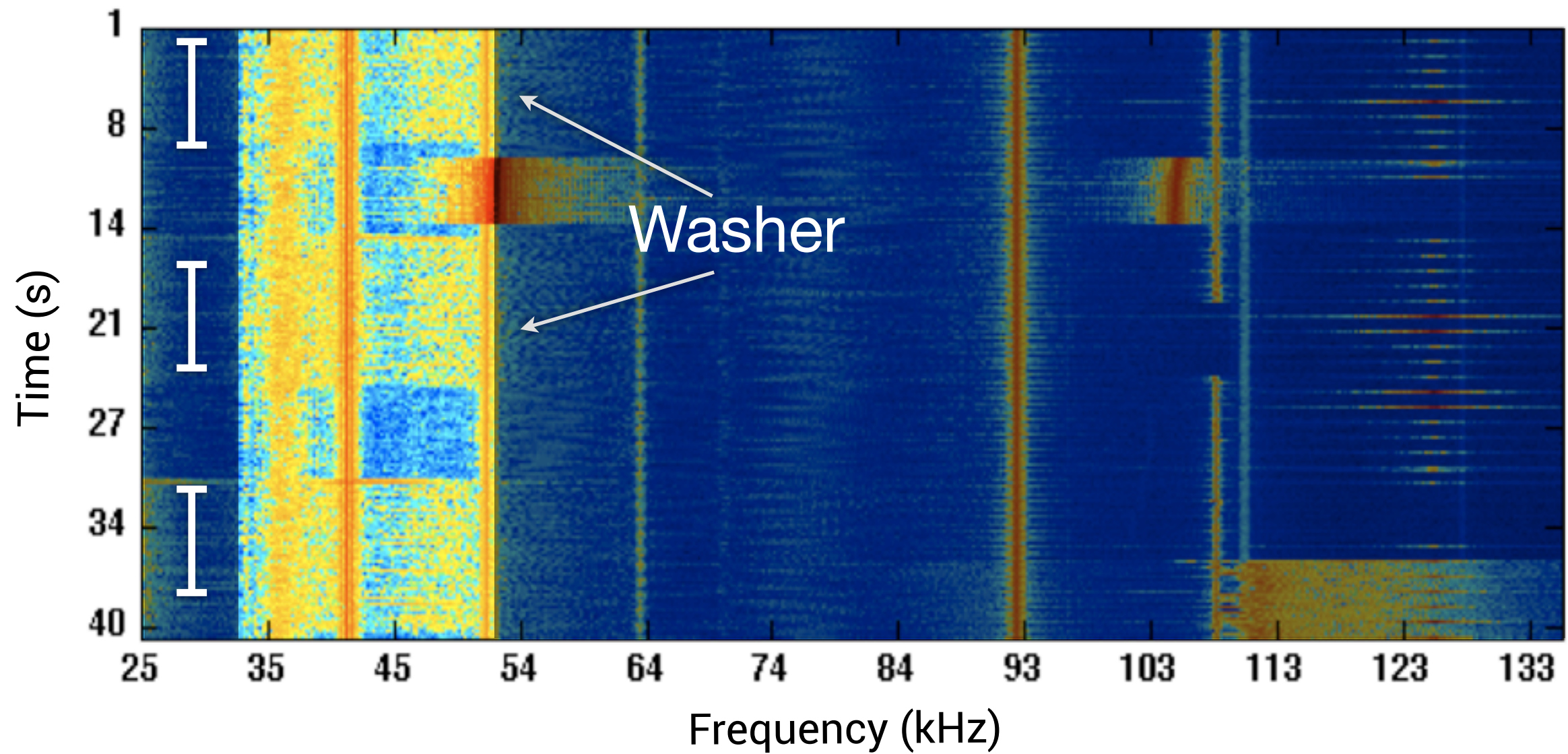
What EMI on power line looks like



Washing Machine EMI



Washing Machine EMI



Electrical Energy Disaggregation

Electrical Energy Disaggregation

What?



Electrical Energy Disaggregation

What?



How much?



Electrical Energy Disaggregation

What?



How much?

Contactless Current
Sensor



Contactless Current Sensor (CCS)



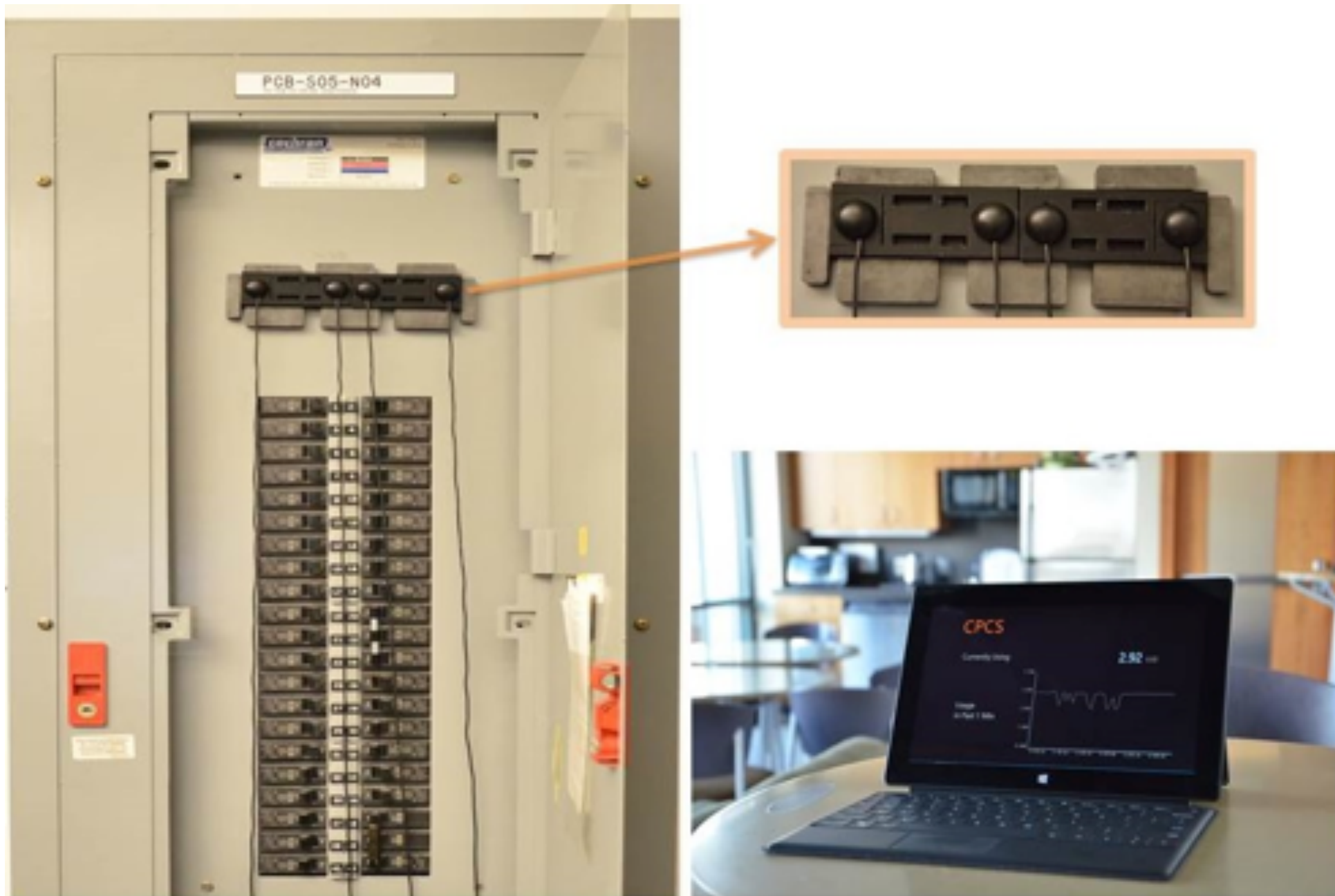
Contactless Current Consumption Sensor, CHI 2010

Contactless Current Sensor (CCS)



Contactless Current Consumption Sensor, CHI 2010

Contactless Current Sensor (CCS)



Self-calibrating Current Sensor, UbiComp 2014







Saturday, July 12, 14



Pool Pump
31%



Pool Pump
31%

DVRs
11%

Commercialized by Belkin Inc.



Commercialized by Belkin Inc.



**Deployed Across
U.S. Through
Utilities & Direct
Installations**

Commercialized by Belkin Inc.



**Deployed Across
U.S. Through
Utilities & Direct
Installations**

**Open Source
Energy Datasets
for Research
Communities**

Thank You!

ElectriSense

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