

Residential Energy Monitoring and Sensing

Dr. Shwetak Patel

Assistant Professor

Computer Science & Engineering

Electrical Engineering

University of Washington

<http://www.shwetak.com>

<http://ubicomplab.cs.washington.edu>

dub
design:
use:
build:
univ. of washington

ubicomp lab

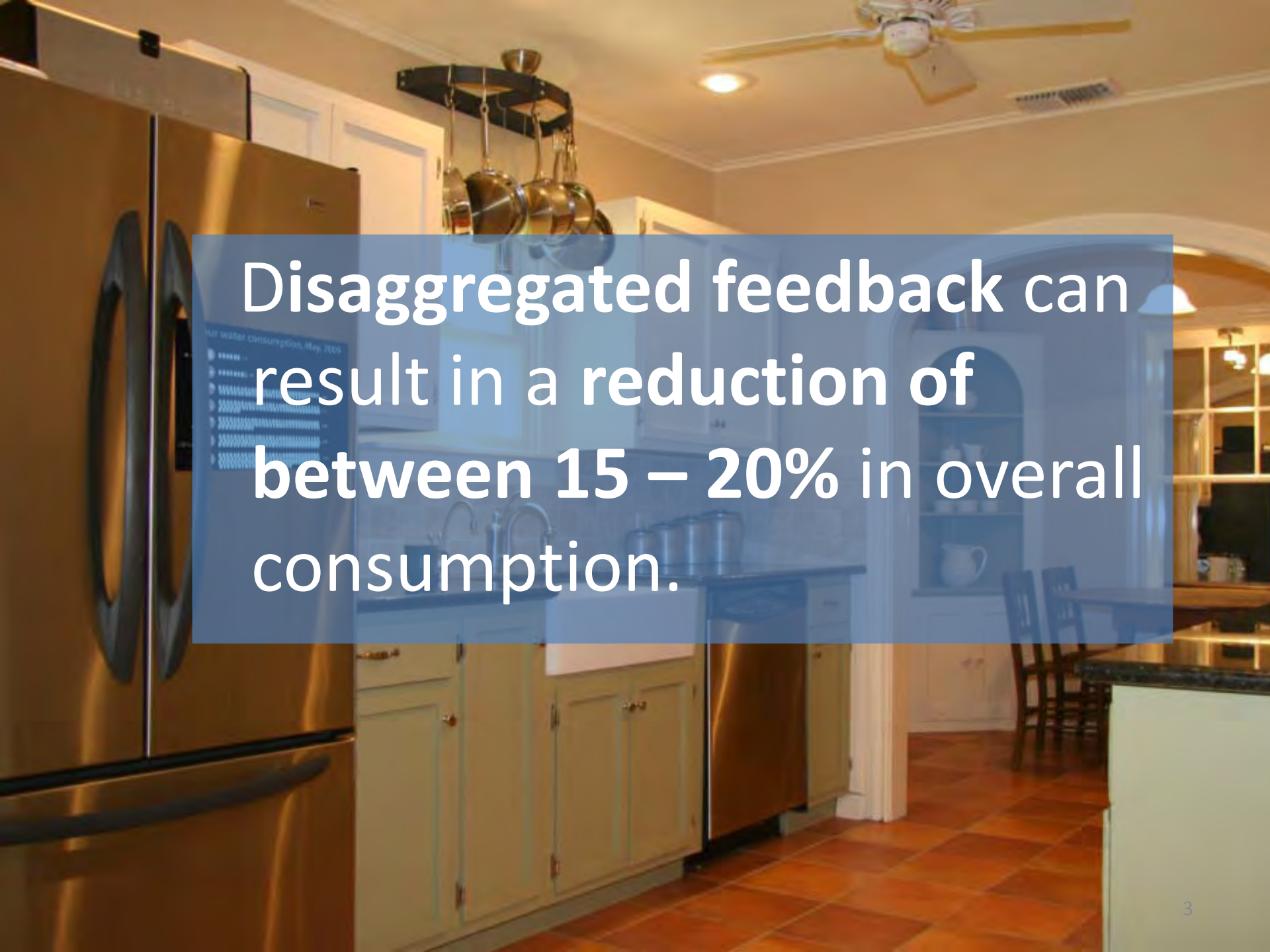
computer science
and engineering





Help consumers reduce their residential consumption

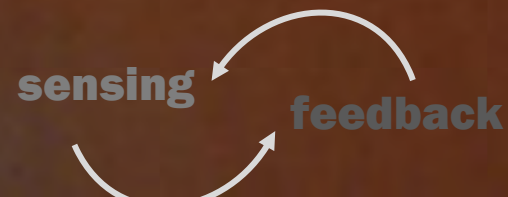
Need for granular consumption information in the home



Disaggregated feedback can result in a reduction of between 15 – 20% in overall consumption.

The Requirements

- Non-expert installable, low-cost, and highly granular sensing technology
- Novel, engaging, and persuasive feedback interfaces



Value of the Data

- Actionable feedback by residential consumers
- Behavior change
- Better models for manufacturers
- Better residential energy use models (i.e., National Energy Use Corpus)

Value for the Utilities

- Conservation
- Validation and verification of conservation activities
- New model for demand response
- No truck roll or costly rollouts
- No need to go into the home

SAFeway

SAVE MORE AT SAFEWAY

GROCERY

SFWY PRTZLE STICK		1.50 B
RegPrice 1.79	CardSav .29	3.79 B
BLKBERY PRES		2.39 B
SFY CANOLA OIL		3.69 B
CEREAL PNT BUTTER		.29 B
CHILI SAUCE SWT		
CHF-B PIZZA		
LK GRCL SCE		

REFRIG/FRO

LUC CHEESE	Ca	
RegPrice 6.79		
SPINACH ARTICHOKE	Ca	
RegPrice 3.79		
3S CRWN VEG RSTD	O	
RegPrice 3.79		
202.50 SFWY SEL M		
RegPrice 7.58		
MARGARINE		

GEN MERCHANDISE

#SFY BENEHIST TAB		7.99 T
-------------------	--	--------

BAKED GOODS

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

**** TAX	6.26	BAL	144.25
VF MC XXXXXXXXX			144.25

CHANGE		.00
--------	--	-----

TOTAL SAVINGS	16.97
---------------	-------

NUMBER OF ITEMS =	35
-------------------	----

12/27/06 12:00 1877 02 0160 8146

SAFeway

SAVE MORE AT SAFEWAY

Month: April 2006

Total Food Units: 1527

Total Price:

\$527



Seattle Public Utilities Bill

Questions? Call 206-684-3000 or 1-800-862-1181 (out of area calls only)
Write us? 700 5th Avenue, Suite 2777, PO Box 34027, Seattle, WA 98124-4027

C00034
LEAK
325
CD-0

Account number:
2-1084347-154771

JAMES LANDAY
5544 ASHWORTH AVE N
SEATTLE, WA 98103-5917

Property owner:
JAMES LANDAY
Service address:
5544 ASHWORTH AVE N

Summary of charges as of August 18, 2009

Payments received after August 19, 2009 are not reflected.

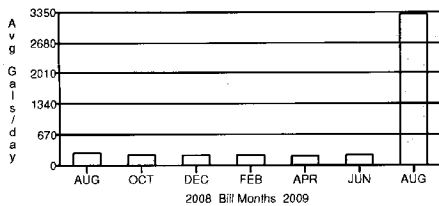
Previous balance:	317.91
Payments applied - THANK YOU!	317.91 CR
Balance:	0.00
Total adjustments:	0.00
Current billing:	2,994.83
TOTAL AMOUNT DUE ON September 08, 2009	\$2,994.83

SUMMER WATER RATES ARE IN EFFECT FROM MAY 16 THROUGH SEPTEMBER 15. THIS BILL SHOWS HIGH CONSUMPTION. PLEASE READ ENCLOSED BROCHURE FOR INFORMATION.

Moving? Call us on the day you move if you are reading your own meter. To have us read your meter for a fee, call us at least 3 days in advance of your move.

Remember: Account openings and account closings cannot be backdated to a day before you contact us.

Compare Your Water Usage



This Period		Same Period Last Year	
No. of days:	64	No. of days:	62
Consumption in CCF:	283	Consumption in CCF:	23
Avg consumption/day:	4.42 CCF	Avg consumption/day:	0.37 CCF
Consumption in gals:	211684	Consumption in gals:	17204
Avg consumption/day:	3307.56 gals	Avg consumption/day:	277.48 gals

1 CCF = 748 gallons

Seattle Public Utilities Bill

Service address: 5544 ASHWORTH AVE N
Property owner: JAMES LANDAY
Account number: 2-1084347-154771

DUE DATE: September 08, 2009
AUTOMATIC PAYMENT

Your account has Automatic Bank Payment. \$2,994.83 will be deducted from your bank account on the payment due date.

JAMES LANDAY
5544 ASHWORTH AVE N
SEATTLE, WA 98103-5917



000000908090200108434701547710000000000299483003

Florida Power & Light Company
PO Box 925576
Miami, FL 33102

Please request changes on the back.
Notes on the front will not be detected.

27
2,3,4,7,8 4118 6
NO *** AUTO **CO 4501 116049 Z
3380485818#
REACH FL 33495-1504

The amount enclosed includes the following donation:
FPL Care To Share \$

Make check payable to FPL in U.S. fund
and mail along with this coupon to:

FPL
GENERAL MAIL FACILITY
MIAMI FL 33168-0001

Account number	Total amount you owe	New charges due by	Amount accepted
	\$295.43	Jul 16 2008	\$

Additional activity (+ or -)	Balance before new charges (=)	New charges (+)	Total amount you owe (=)	New charges due by
CR 0.00	0.00	295.43	\$295.43	Jul 16 2008

Amount of your last bill		
Payment received - Thank you		
Balance before new charges		
New charges (Rate: RS-1 RESIDENTIAL SERVICE)		328.10
Electric service amount		328.10C
Gross receipts tax		\$0.00
Storm charge		
Franchise charge	251.15**	
Utility tax	2.50	
Late payment charge	6.51	
Total new charges	15.75	
	4.92	
Total amount you owe		\$295.43

* A late payment charge of 1.50% will apply if not paid by July 16, 2008, and your account may be subject to being billed an additional amount.
- Would you like one less bill to think about & help the environment? Please call in FPL Automatic Bill Pay & your bill is always paid on time. Save time, postage, check writing & paper. Plus, cut fuel consumption of cars & trucks that transport checks. Enroll at FPL.com or see authorization form in this bill.

Please have your account number ready when contacting FPL.
Customer service: (561) 994-8227
Outside Florida: 1-800-225-3545
To report power outages: 1-800-4CUTAGE (468-8544)
Hearing/speech impaired: 711 (RELAY)







KILOWATTHOURS

• 60 200 240V 3W • TYPE J55 - 350

DE 4354620

sensing feedback

hydrosense



electrisense



gassense





coffee

bean grinder

refrigerator

microwave

Distributed Direct Sensing

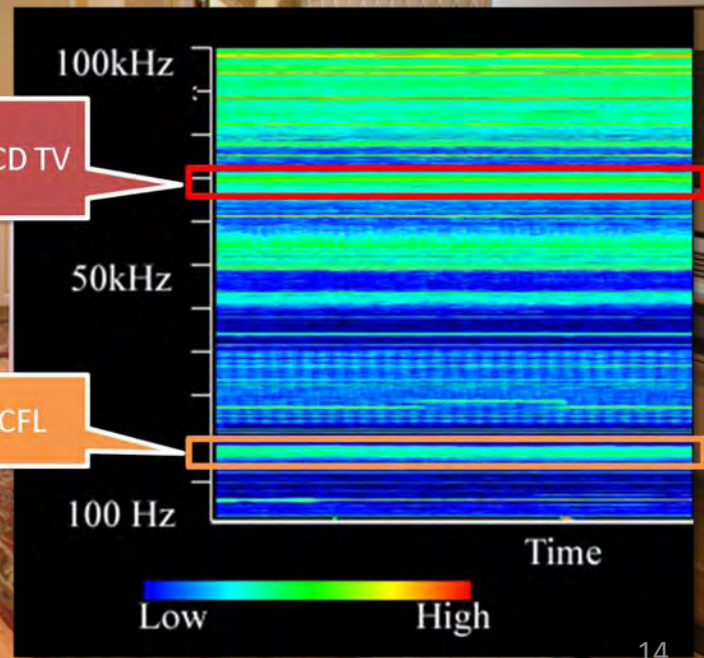
Single-Point Sensing

Single Plug-in module



Device 2: LCD TV

Device 1: CFL



Water Sensing



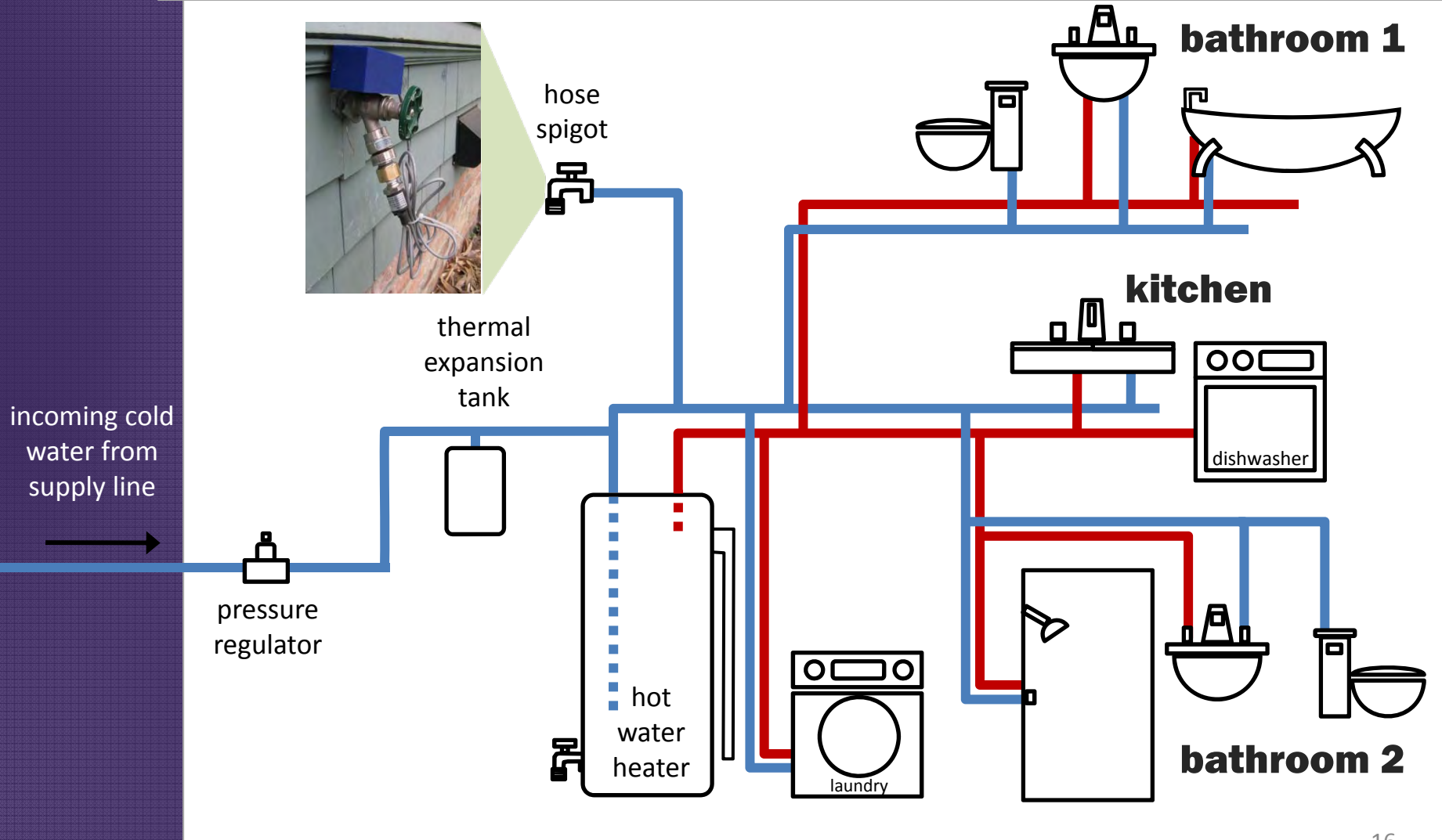
- Single-point sensor of water usage
- Identifies water usage activity down to a fixture level (e.g., toilet)
- Provides estimates of flow at each fixture

hydrosense



water tower

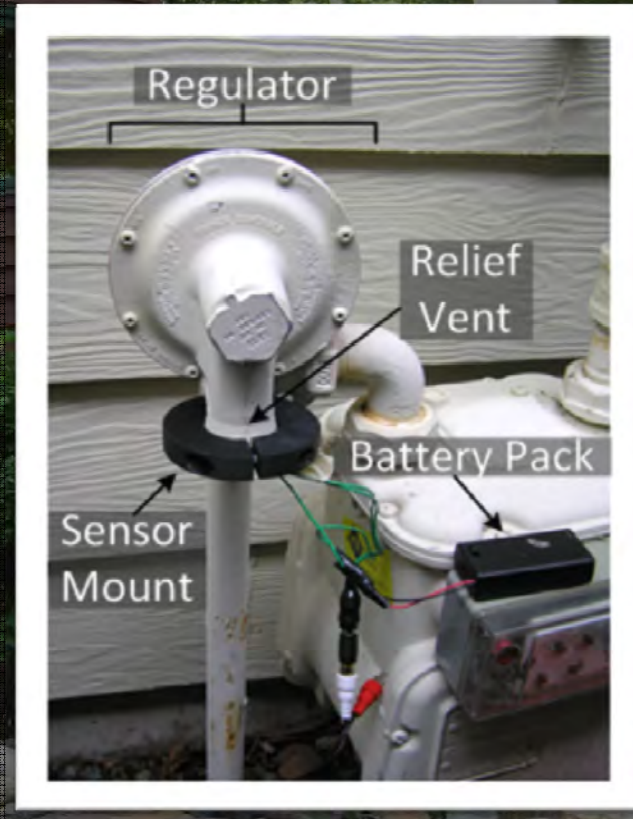
Closed Pressure System



Gas Sensing



GasSense



In-home Validation

- Performance benchmarks in real homes
- Non-expert deployments
 - Evaluated the installation procedure by homeowners and end-users
 - Mental models
 - Installation times

Other CS Challenges

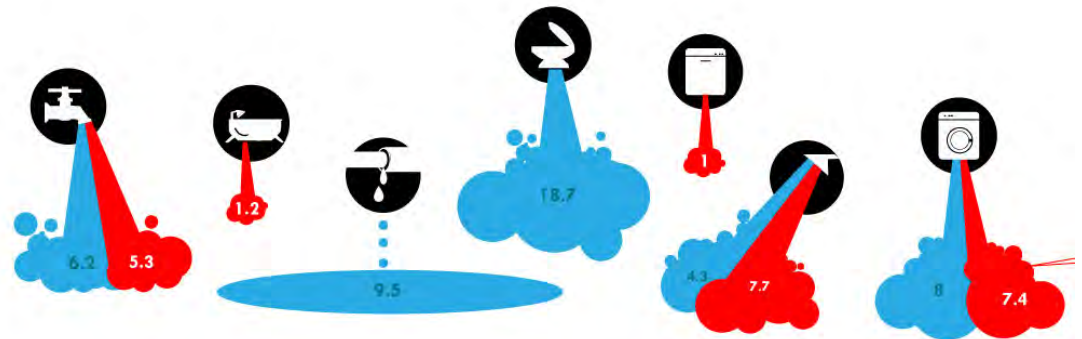
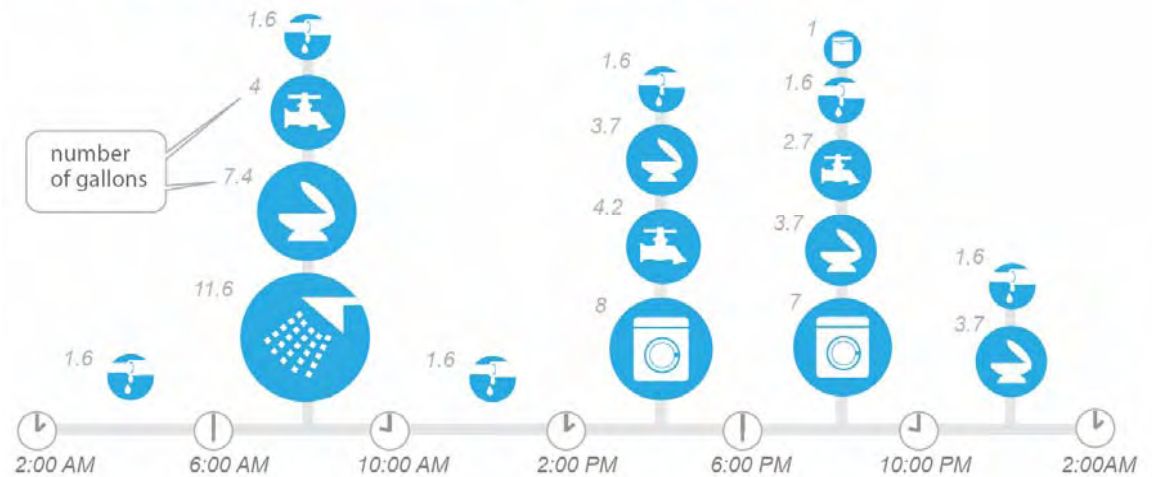
A person is working on a laptop in a laboratory setting. The person's hands are visible, and they are wearing a watch. The laptop screen displays a dark interface with some faint lines. The background is a laboratory bench with various equipment and cables.

- **Signal processing and machine learning**
- **Embedded Systems**
- **Network and backhaul infrastructure**

Feedback Interfaces



TODAY's water usage (in gallons)



Home Recommendations Energy Data

my hohm center | home profile | my news

My Hohm Center

How energy-efficient home? Let's

When you fill out your energy provider home energy report recommendations.

Complete Your



Google™ POWERMETER

Home Electricity Use



Available

Energy Cost Breakdown



Annual Energy Costs In Your Area



Making it Available

Zensi, Shwetak Patel's Energy Monitoring Startup, Purchased by Belkin

Zensi, an energy monitoring company based on technology developed by UW CSE professor [Shwetak Patel](#) and collaborators, has been purchased by Belkin.

Zensi's technology was licensed from the University of Washington and from the Georgia Institute of Technology, Patel's Ph.D. institution. The technology includes single-point-of-attachment sensors for electrical power, water, and natural gas — a single sensor in a home or business uses signal processing and machine learning to identify sources and rates of consumption. This dramatically reduces the cost of instrumenting the home or business and providing occupants with the information they need to behave in more economical and environmentally responsible ways.

xconomy | Seattle
Business + Technology in the Exponential Economy

Seattle Home | Local Events | Blogroll | Jobs | xconomists

STARTUPS, CLEANTECH, DEALS

UW Prof Shwetak Patel's Energy Startup, Zensi, Bought by Belkin

Gregory T. Huang 4/21/10

Zensi, an energy monitoring startup co-founded by University of Washington assistant professor Shwetak Patel, has been acquired by Belkin, the computer hardware and wireless company based in the Los Angeles area. Financial terms of the cash deal weren't given. The news was reported earlier today by CNET.

Patel co-founded Zensi in 2008 while he was in graduate school at Georgia Tech in Atlanta, but he has continued to develop the technology at UW as a faculty member in computer science & engineering and electrical engineering. The company's technology includes sensors that you plug into a wall outlet to measure the amount of electricity used by each appliance or device in a home. Zensi's similar systems for water



cnet news

Latest News

CNET River

Webware

Crave

Business

Home > News > Green Tech

Green Tech
Edited by Martin LaMonica



April 21, 2010 5:35 AM PDT

Belkin buys crafty power-tracking start-up

by Martin LaMonica

Font size Print E-mail Share

109 retweet Share 10 1 digg

Electronics and wireless equipment maker Belkin is getting deeper into energy management as it acquires a company with technology that detects how electricity is used within a home. 23



The company, called Zensi, was founded by academics-



Thanks!

•Questions?