The Energy Efficiency Gap: Evidence and Policy Insights

Energy Economics Seminar

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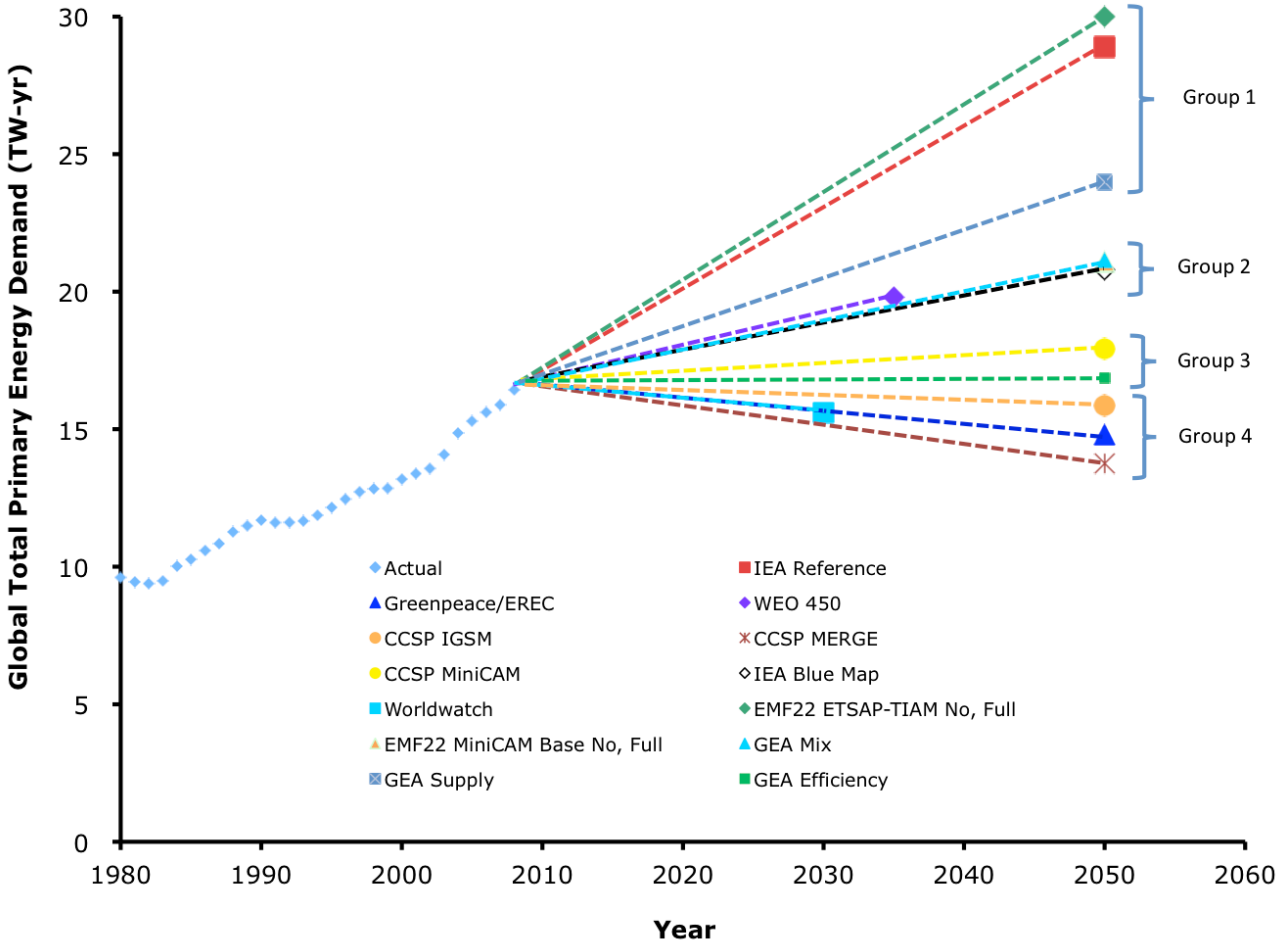
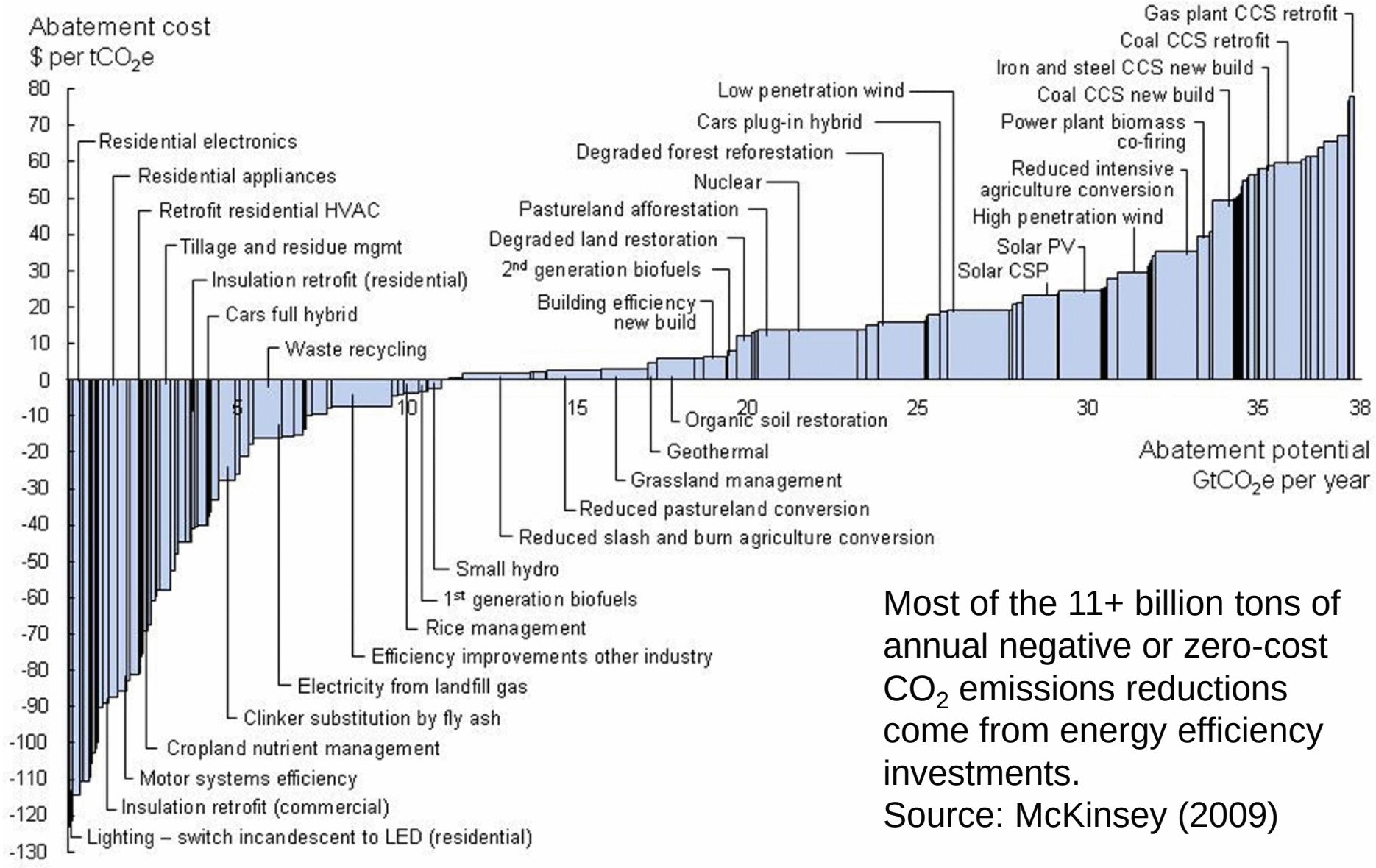
The Climate Challenge: Flatten Energy Demand



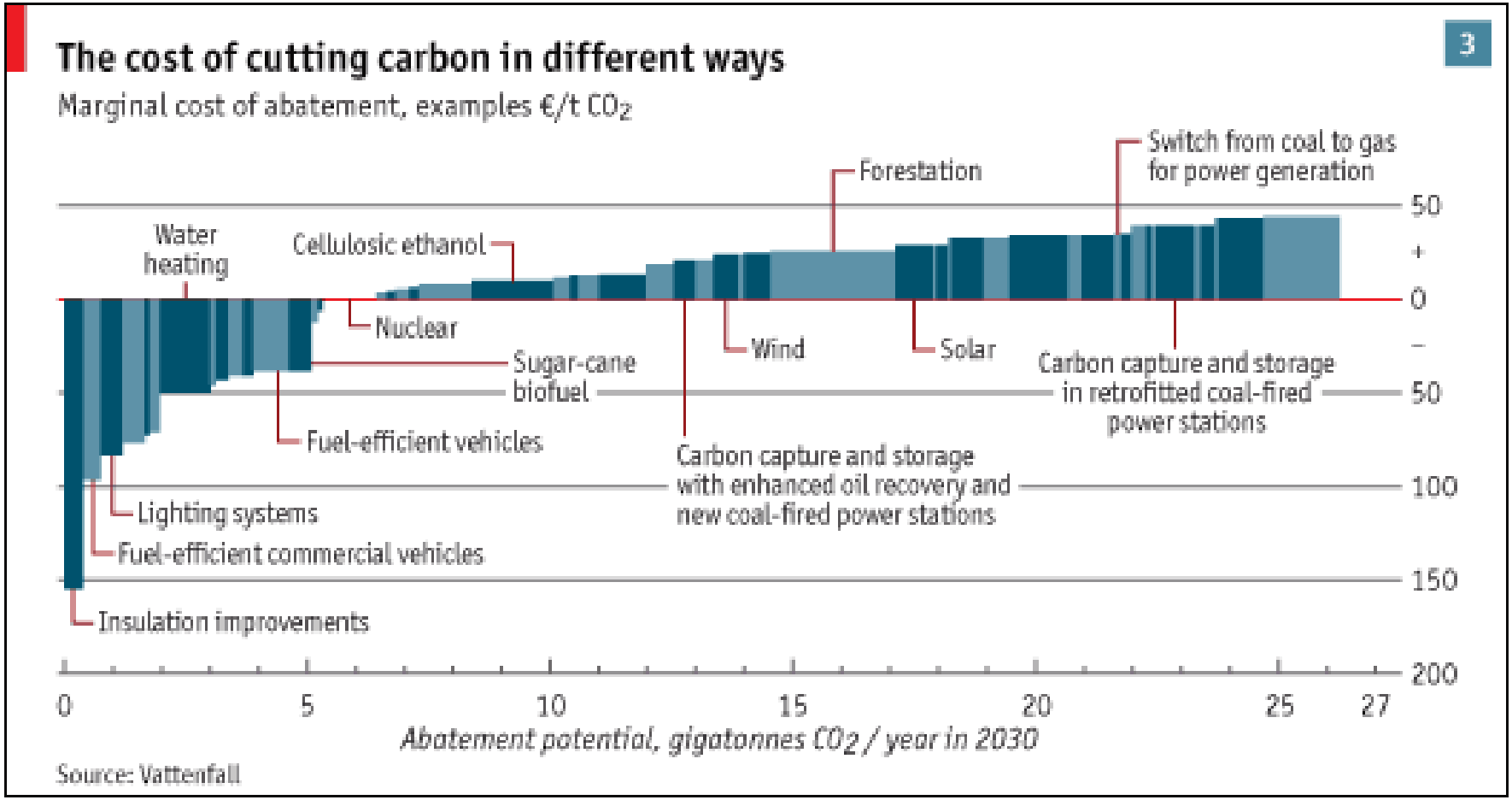
Contribution from Energy Efficiency?



Most of the 11+ billion tons of annual negative or zero-cost CO_2 emissions reductions come from energy efficiency investments.

Source: McKinsey (2009)

Global Cost Curve by Vattenfall



Key Policy Questions

1. What is behind these negative cost investments?

2. Why are markets inefficient here?

3. What is the optimal policy for energy efficiency?

“The Energy Efficiency Gap”

What is this so-called gap? All of these:

- Individuals make decisions about energy efficiency that leads to a slower penetration of energy efficient products into the market *than might be expected* if consumers made all positive net present value investments
- Consumers appear to use high *implicit* discount rates for energy efficiency purchases

Sometimes called the “energy efficiency paradox”

Let's Reconsider the Curves

Consider energy efficient lighting…

- How do we calculate the negative costs:
  - Start with the upfront cost of the more efficient lighting
  - Take the energy bill savings in each year
  - Apply a discount rate to those future cash flows
- Voila! We have the NPV of the investment

Neoclassical Explanations

Why aren't those investments being made?

- Consumers appear to "undervalue" efficiency.

Perhaps the analyst is incorrect…

- There may be hidden costs
  - Search costs, time costs, value of foregone attributes, etc.
- Incorrect models of energy savings
  - Perhaps due to heterogeneity in consumers
  - Ignoring the rebound effect
- Uncertain future energy savings
  - Irreversibility of energy efficiency investments

Neoclassical Explanations

Perhaps there are market failures:

- Capital market failures
  - Liquidity constraints
- Information problems
  - Asymmetric information
  - Lack of information
  - Principal-agent problems (i.e., split incentives)
  - Learning-by-using
- Innovation market failures (on the supply side)
  - R&D market failures
  - Learning-by-doing spillovers

But Consider Chetty et al. (2009)

- Field experiment at a grocery store
- Post tax-inclusive price tags instead of tax-exclusive price tags
- Survey to make sure that consumers understand the tax
- Find that increases in taxes included in the posted prices reduce alcohol consumption more than increases in taxes taken at the register

In other words: consumers appear to be *inattentive*

Behavioral Anomalies

These are *any* deviation in behavior from standard neoclassical assumptions

- Non-standard preferences
  - Self-control problems
  - Reference-dependent preferences (e.g., loss aversion)
- Non-standard beliefs
  - Systematically incorrect beliefs about the future
- Non-standard decision-making
  - *Limited attention*
  - Framing
  - Suboptimal heuristics

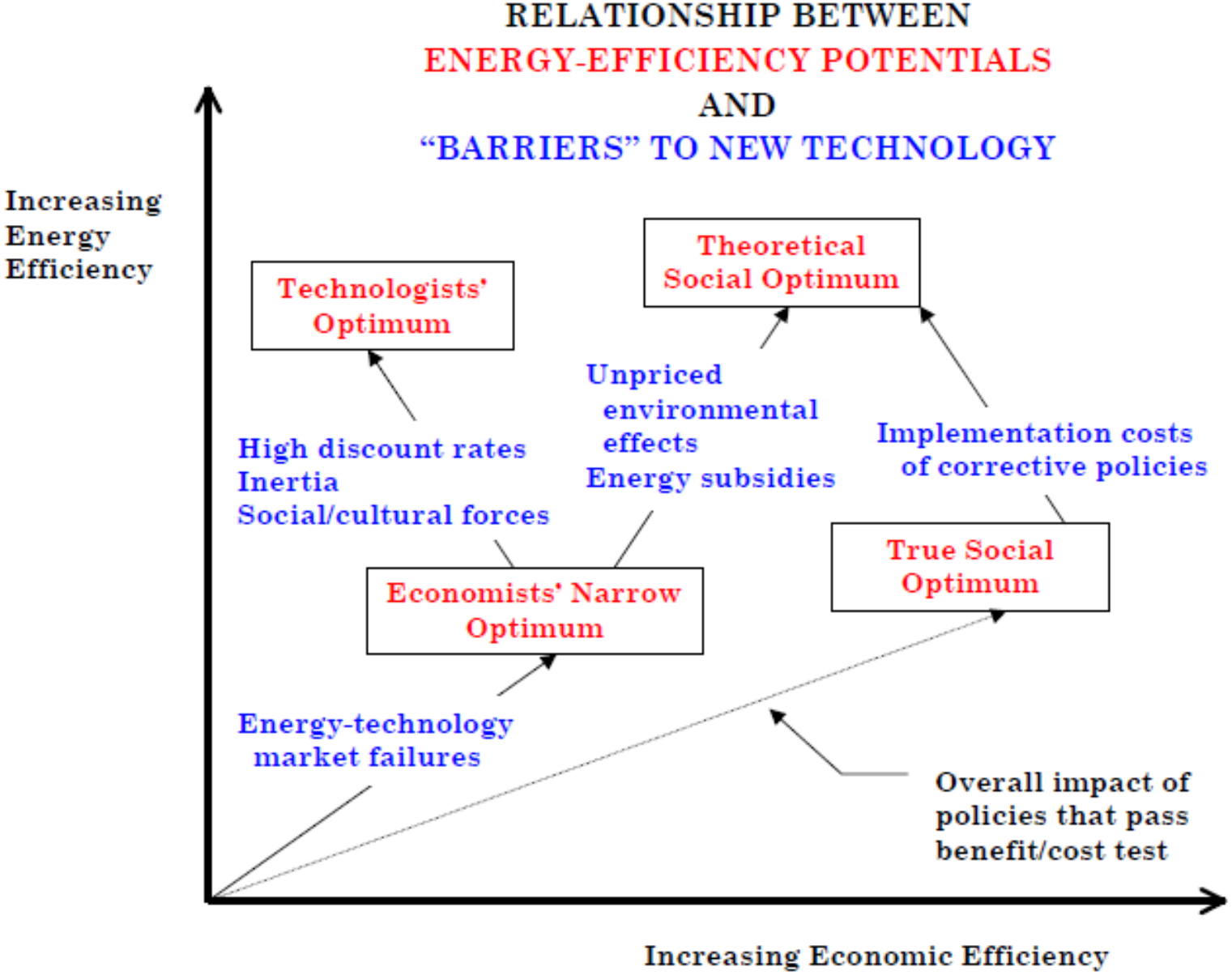
Behavioral Failures

Behavioral Anomaly – any deviation from the standard neoclassical assumptions

Behavioral Failure – a difference between *decision utility* and *experienced utility*

- Provides motivation for policy
- In the context of energy efficiency, also called "investment inefficiencies"

- Most, but not all, behavioral anomalies are behavioral failures
  - One exception could be reference dependent preferences
  - Non-standard beliefs *may* also be an exception



Adam B. Jaffe, 2000 AEA Session on IPCC

Evidence on Undervaluation

Growing body of evidence is mixed

- Mostly from autos in the United States
  - Busse et al. (2013) – no strong evidence for undervaluation
  - Allcott & Wozny (2014) – evidence of slight undervaluation
- Refrigerators in the U.K.
  - Cohen, Glachant, Soderberg (2014) – working paper results indicate some degree of undervaluation (22%)

Several further studies are underway…

Policy Options for Behavioral Failures

What do we do about behavioral failures?

- Information provision?
  - May work in some cases
  - Many types of information
- Product standards?
  - What about those who don't plan to use the product much?
  - What about those who did not face behavioral failures?

- "Nudges"?
  - E.g., reordering of choices, making a new "default" choice

Can we do "behavioral targeting" to focus policies on certain audiences?

Non-price Behavioral Interventions

Allcott and Mullainathan (2010)

- Take advantage of psychological features of human decision-making:
  - Social approval
  - Consumption
  - Feedback
  - Goal setting
  - Commitment

- Example: OPower
- Robert Cialdini's "Influence: The Psychology of Persuasion"

Information Provision

OPower uses an information program to take advantage of psychological features

- Social approval
- Goal setting

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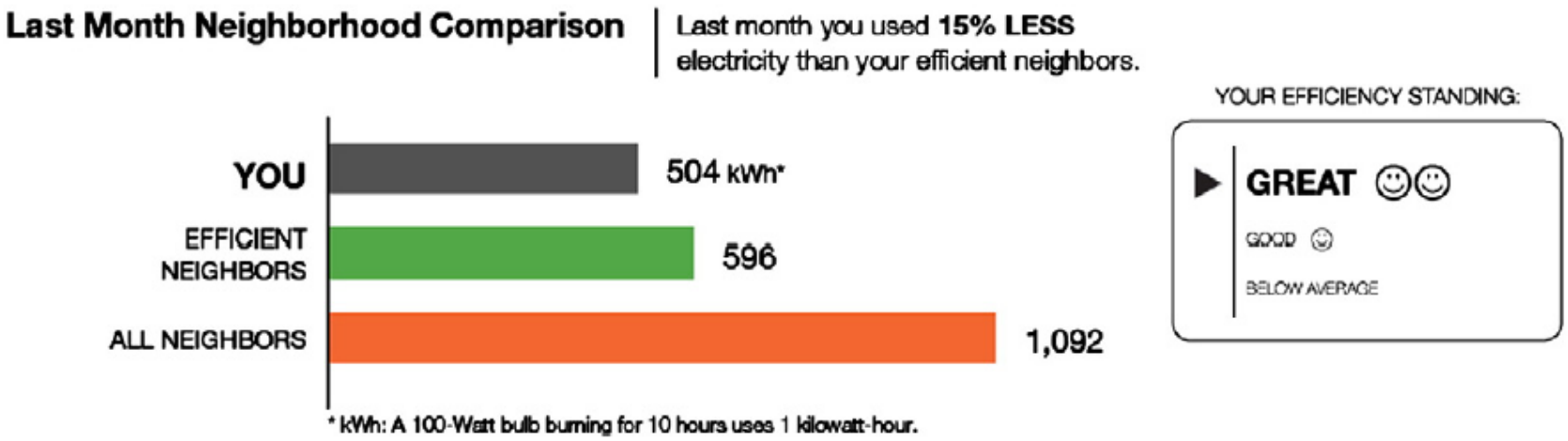
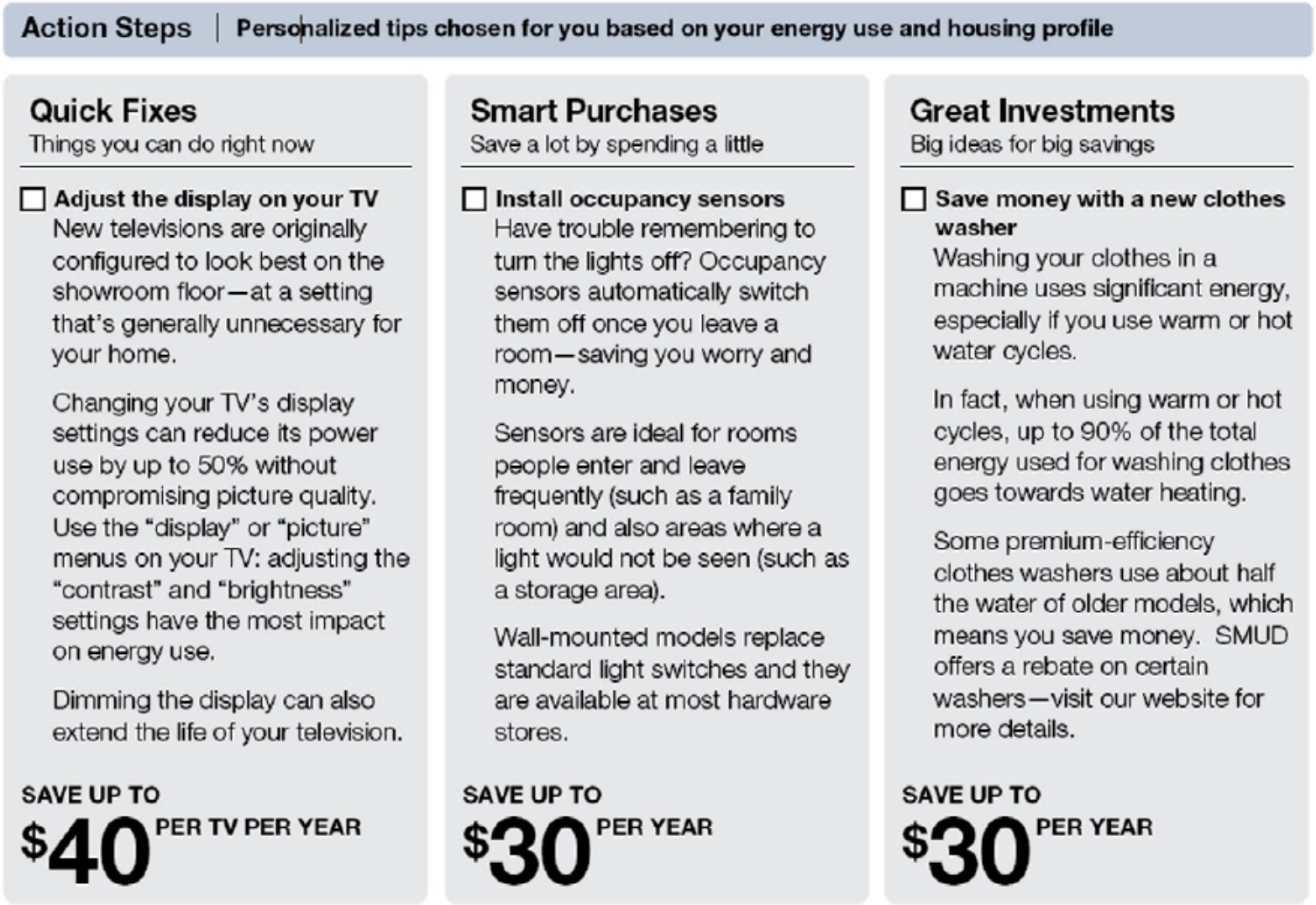


Allcott (2011) Finds a 2% Decline in Energy Use



Action Steps | **Personalized tips chosen for you based on your energy use and housing profile**

Quick Fixes

Things you can do right now

☐ **Adjust the display on your TV**

New televisions are originally configured to look best on the showroom floor—at a setting that's generally unnecessary for your home.

Changing your TV's display settings can reduce its power use by up to 50% without compromising picture quality. Use the "display" or "picture" menus on your TV: adjusting the "contrast" and "brightness" settings have the most impact on energy use.

Dimming the display can also extend the life of your television.

SAVE UP TO
$40 PER TV PER YEAR

Smart Purchases

Save a lot by spending a little

☐ **Install occupancy sensors**

Have trouble remembering to turn the lights off? Occupancy sensors automatically switch them off once you leave a room—saving you worry and money.

Sensors are ideal for rooms people enter and leave frequently (such as a family room) and also areas where a light would not be seen (such as a storage area).

Wall-mounted models replace standard light switches and they are available at most hardware stores.

SAVE UP TO
$30 PER YEAR

Great Investments

Big ideas for big savings

☐ **Save money with a new clothes washer**

Washing your clothes in a machine uses significant energy, especially if you use warm or hot water cycles.

In fact, when using warm or hot cycles, up to 90% of the total energy used for washing clothes goes towards water heating.

Some premium-efficiency clothes washers use about half the water of older models, which means you save money. SMUD offers a rebate on certain washers—visit our website for more details.

SAVE UP TO
$30 PER YEAR

Allcott & Mullainathan Calculations

COSTS AND BENEFITS OF BEHAVIORAL INTERVENTIONS IN THE UNITED STATES*	
Cost-effectiveness of behavioral program	
Reduction in electricity consumption (%)	2.7
Average household electricity consumption (kWh/year)	11,232
Savings (kWh/household-year)	305
Program cost to the utility ($/household-year)	$7.48
Cost effectiveness (¢/kWh)	2.5
Comparison: other efficiency programs (¢/kWh)	1.6–6.4
Cost per ton of carbon abatement	
Long-run marginal cost of electricity (¢/kWh)	8.0
Net savings from behavioral program (¢/kWh)	5.5
Marginal carbon intensity (metric tons/MWh)	0.34
Carbon abatement cost ($/metric ton CO_2)	–$165
Comparison: Wind, carbon capture, hybrids	$20, $44, $15
Value of a comparable intervention, scaled across entire U.S.A.	
Annual carbon abatement (MMT CO_2/year)	12.7
Assumed value of CO_2 reduction ($/metric ton)	$10
Total value of CO_2 reduction (millions of $/year)	$127
Value of electricity saved (millions of $/year)	$3,020
Total cost to the utility (millions of $/year)	$927
Net value of intervention (millions of $/year)	$2,220

* See supporting online material for data sources and analysis details.

Gaps in Our Knowledge Remain

- What are the actual energy savings from energy efficiency programs? Cost-effectiveness?
  - Davis et al. (2014) finds savings of ¼ of predicted estimates for the cash-for-coolers program in Mexico.
  - Studies in the U.S. come to different conclusions of the cost of utility demand-side management programs *using utility-reported data* (e.g., Arimura et al. (2011), Auffhammer et al. (2008),…)
- What is the degree of undervaluation in other countries and sectors?
- Can undervaluation be attributed to behavioral failures?
  - Neuroeconomics work underway at Stanford looking at pleasure sensors from consumer decisions

How to Best Move Forward?

Three strands of research:

1. Overcome an "energy efficiency evaluation gap" with more studies on the cost-effectiveness of energy efficiency programs
   - Randomized controlled trials to calculate the actual energy savings
2. More studies on the undervaluation of energy efficiency
   - Randomized controlled trials or natural experiments to quantify the value of energy efficiency and heterogeneity in the valuation
3. Neuroeconomics studies
   - How do consumers actually make decisions and receive utility from these choices?

What About Policy?

In this world with potential behavioral failures, how do we perform policy analysis? What policies make sense?

- Recent work in "behavioral welfare economics" holds some promise
  - Bernheim and Rangel (2007) discuss *libertarian paternalism* – individuals should be allowed freedom in decision-making, but the government can establish conditions that lead to ex post "good decisions" (i.e., nudges)
  - Difficulty 1: how does the government know what the ex post good decisions are?
  - Difficulty 2: how to perform an economic analysis?

Humble Suggestions…

- Given all this, Gillingham & Palmer (2014) have the following humble suggestions:

  We have many unaddressed externalities…

  – In these cases, nudges to move consumer decisions in the direction of internalizing externalities seem prudent

  Moreover, many behavioral failures appear to come about due to interactions with informational market failures…

  – So efforts to address these first may in many cases be low cost *and* serve to reduce behavioral failures

  All of these may make more sense for some consumers than others – so behavioral targeting *is* worth considering.

Thank you!

Comments, suggestions, and critiques are very welcome.

This is an exciting area, with rapid progress and much still to be learned…

Recent Papers Behind This Talk

Gillingham, K. and K. Palmer (2014) Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Analysis. *Review of Environmental Economics & Policy*, 8(1): 18-38.

Gillingham, K., R. Newell, and K. Palmer (2009) Energy Efficiency Economics and Policy. *Annual Review of Resource Economics*, 1: 597-619.

Gillingham, K., R. Newell, and K. Palmer (2006) Energy Efficiency Policies: A Retrospective Examination. *Annual Review of Environment and Resources*, 31: 193-237