

# User Interfaces for Energy Efficiency

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**Low-Res Online Version**

# User Interfaces for Energy Efficiency

The background image shows a brick building with several windows. In the foreground, there is a utility pole with alternating red and white horizontal stripes. The pole is surrounded by construction barriers, including a red and white striped barrier and a red traffic cone. A dark car is parked in the background. The scene appears to be an outdoor construction or utility site.

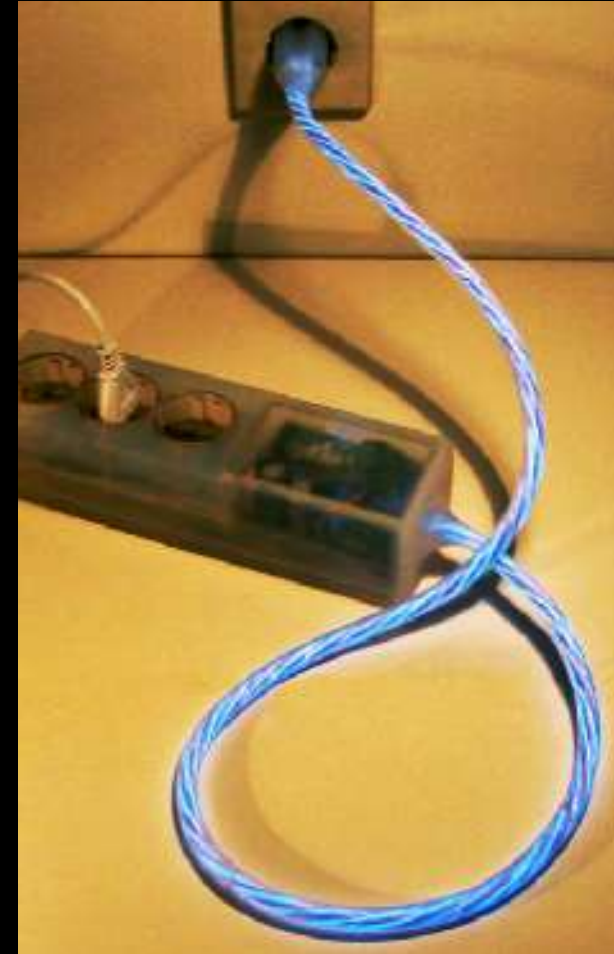
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# What is this about?

A survey to provoke ideas about such things as:

- Glowing power cords
- Web 2.0 Karma points
- Washing mashines that know when the sun is going to shine



A. Gustafsson, M. Gyllenswärd.  
The Power-Aware Cord: Energy Awareness through Ambient Information Display. CHI 2005

J. Mankoff et al. Leveraging Social Networks To Motivate Individuals to Reduce their Ecological Footprints. HICSS 2007

# Outline

- The academic field
- Potential benefits
- Three main themes
  - Sensing and acting
  - Feedback and sociodynamics
  - Smart control
- Potential collateral damage
- Research ideas

# The Academic Field



# Growing Activity

C. Seligman, J. M. Darley. Feedback as a Means of Decreasing Residential Energy Consumption. J Appl Psy 1977



CHI 2007: Environmental Sustainability and Interaction

Ubicomp 2007: Ubiquitous Sustainability: Technologies  
for Green Values

CHI 2008: Beyond the hype: sustainability & HCI

CHI 2009: Defining the Role of HCI in the Challenges of  
Sustainability

Pervasive 2010: Energy Awareness and Conservation  
through Pervasive Applications

# Interdisciplinarity

Art  
Architecture  
Industrial Design  
Sociology  
Psychology  
Ergonomics

Human-Computer Interfaces  
Data Visualization

Sensors & Actuators  
Power Electronics  
Networks & Communication  
Air Conditioning  
Control Systems  
Intelligent Systems  
Signal Processing  
Information Systems  
Data Mining

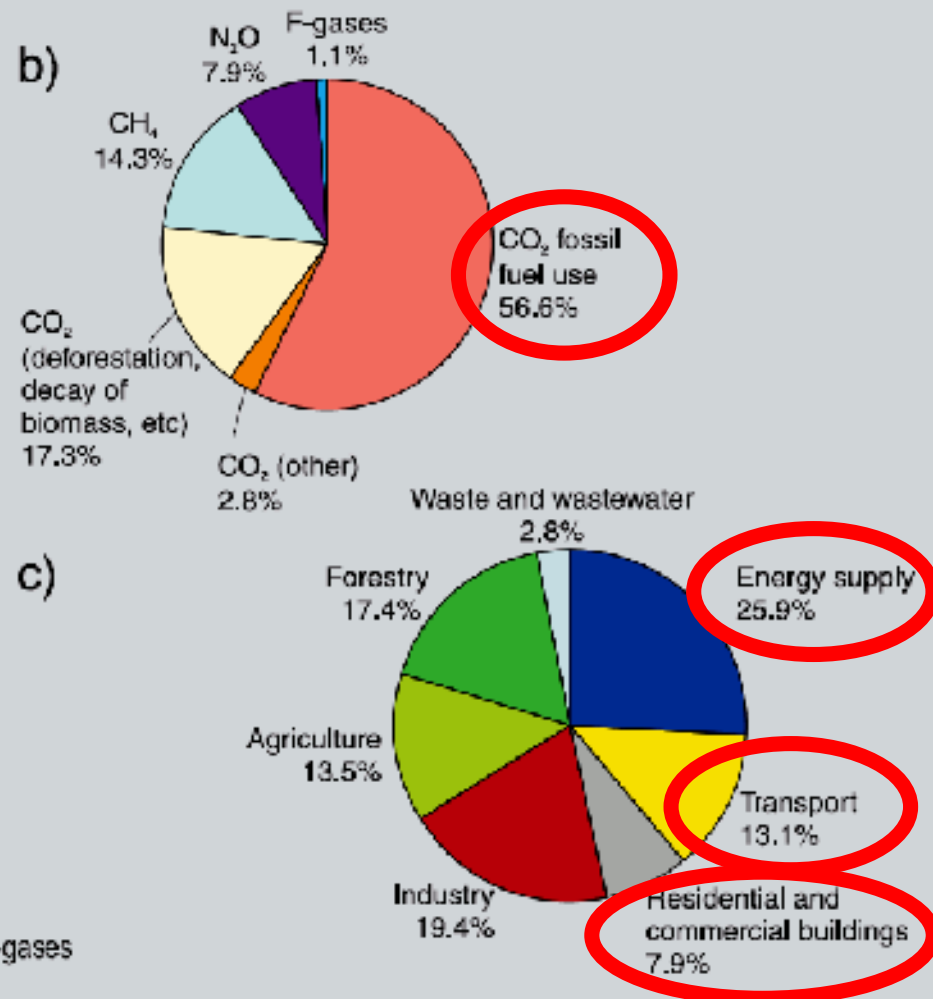
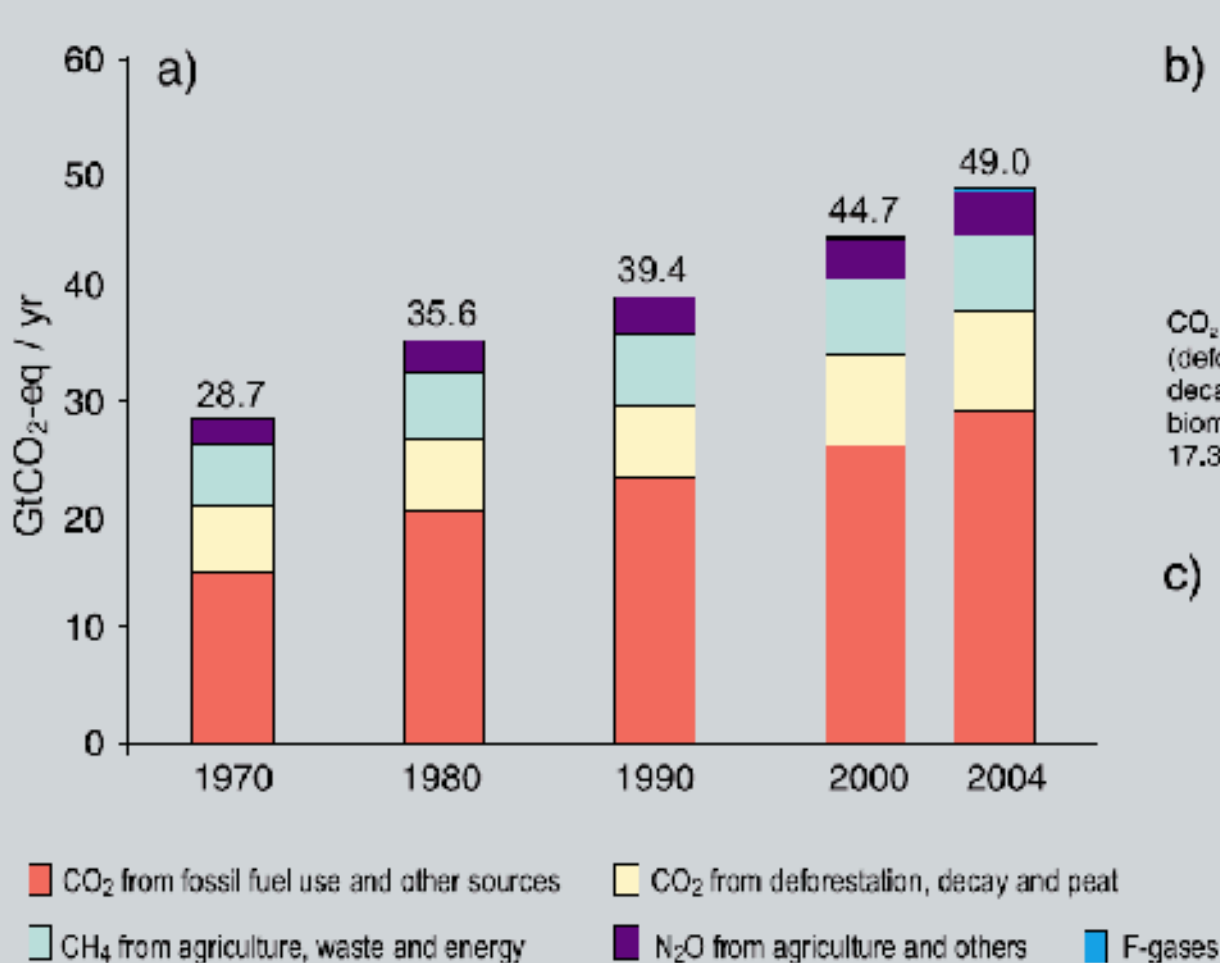
Pervasive Computing  
Mobile Computing

... which motivates  
me academically.

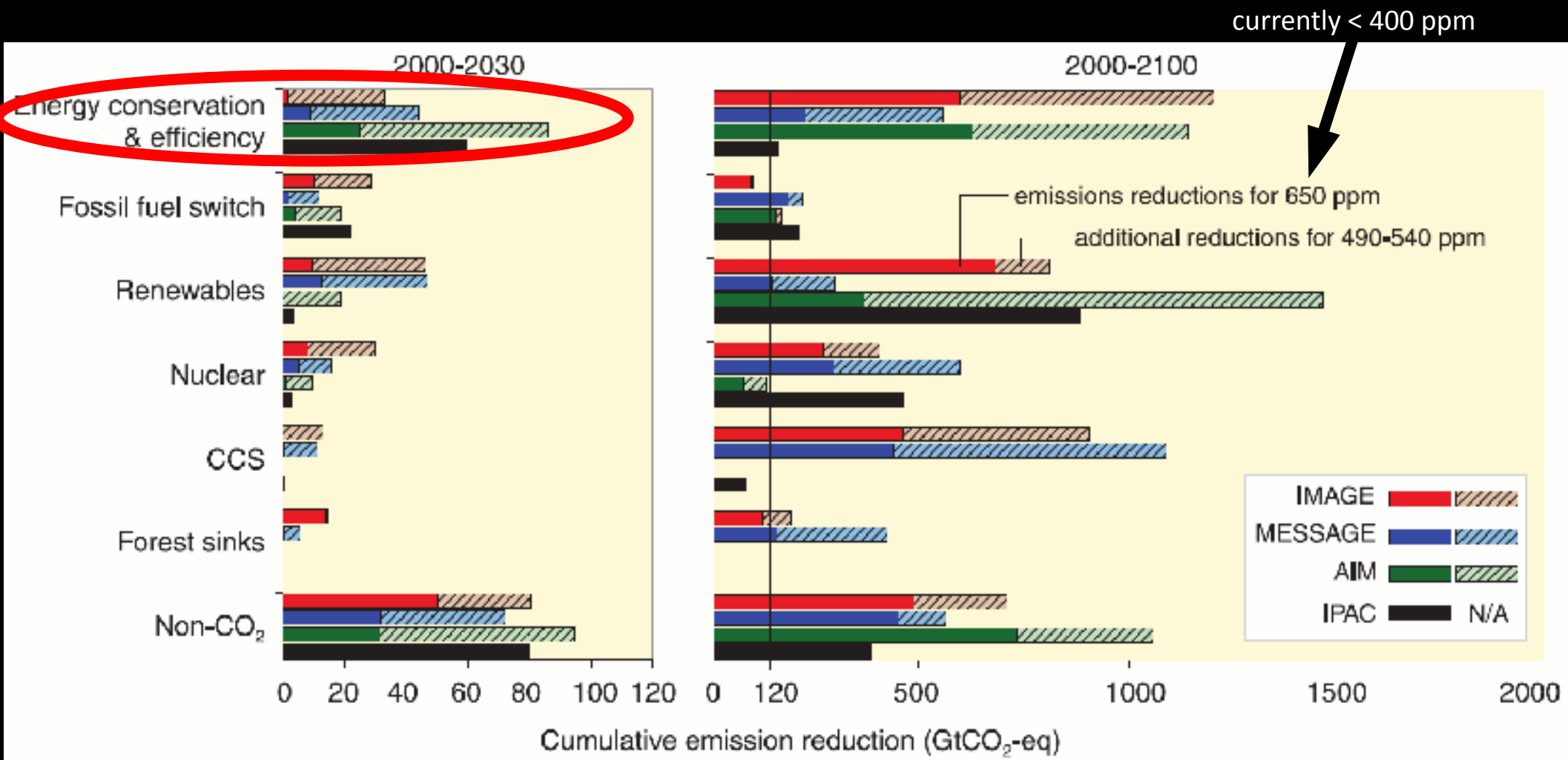
# Potential Benefits



# Why We Feel Queasy



# Why We Feel Queasy



# Three Main Themes

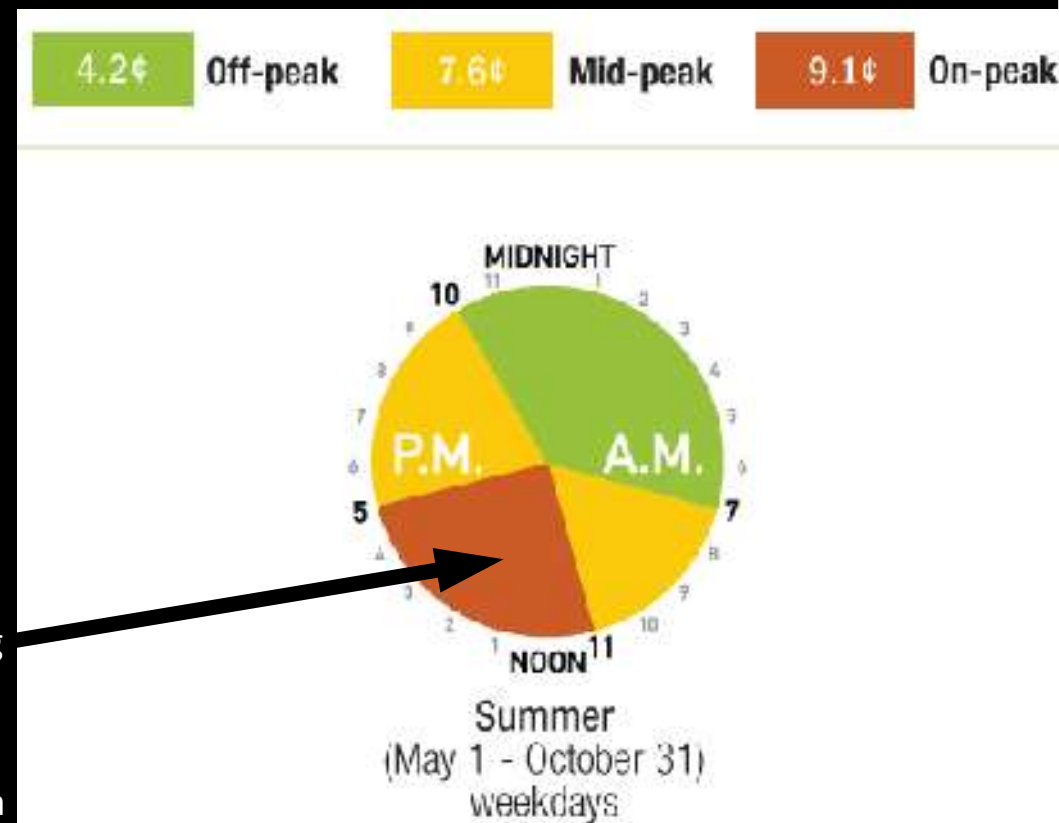
- Sensing and acting
- Feedback and sociodynamics
- Smart control

# Smart Meters for Electric Power

- Power meter reports consumption to the utility
- Supports time-of-use (TOU) pricing (otherwise, a plug-in load meter would work as well)



EnBW





# Smart Meters for Electric Power, cont'd

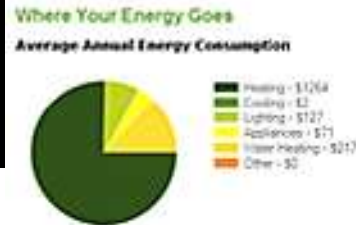
Data can be sent to the user locally or via the Internet



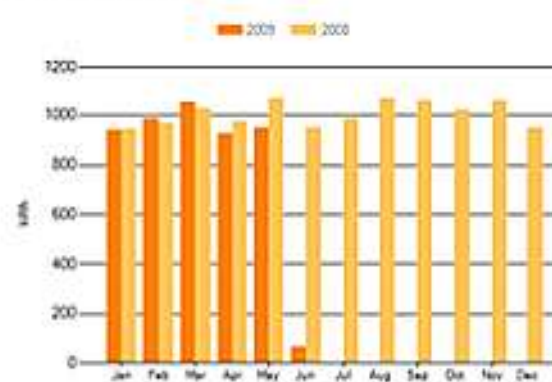
**Summary of Potential Savings**

Thank you for using our service. You can use the following upgrades and repairs. You may want to consult a professional.

Your average annual energy costs are **\$1682**. This does not include auxiliary energy usage such as propane.



Annual Electricity Usage



Average Cost per kWh \$0.097



- Analyze:** Get better information about how you use energy and what you can do to be more efficient.
- Save:** Reduce your energy bills and carbon footprint by making smart decisions about your energy use.
- Share:** Shake up a little friendly competition to see how your energy consumption compares to your friends and neighbors.

Microsoft Hohm

Google PowerMeter

EnBW

# Smart Meters for Electric Power, cont'd

- Market penetration: Sweden: 100%, Germany: 1%  
M. Sánchez. Pilots Projects on ICT for Energy Efficiency in Social Housing. EU Sustainable Energy Week 2009
- But new rulings in Germany
- Communication:  
customer's DSL line? GPRS? Powerline?
- Data exchange formats?
- How to extend to natural gas and to water?
- Price? Installation? Maintenance?

# Sensing & Control as Installed Today

- Building automation: KNX bus
- Remote control of appliances: Miele@home
- Classical GUIs, but that could change



Busch-Jäger  
Comfort Panel



GIRA Homeserver

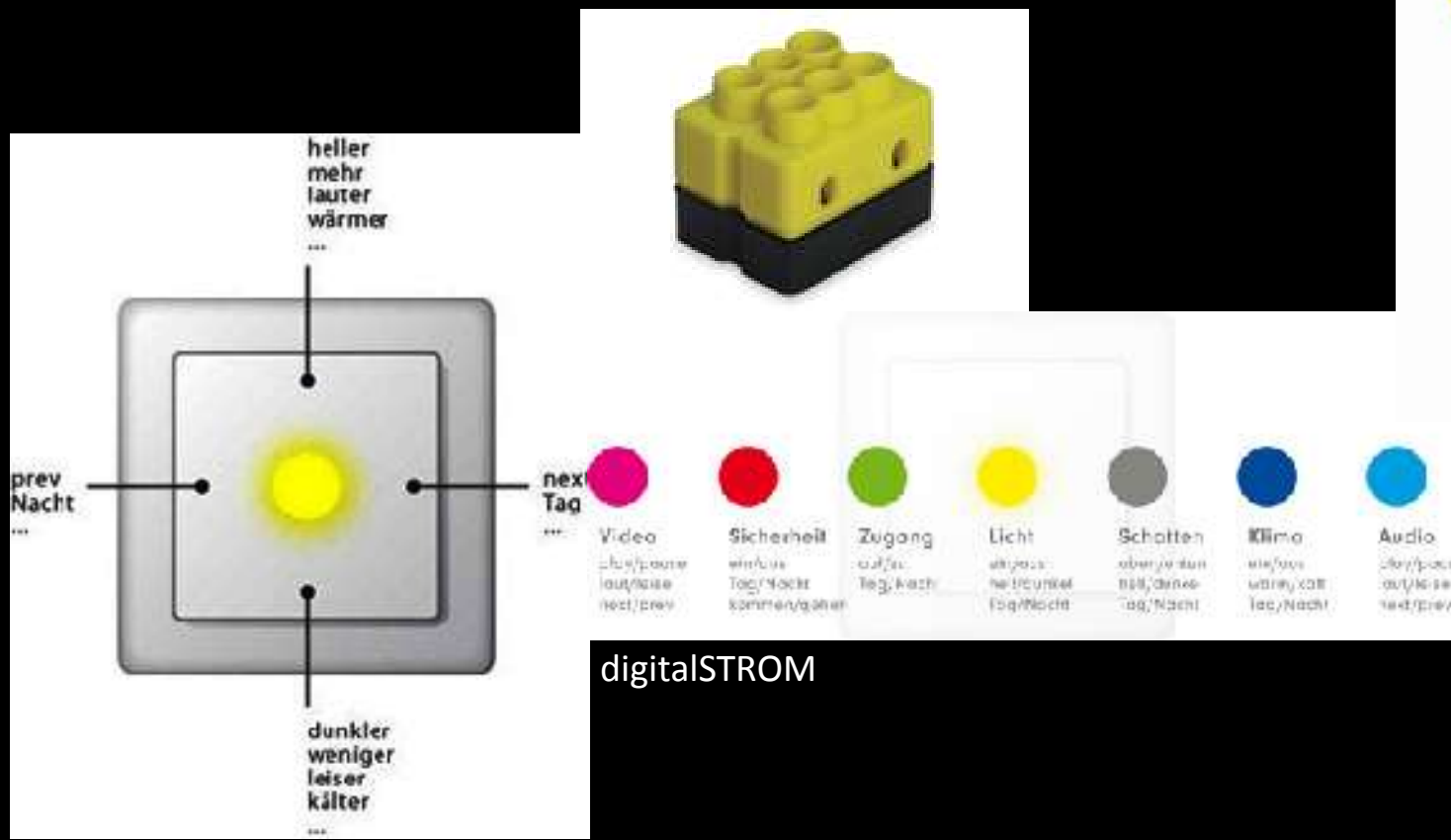


# Retrofitting Sensors & Control

- Add data acquisition to standard meters
- Reuse existing electrical installation



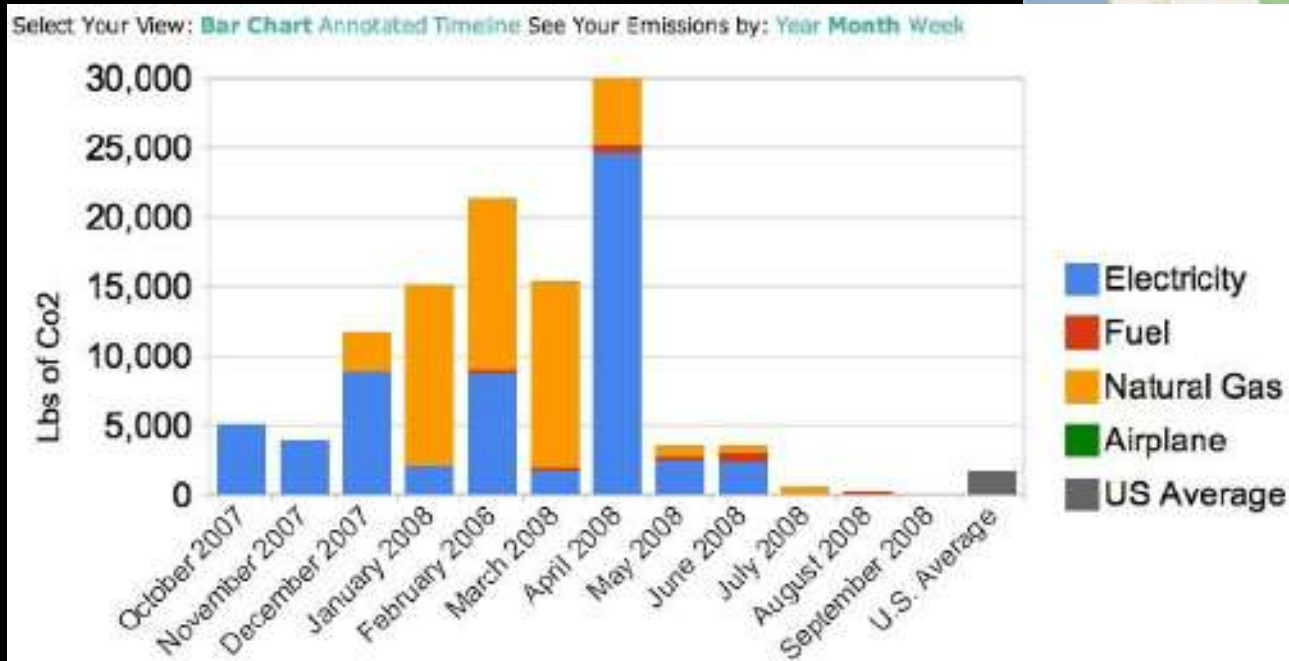
Blue Line Innovations  
Power Cost Monitor





# Sensing without Sensors

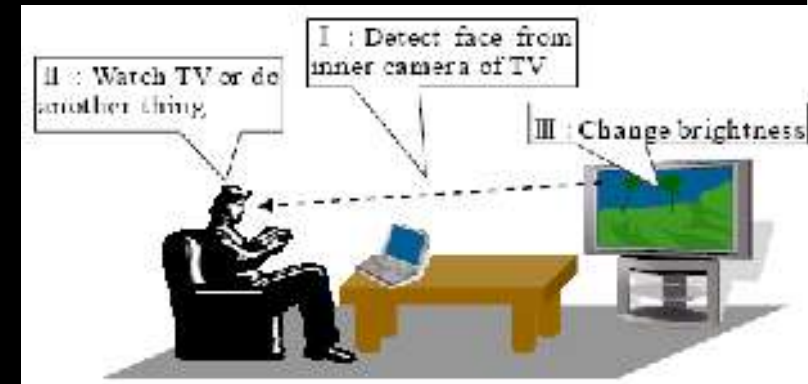
Computing one's eco footprint  
from personal finance manager data



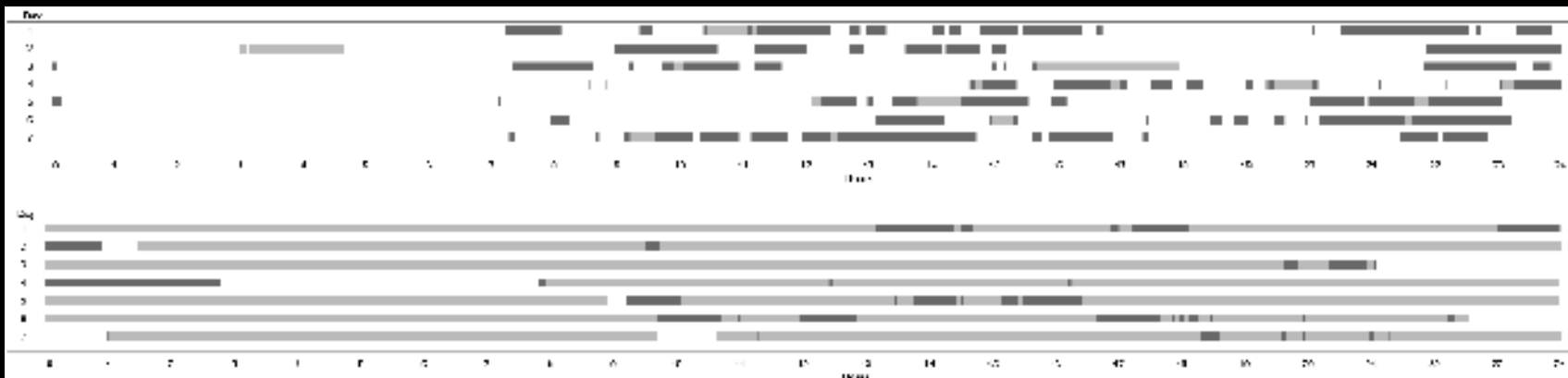
J. Schwarz et al. Reflections  
of Everyday Activities in  
Spending Data. CHI 2009

# Devices that Turn Themselves off

- TV set turns off on no motion (Sony)
- TV set turns dark if all eyes are turned away
- PC power management



R. Ariizumi et al.  
Energy Saving of  
TV by Face  
Detection.  
PETRA 08



# Three Main Themes

- Sensing and acting
- Feedback and sociodynamics
- Smart control

# Persuasive Design

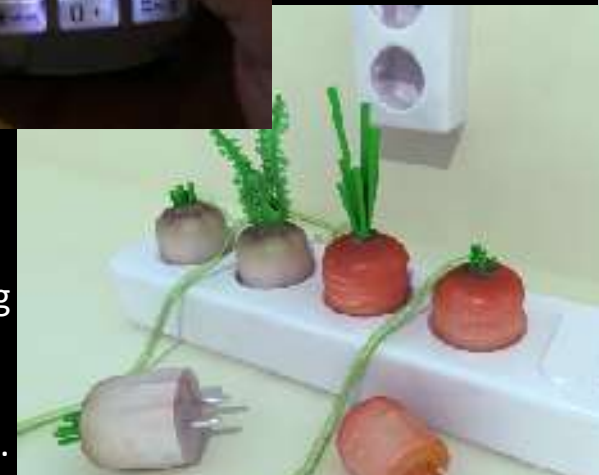
- Facts plus an opinion
- Includes ambient displays, games



M. Bang et al. Promoting new Patterns in Household Energy Consumption with Pervasive Learning Games. Persuasive 2007



K. Kappel, T. Grechenig. "show-me": Water Consumption at a glance to promote Water Conservation in the Shower. Persuasive 09



M. Sohn et al. Designing with Unconscious Human Behaviors for Eco-friendly Interaction. CHI 2009





# Artistic Renderings

Rendering energy usage  
visible, audible, touchable



A. Ernevi et al.  
Erratic Appliances and  
Energy Awareness.  
NordiCHI 05



Nuage Vert Project



S. Backlund et al.  
The Aesthetics of  
Energy in Everyday  
Things. IADE 2006

# Social Mechanics

- Comparison, competition
- Discussions, advice
- Commitments
- Criticism

C. Midden, J. Ham. Using Negative and Positive Social Feedback From a Robotic Agent to Save Energy. Persuasive '09



www.wattzon.com

CONTROLE

- Waterfaan: [slider]
- Waterbeve: [slider]
- Droering: [slider]
- Vergroen: [slider]

35 TEMPERAATUR CENTRIFUGEREN VERDOP EBERGE

36 C 1500 rev/min

30 C 1200 rev/min

70 C 900 rev/min

50 C 600 rev/min

40 C 400 rev/min

30 C 200 rev/min

Well Zander centrif. Persoon Sani-fluorator



M. Shiraishi et al. Using Individual, Social and Economic Persuasion Techniques to Reduce CO2 Emissions in a Family Setting. Persuasive 09

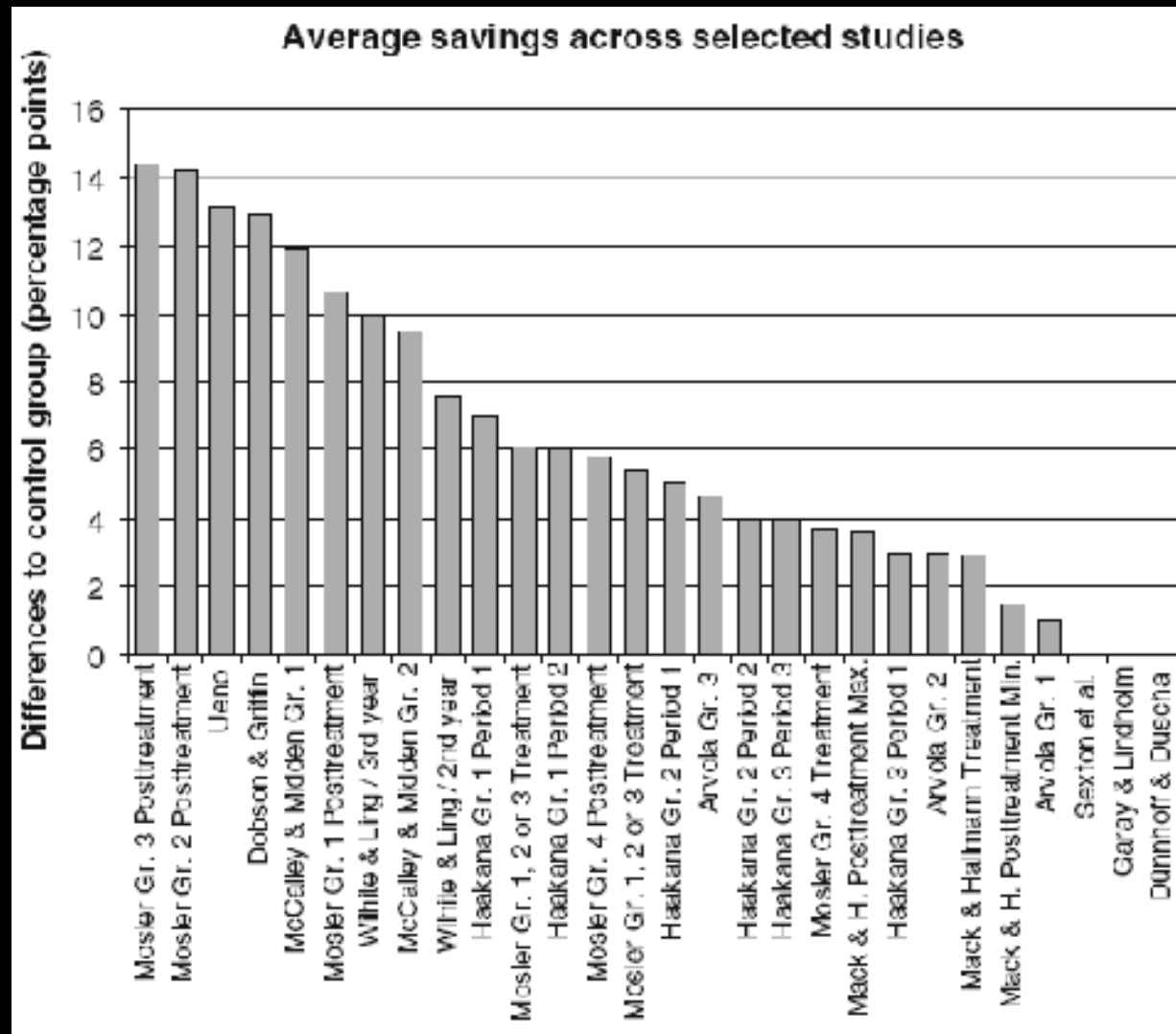
Name	Dollar / CO2 savings	Bank Updated	Comments
Turn off the lights when you exit the house in the morning for the day.	\$6.26/year \$7.04 /day/year	1	Discuss
Don't feed the fish-bushered w...	\$8.00/year \$0.25 /day/year	2 10 Sep 3 comments	Discuss
Turn off the lights if you are leaving a room for more than 10 minutes.	\$8.02/year \$0.22 /day/year	3	Discuss
Recycle glass.	\$8.09/year \$22.50 /day/year	4	Discuss
Use a metered shower instead of an un-metered one.	\$8.16/year \$2.76 /day/year	5 21 Jul 1 comment	Discuss
Set your home computer to automatically hibernate/sleep after a short period of inactivity.	\$8.58/year \$1.70 /day/year	6 18 Jun 3 comments	Discuss
Turn off the TV if you are not watching it.	\$8.76/year	7	Discuss

www.stepgreen.org

# A Sizeable or a Debatable Effect?

- Feedback alone: some percent?
- For comparison:  
Photovoltaic energy in Germany  
< 1% despite  
billions € seeding

C. Fischer. Feedback on household electricity consumption: a tool for saving energy? Energy Efficiency (2008)



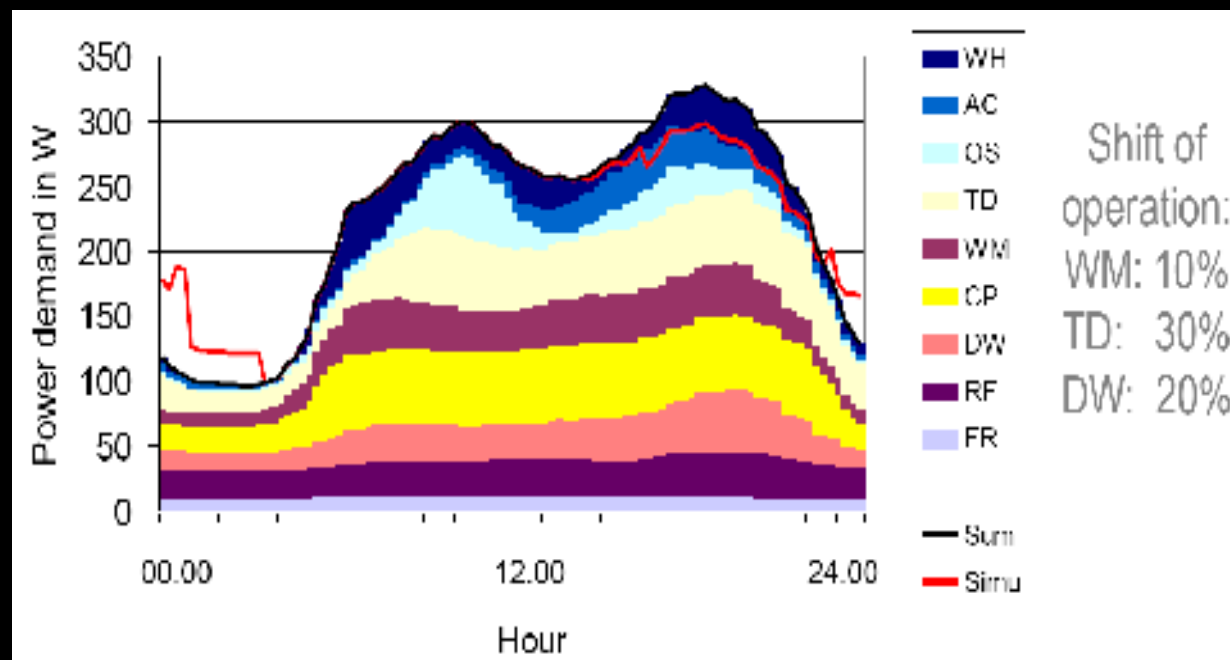
# Three Main Themes

- Sensing and acting
- Feedback and sociodynamics
- Smart control

# Demand-Side Management

- Shave off peaks through automated scheduling of home appliances (smart grid)
- Potential to save 100 W per household = 30 conventional power plants in Europe?
- User Interfaces:  
How much control?

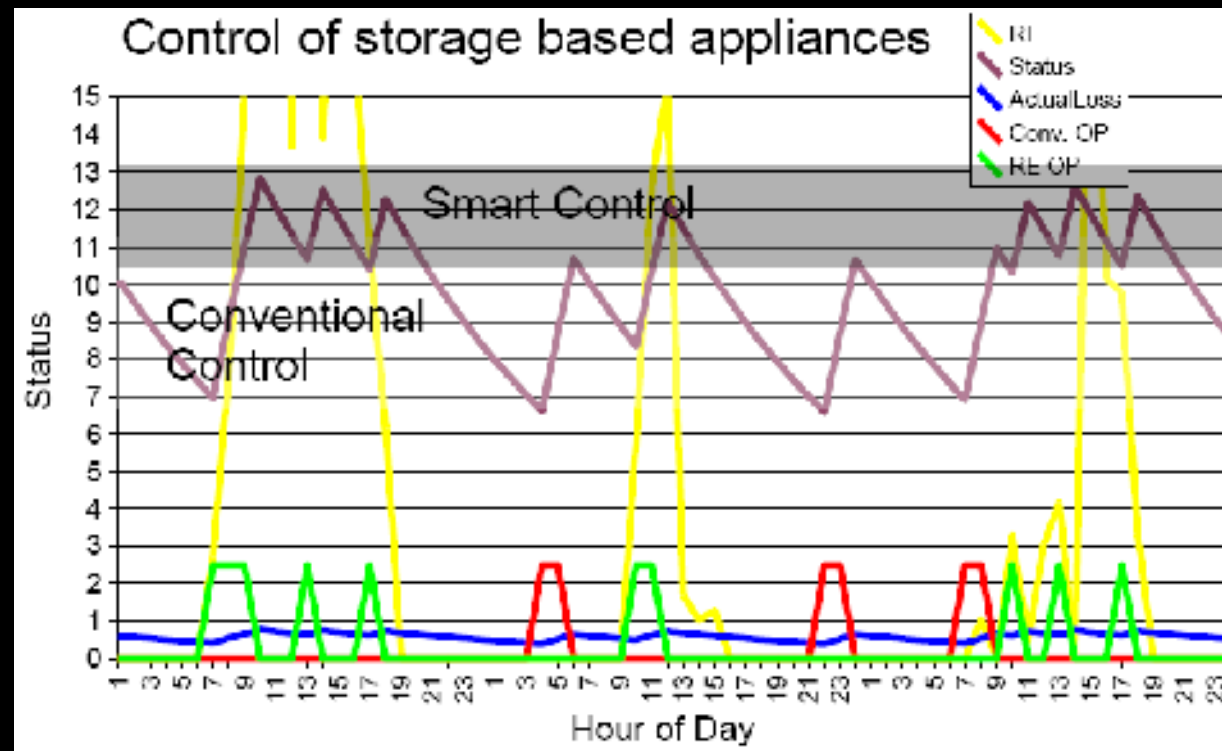
R. Stamminger. Smart Use of Domestic Appliances in Renewable Energy Systems. EEDAL 09





# Demand-Side Management, cont'd

- Increasing use of wind and solar power: high temporal fluctuations of available energy
- Adapt use to local energy sources, possibly speculative (weather report?)



C. Möllering. Local Energy & Smart Appliances. Impact of Smart Appliances on the use of Locally Generated Renewable Energy. Smart-A 2009

# Demand-Side Management, cont'd

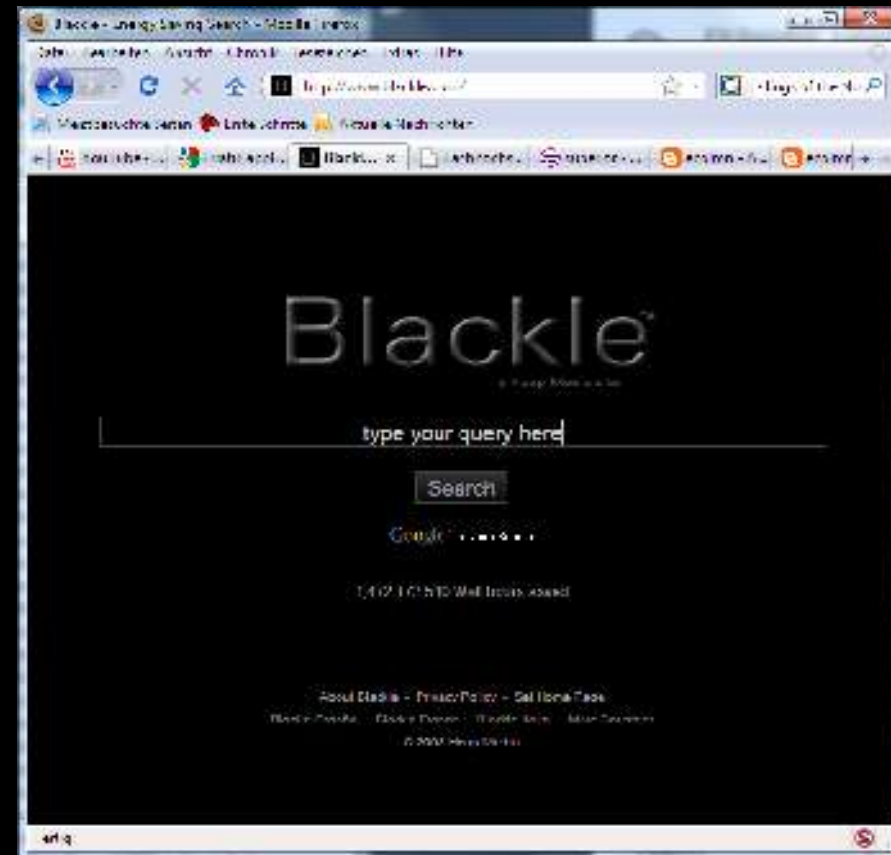
- Increasing load on power grid from electric cars?
- Use them for demand-side management and as buffers
- Profit of US\$ 135,000 to 450,000 per year for 250 electric cars

J Tomic, W. Kempton. Using Fleets of Electric-Drive Vehicles for Grid Support. J Power Sources 2007

# Potential Collateral Damage

# Should We Go for Minor Effects?

- Some computer displays consume a few watts less with a black background
- Save about 30 Ws  
= 0.000008 kWh  
for a single Web search
- 200,000,000 queries per day:  
1.6 MWh/day = 70 kW saved
- Eyes and displays strained by frequent switching?



# Odd Counter-Effects

- Wireless power for TV sets:  
losses around 30%, only for less clutter
- Rebound effect?
- Buying new stuff worse than keeping the old?  
Ecological damage over product lifetime?
- Washing machines at low temperature:  
Highly polluting detergents?  
Development of germs?
- ...



# Sometimes, less Tech may be best

- Low-tech may be cheaper, more robust, easier to understand, and require less energy in production
- Do we need ventilation when we can open the windows?
- Do we need electrical shades?
- Could we have lunch when the sun is brightest?
- Promising for less industrialized countries:
  - Save resources
  - Create employment

# Research Ideas

# Research Ideas

- Recommender systems for washing, cooking
  - Sensor data (fridge's content, weather report, ...)
  - Machine learning (usage patterns)
  - Social webs (suggestions, recipes, ...)
- User Interfaces for demand-side management
  - Balance control between user and grid
  - Manage the level of detail presented
  - Plan ahead but be flexible

# Research Ideas, cont'd

- Optimize schedules (meetings, classes, travel, ...) with respect to energy use and personal preferences
  - E.g., arrange a meeting so that the sum of energy spend for travel, air conditioning, etc. is minimum
  - Updates needed if estimates change
  - How to enter personal preferences?
- Get rid of (regular) human-computer interfaces?
  - Could there be a “Do what I mean” button?
  - Or even no button at all?
  - Again: flexibility vs. complexity in the UI

**Thank you!**

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