ElectriSense

Using EMI for Electrical Energy Disaggregation in the Home

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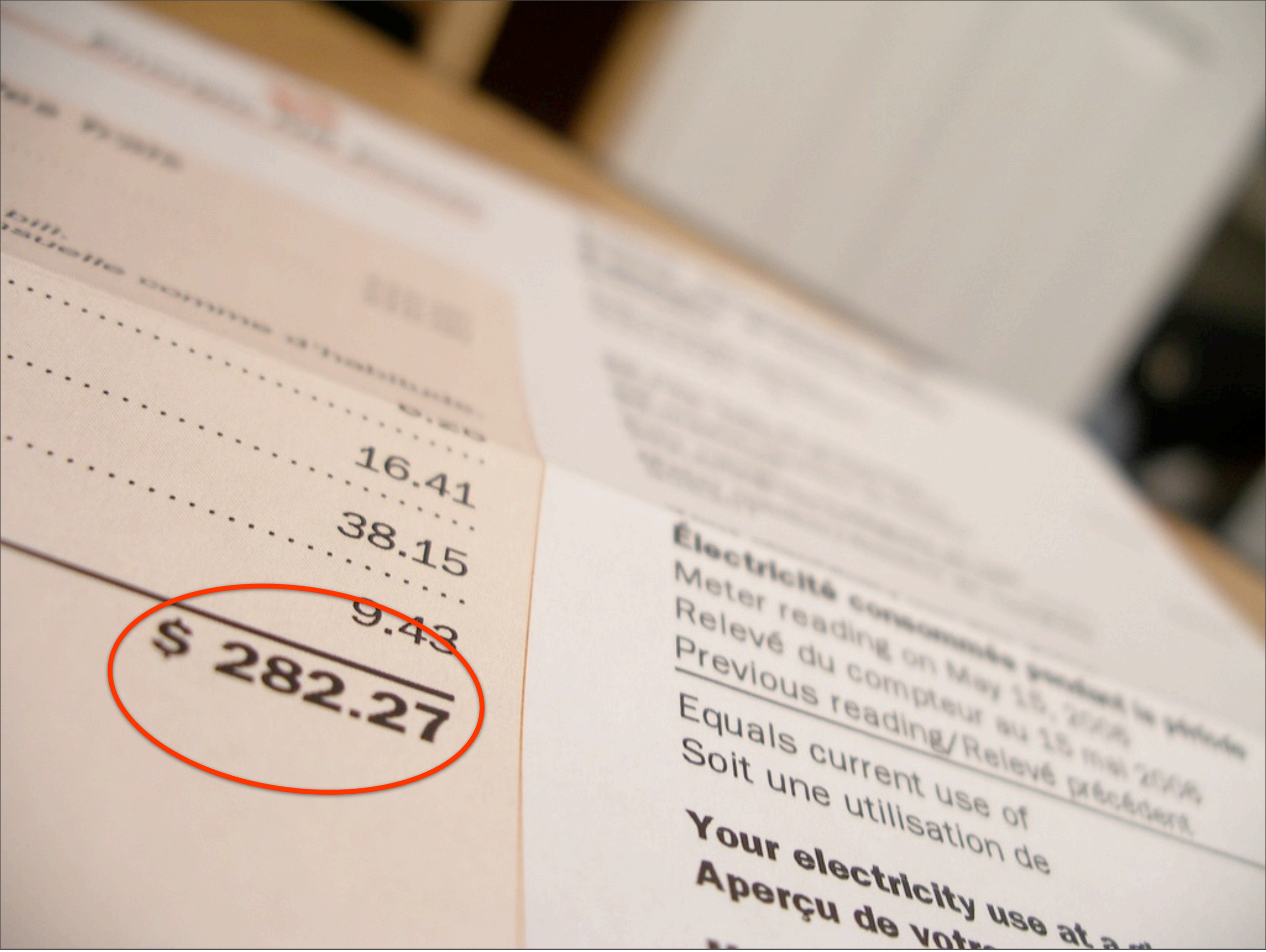
Microsoft Research

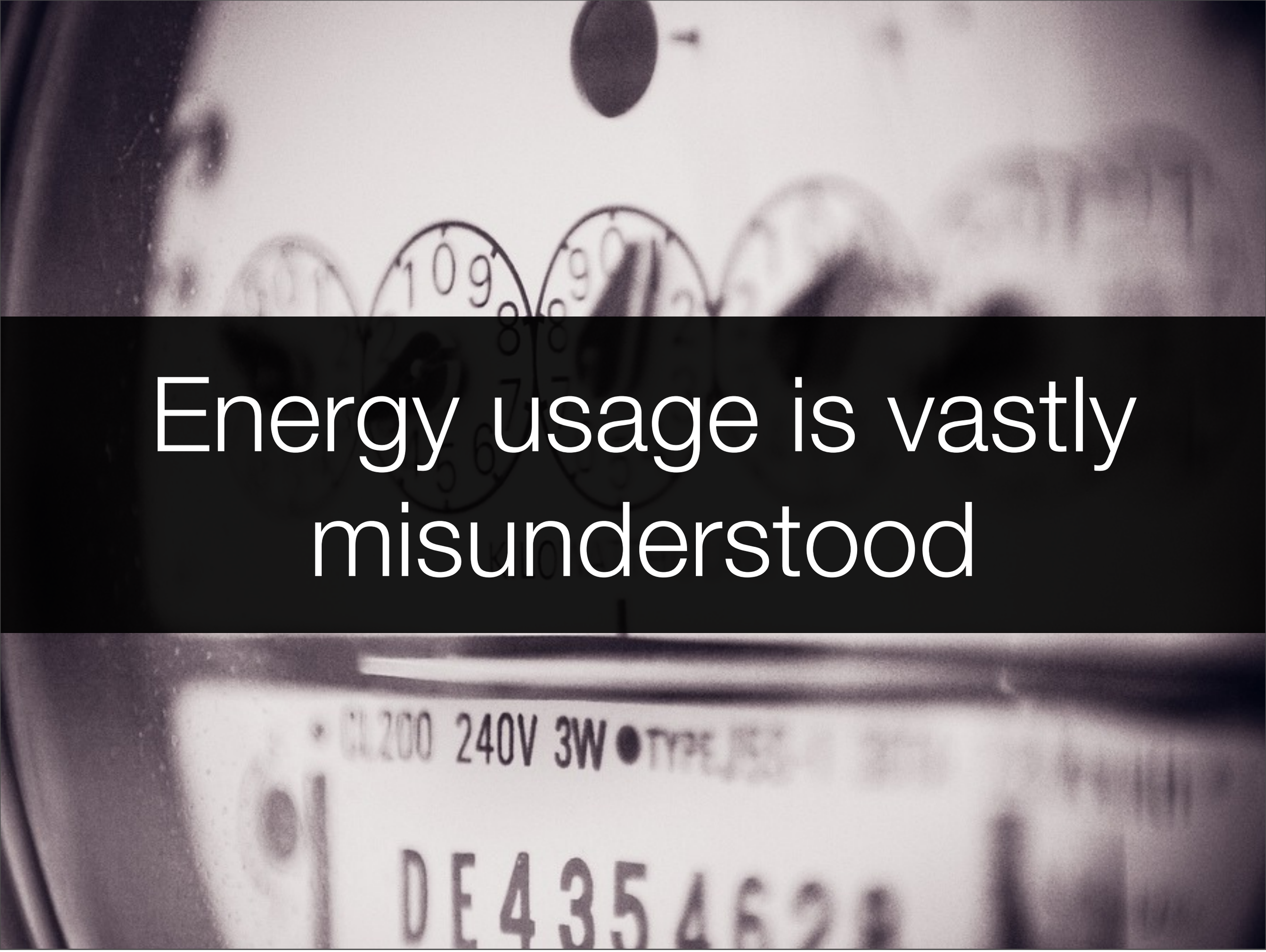
ARPA-E Workshop 2014

UbiComp Lab

Electrical energy disaggregation in the home using a single sensor

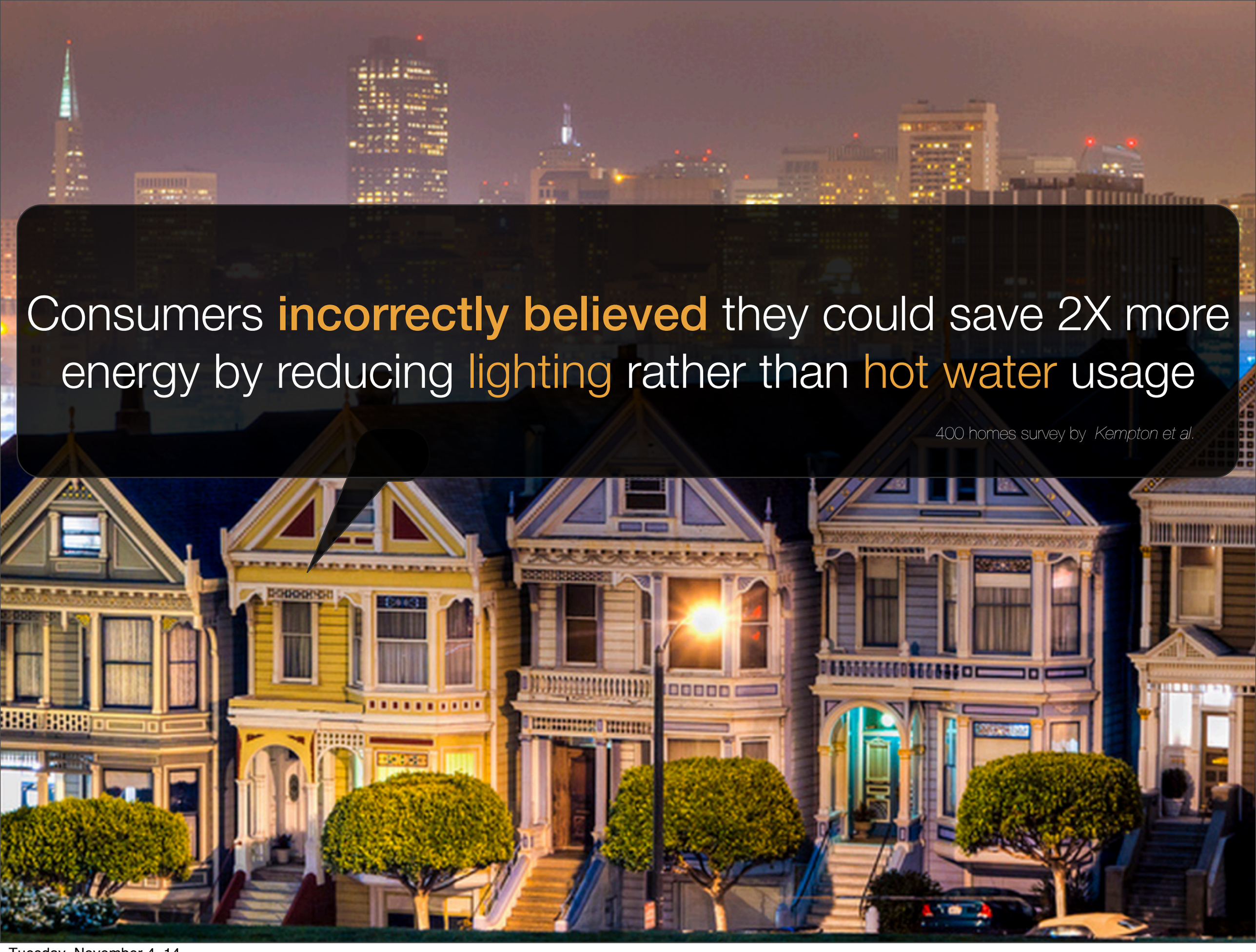
SAFEWAY
SAVE MORE AT SAFEWAY
GROCERY
SFWY PRTZLE STICK 1.50 B
ResPrice 1.79 CardSav .29
BLKBERY PRES 3.79 B
SFY CANOLA OIL 2.39 B
CEREAL PNT BUTTER 3.69 B
CHILI SAUCE SWT 3.29 B
CHF-B PIZZA 3.79 B
LK GRLC SCE 3.29 B
LUC CHEESE
ResPrice 6.79
SPINACH ARTICHOKE
ResPrice 3.79
3S CRWN VEG RSTD
ResPrice 3.79
202.50 SFWY SE
ResPrice 7.58
MARGARINE
BSFY BENEHIST TAB
BAKED GOODS
LD COSMIC BROWNIES 1.29 B
DROWEAT RYE 3.14 B
CUSTARD PIE 9IN 4.99 B
ResPrice 5.99 CardSav 1.00
CHOC CREAM PIE 4.99 B
ResPrice 5.99 CardSav 1.00
**** TAX 6.26 BAL 144.25
VF MC XXXXXXXX 144.25
.00
CHANGE
TOTAL SAVINGS 16.97
NUMBER OF ITEMS = 35
SAFEWAY
SAVE MORE AT SAFEWAY
Month: April 2006
Total Food Units: 1527
Total Price:
$527


16.41
38.15
9.43
$ 282.27
Electricité consommée pendant le période
Meter reading on May 15, 2005
Relevé du compteur au 15 mai 2005
Previous reading/Relevé précédent
Equals current use of
Soit une utilisation de
Your electricity use at a
Aperçu de votre

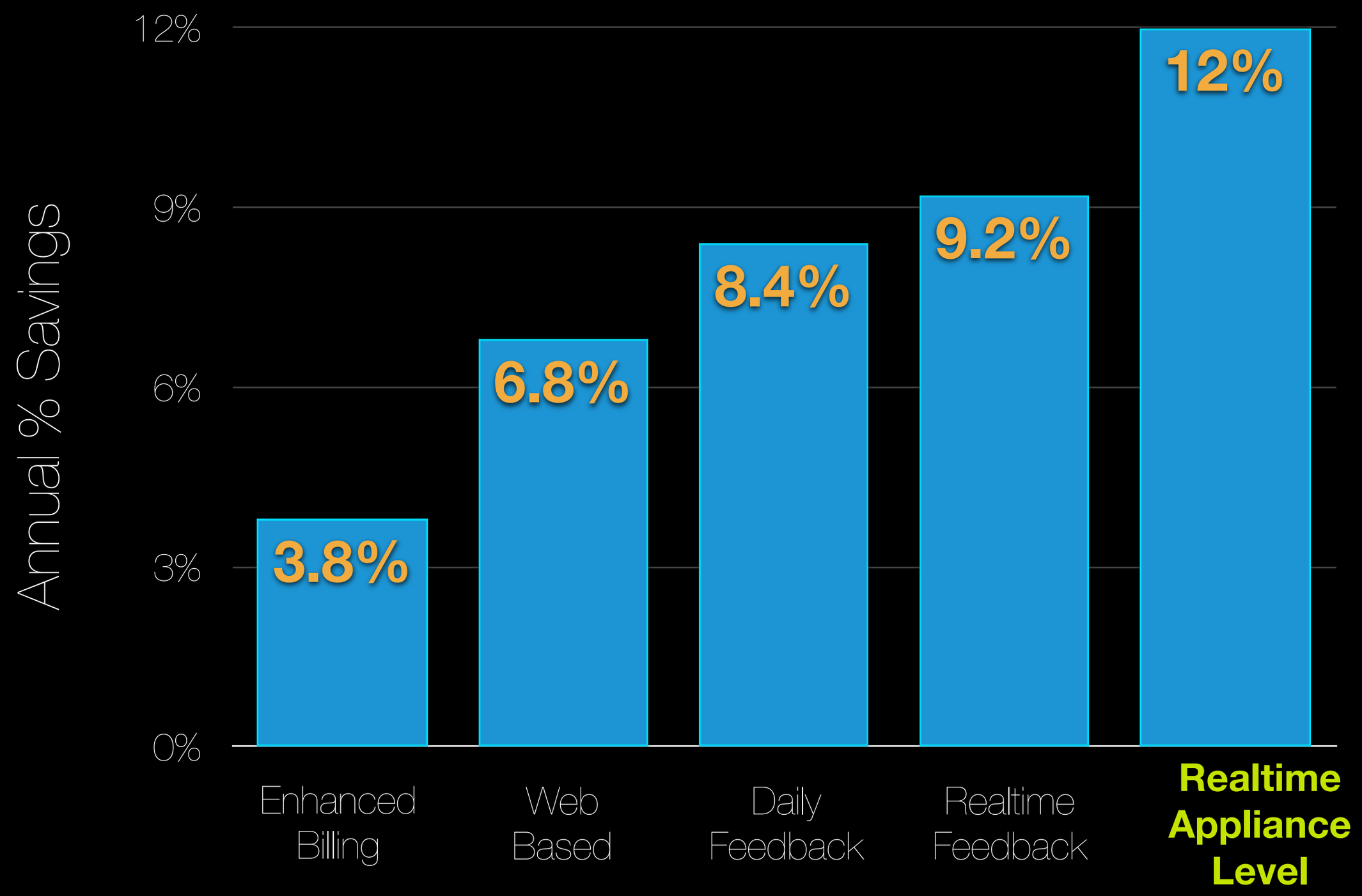


Energy usage is vastly misunderstood

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

$264

Disaggregated Energy Usage

not just ‘visible’
energy uses

Electricity

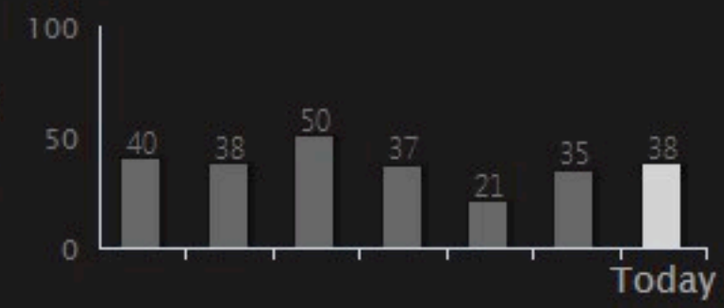
Saterday February 2 | 0:38

$319.18 / 1081.3 kWh used this month

Currently Using 270 W

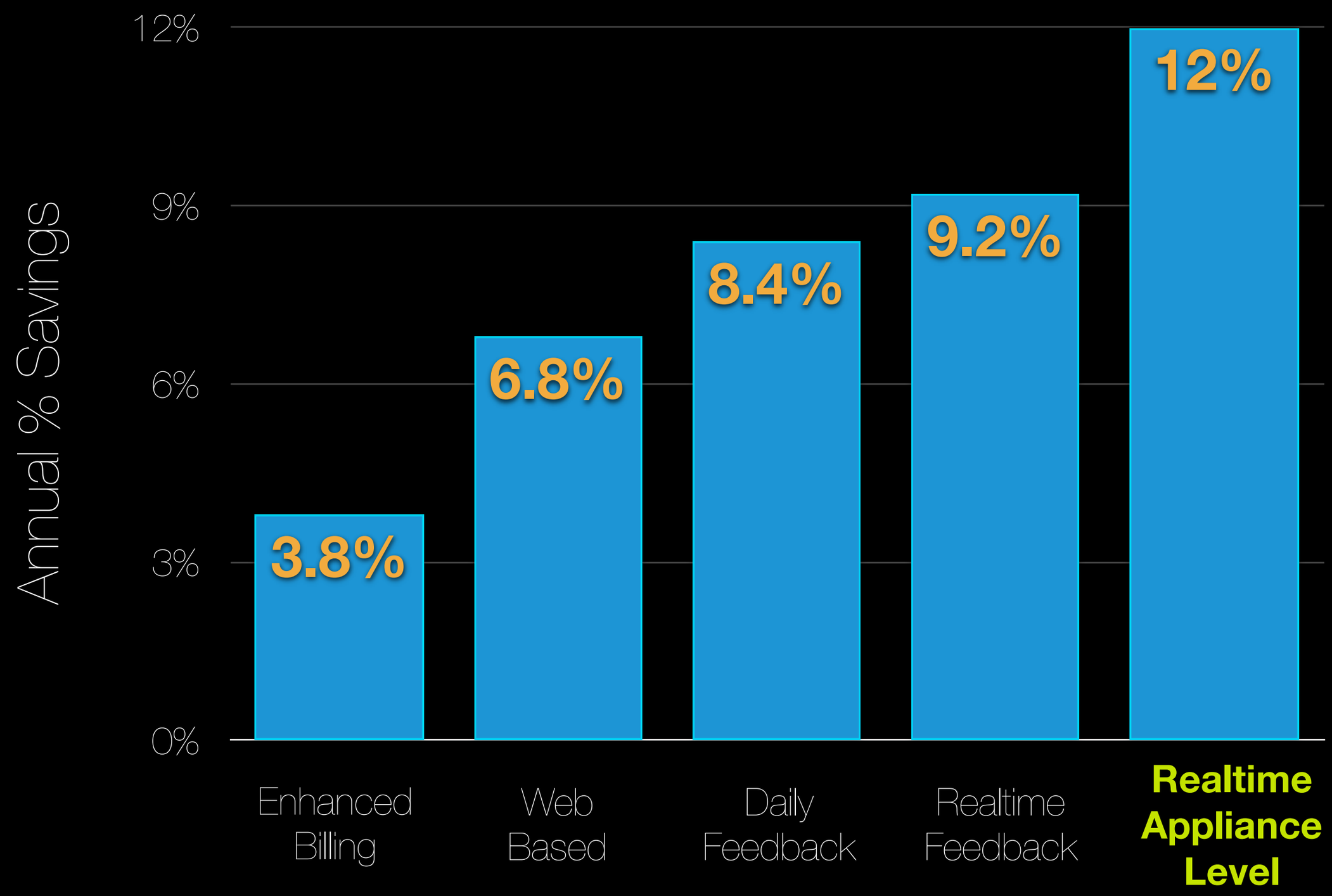
Usage in Past 1 Min

Usage Over Last 7 Days (kWh)



Usage Details

Pool Pump		32%
DVR		11%
Kitchen Fridge		7%
Kitchen Light		6%
Master Bedroom TV		5%
Garage Fridge		5%
Varsa's PC		5%
Master Bedroom Lights		5%
HVAC Fan		5%
Living Room TV		3%
Dish Washer		3%
Sy's Laptop		3%
Living Room PC		2%
Others		8%



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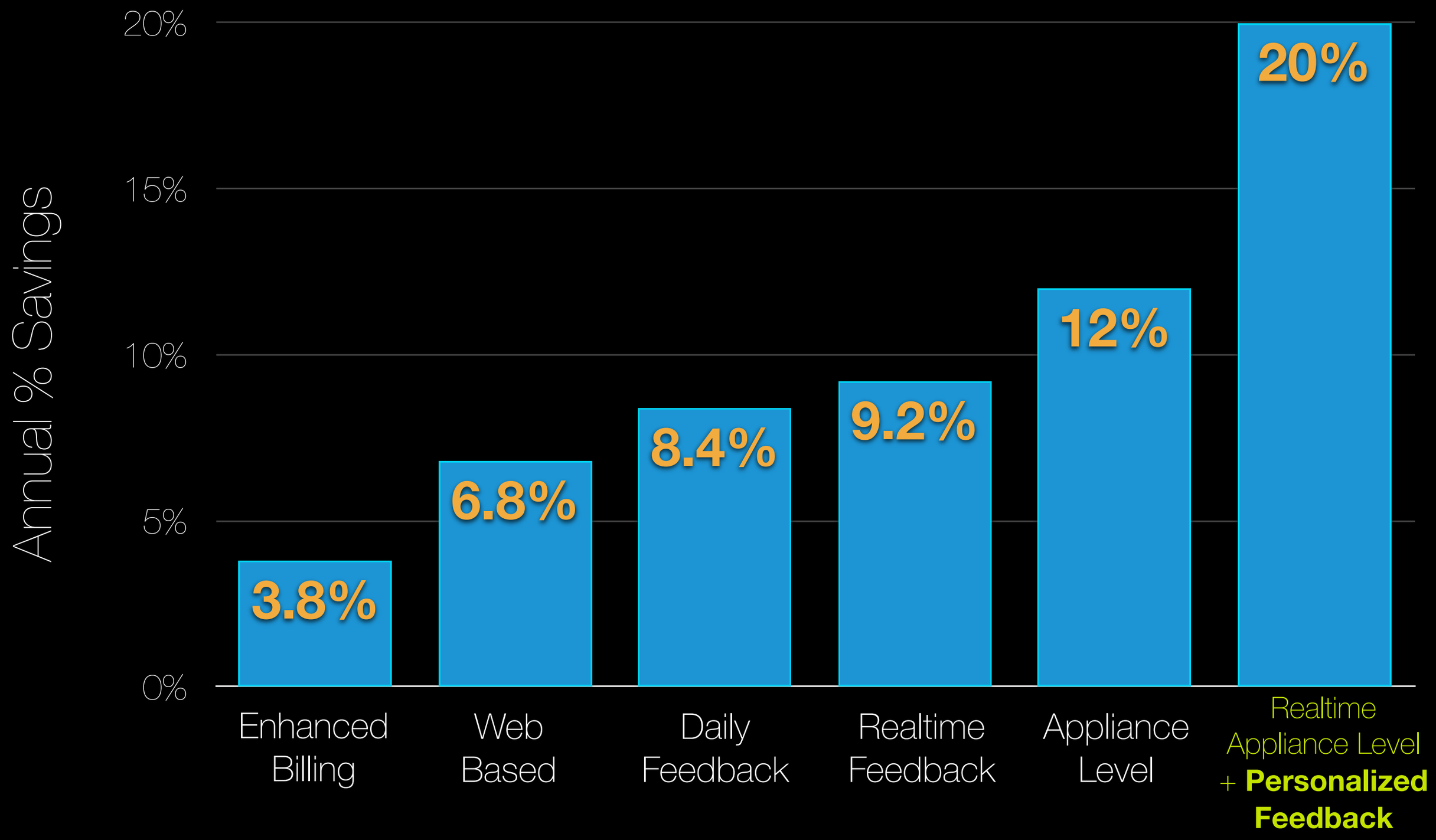


>20% reduction: *Gardner et al. (2008) and Laitner et al. (2009)*

Your Energy Efficiency Report

ComEd
A Unicom Company

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.

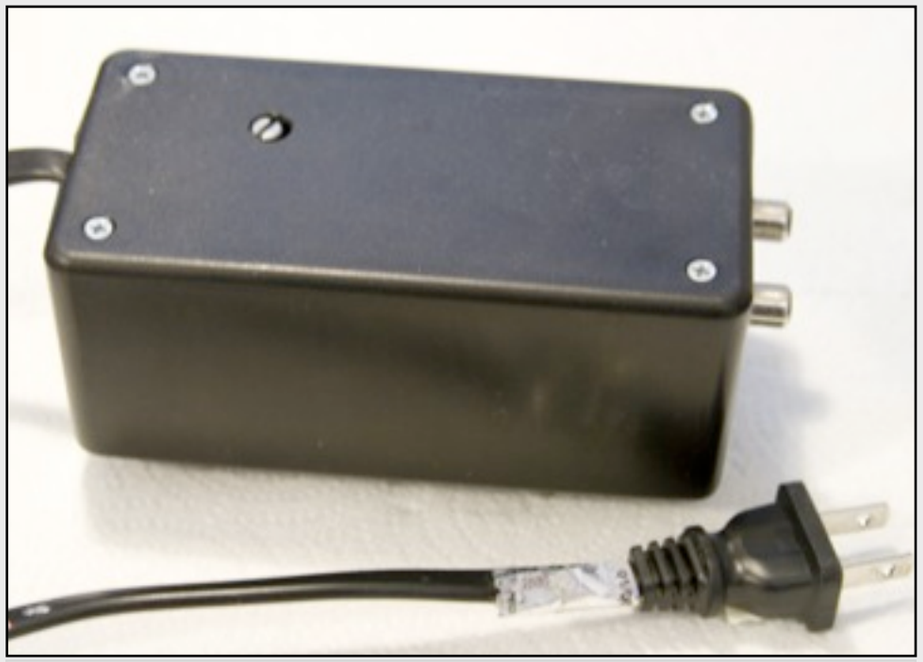
Courtesy: Belkin, Inc.

Real-time Appliance Level Personalized Feedback

How to Sense Appliance Level Energy Usage?

refrigerator
microwave
coffee
maker

ElectriSense: Single Sensor



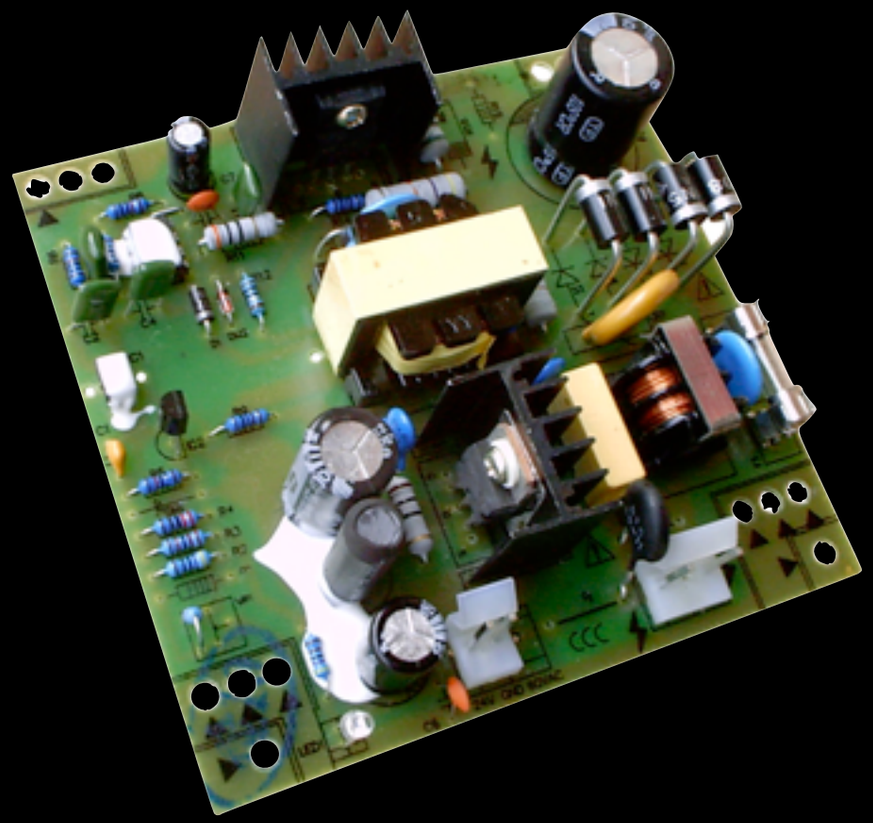
Leverage Noise From Electrical Appliances

Switched Mode Power Supply

SMPS based appliances are becoming

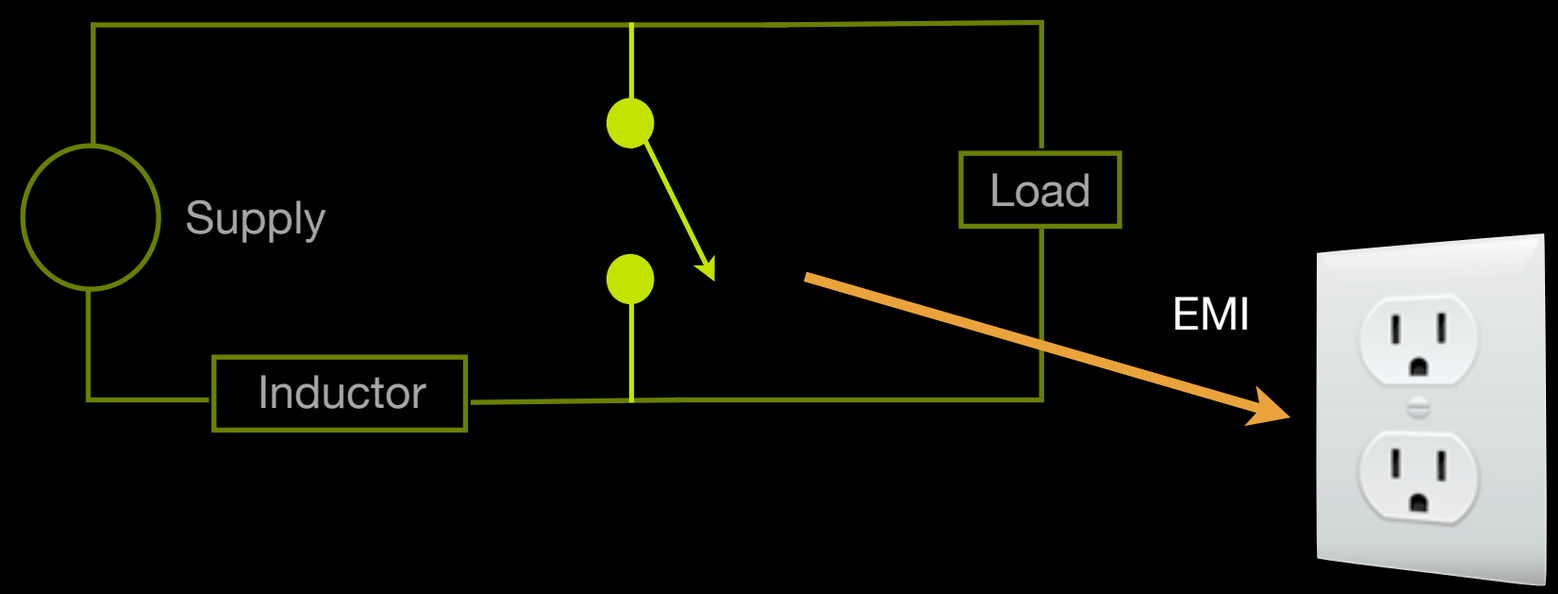
increasingly prevalent

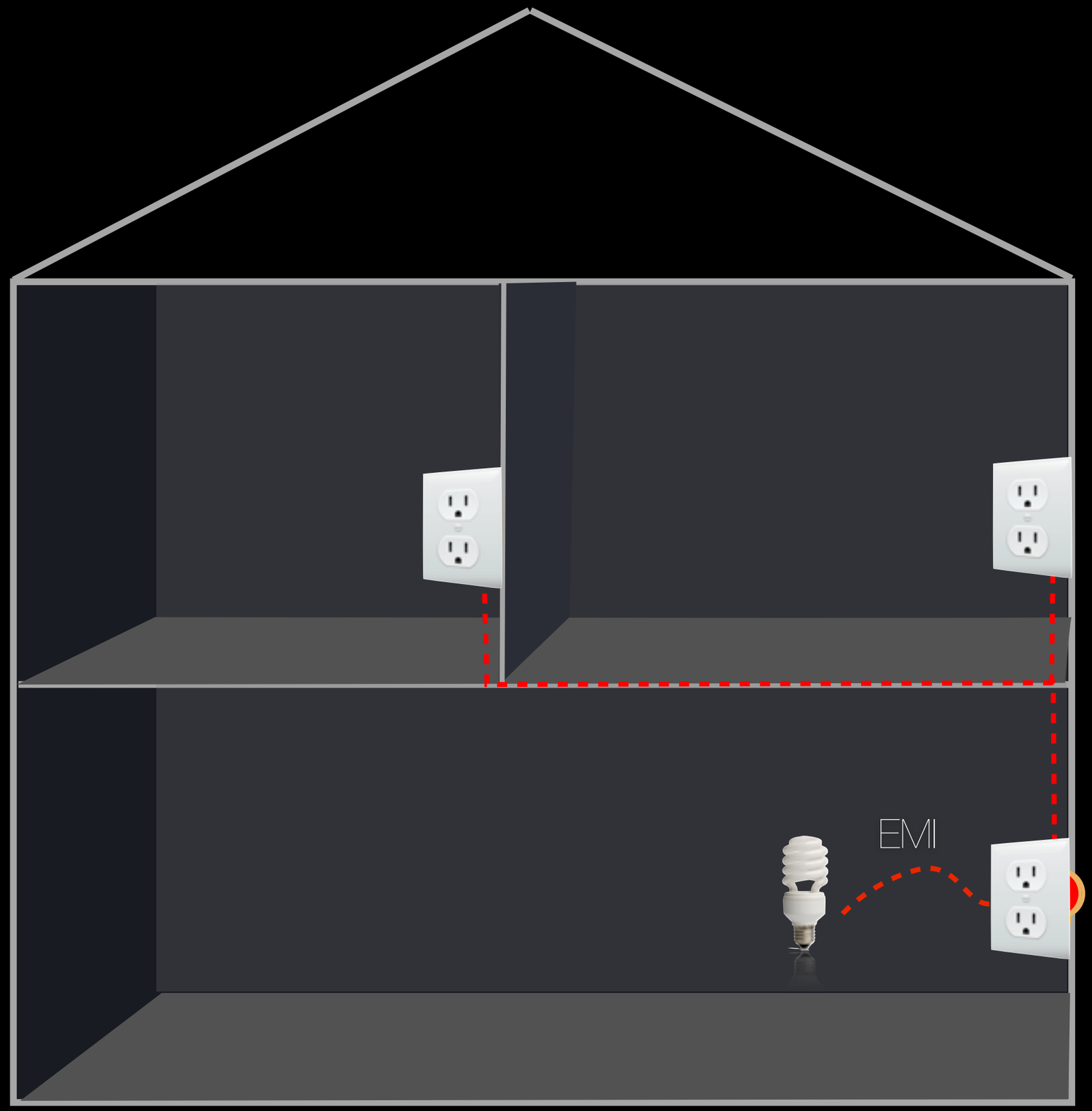
PLAYSTATION 3



Efficient and small in size

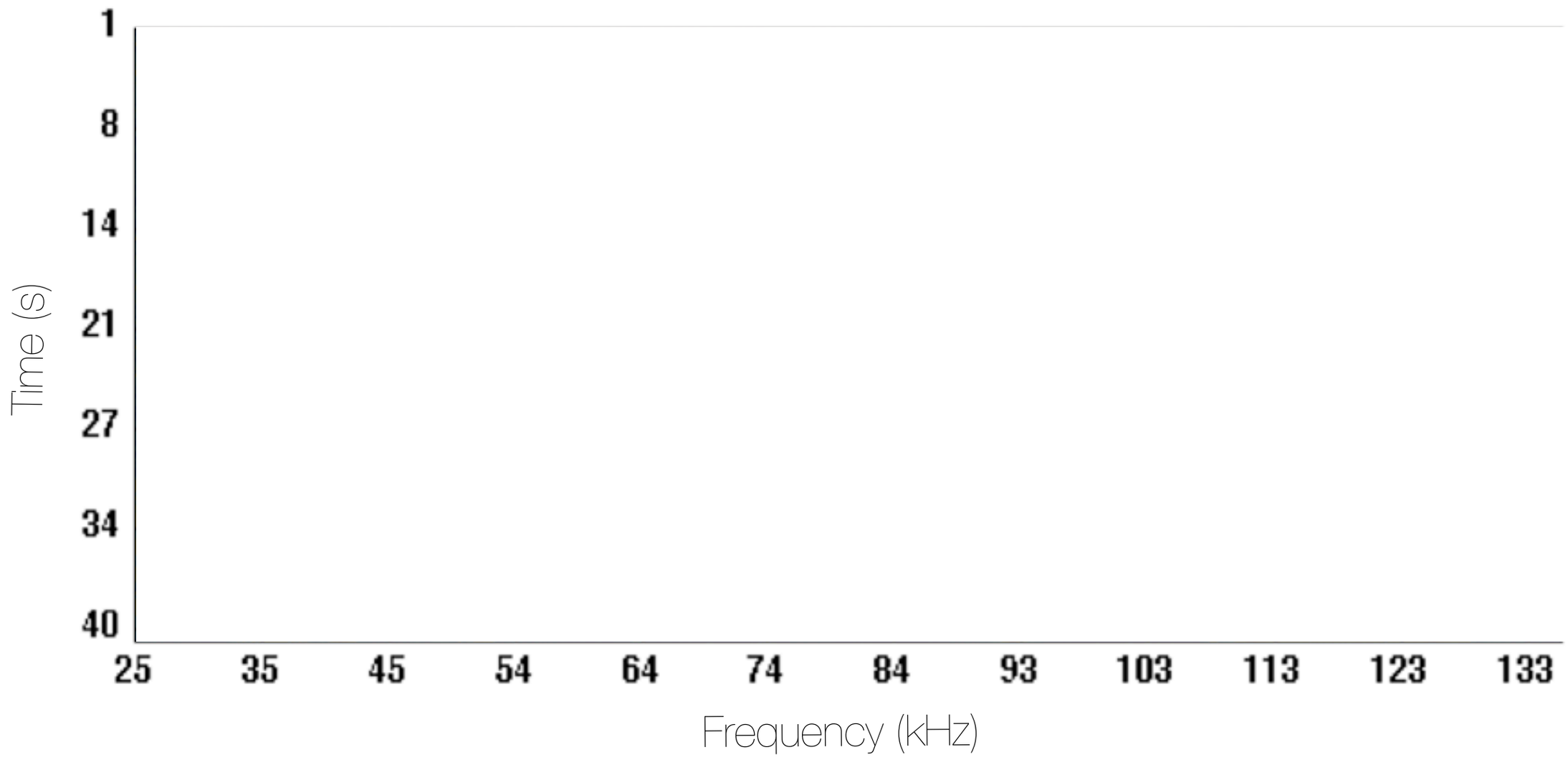
Switching Operation generates high frequency Electro-Magnetic Interference (EMI)



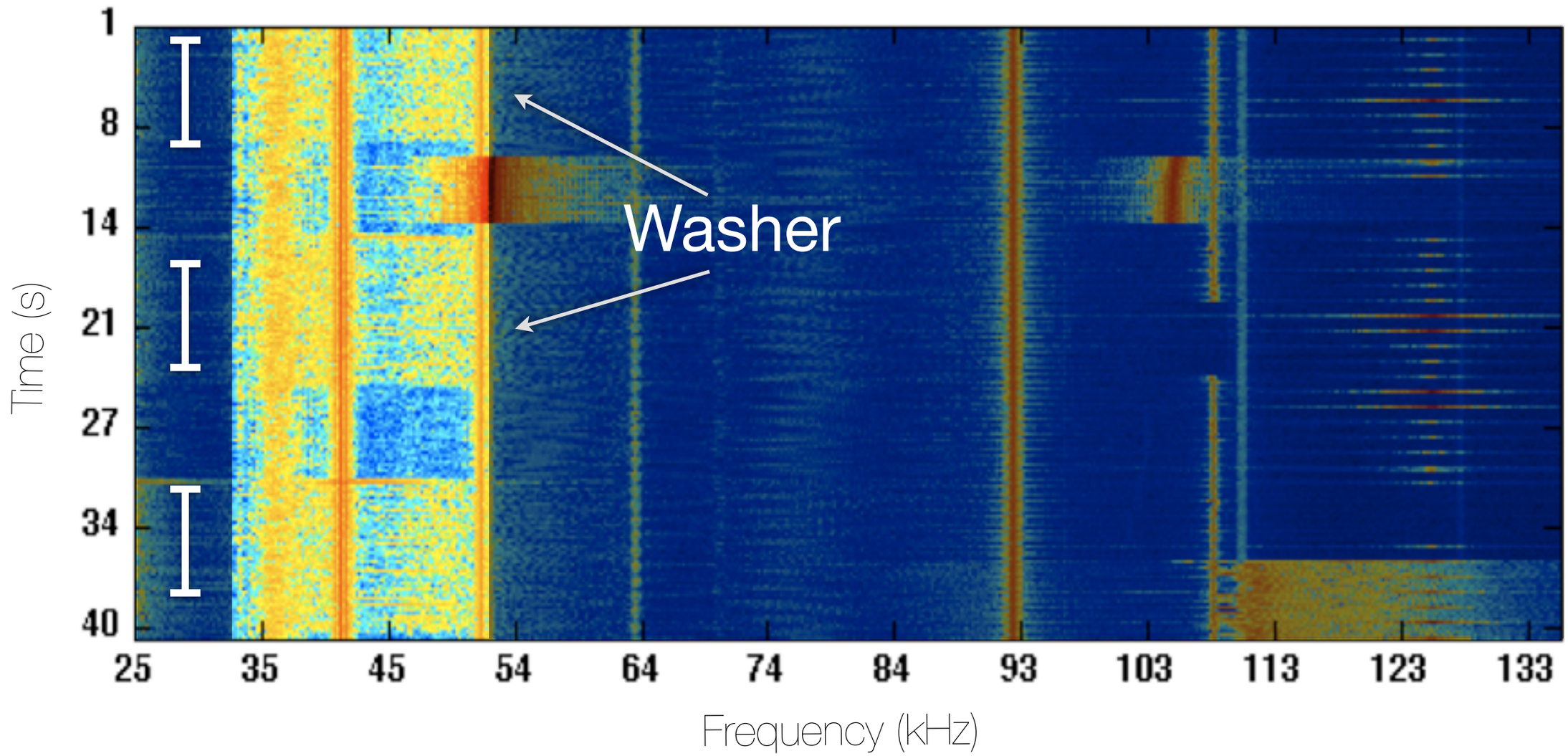

EMI

cfl off

What EMI on power line looks like



Washing Machine EMI



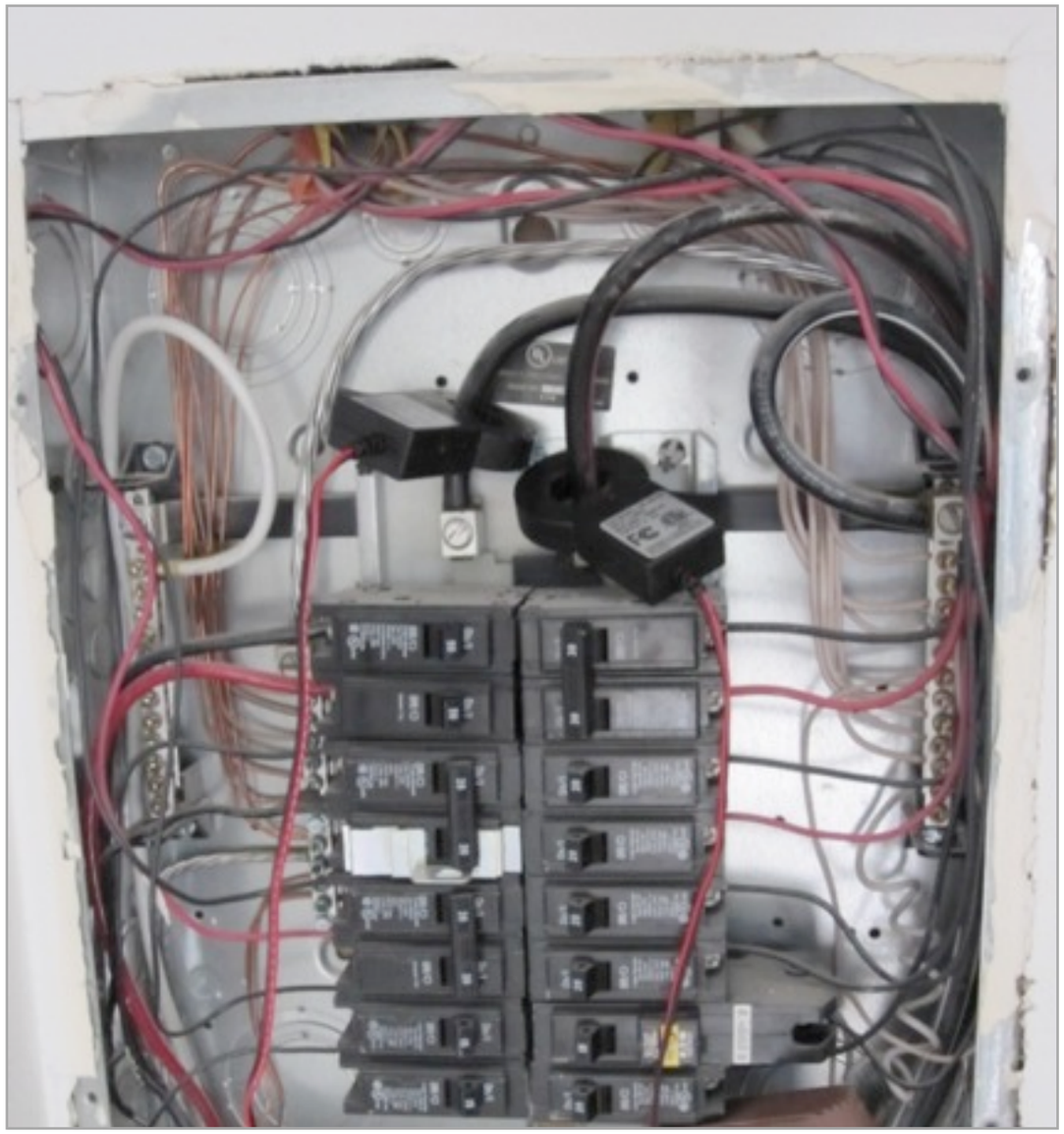
Electrical Energy Disaggregation

What?

How much?

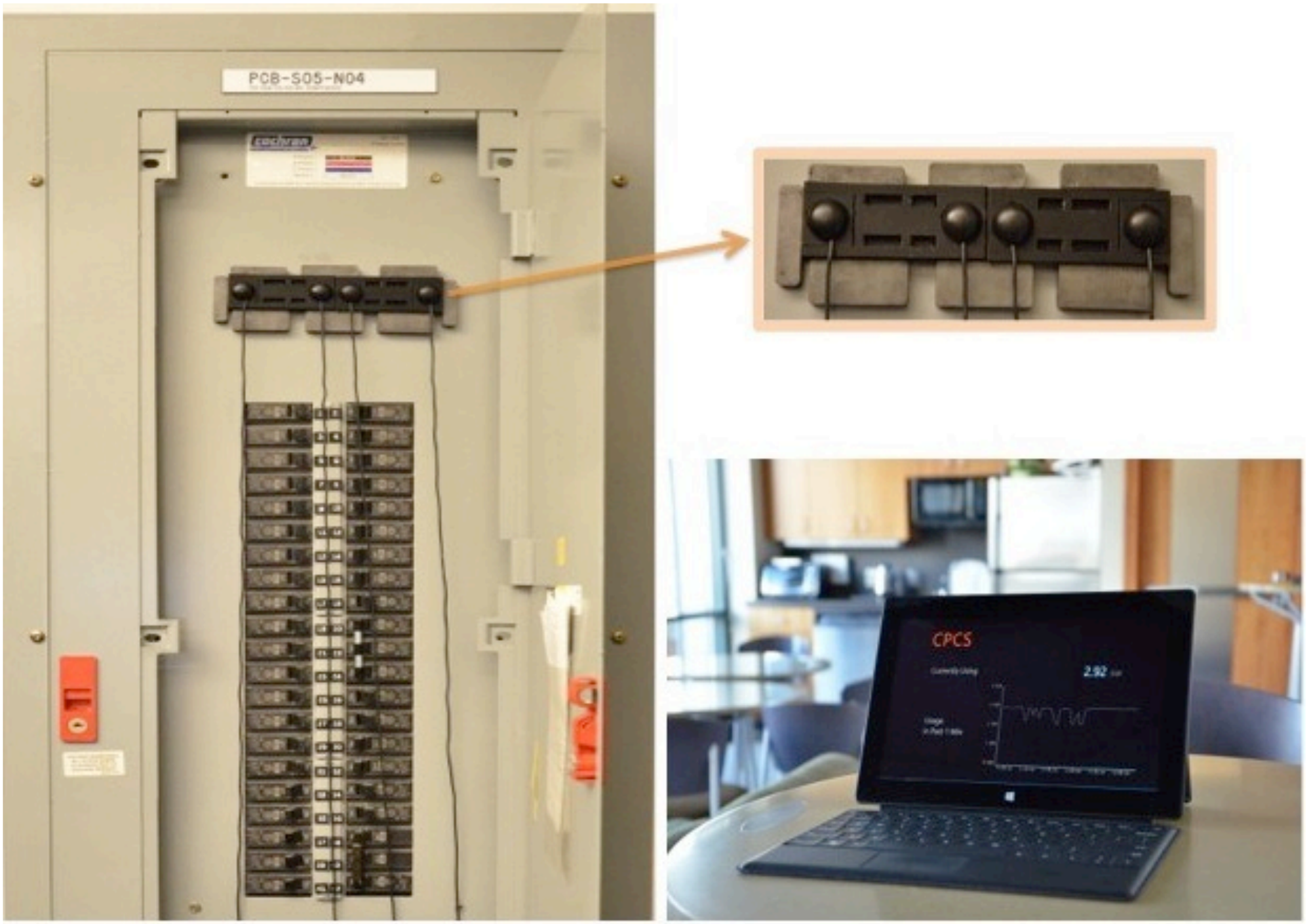
Contactless Current Sensor

Contactless Current Sensor (CCS)



Contactless Current Consumption Sensor, CHI 2010

Contactless Current Sensor (CCS)



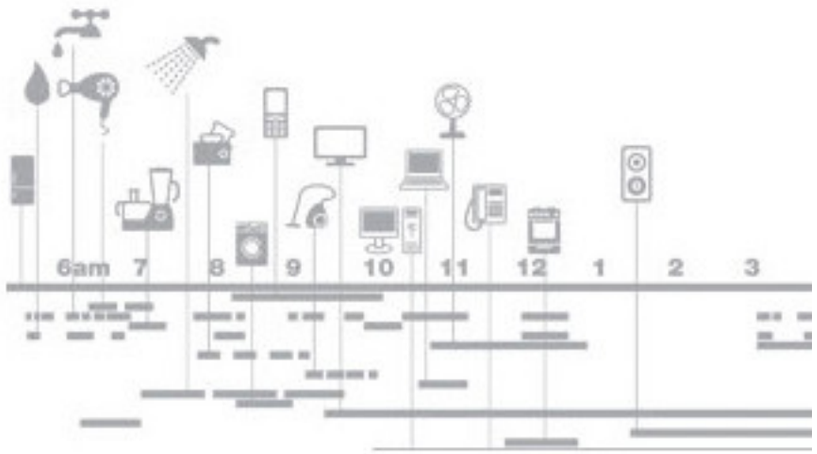
Self-calibrating Current Sensor, UbiComp 2014

iPad
11:35 AM
Electricity
Monday October 24 | 11:35
$46.27 / 329.2 kWh used this month
Currently Using
1.04 kW
Usage in Past 3 Mins
2k
1k
0k
11:34:30
11:35:00
11:35:
Usage Over Last 7 Days
50
25
0
20
18
30
17
21
18
5
Today
Usage Details
Main Floor Lighting 19%
Living Room Lighting 12%
Kitchen Lighting 14%
Other Lighting 3%
Refrigerator 10%
Oven 5%
Other Devices 2%
Cable Boxes 16%
Laptop 1%
Gaming Console 1%
Living Room TV 5%
Dryer 5%
Home AV 2%
HVAC & Exhaust Fans 5%

Pool Pump
31%
DVRs
11%

Commercialized by Belkin Inc.

belkin echo



Deployed Across U.S. Through Utilities & Direct Installations

Open Source Energy Datasets for Research Communities

Thank You!

ElectriSense

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Microsoft Research