Energy Demand

Michael Hanemann

michael.hanemann@asu.edu

The question being posed

The question being posed is not:

Is there an energy efficiency gap?

Instead, the questions are:

If you wanted to reduce residential energy use, is this possible?

How could you do it?

2

The elusive demand function for energy

- To be sure, there is a huge literature in which economists have estimated residential demand curves for energy.
  - I myself have participated in such exercises.
- But, does there really exist a residential demand curve for energy?
- Or, equivalently: Are the estimated demand curves meaningful?
  - Do they reliably tell us what future demand will be a month from now, a year from now, or five years from now, either with or without some policy intervention?
- I am not sure that the answer is YES.
- I have the same doubt about commercial demand functions for energy
- And I have the same doubt about residential demand functions for water.

Why do I think the demand curve is problematic?

(1) For most residential users, their consumption of energy is invisible to them.

They have no way of knowing what quantity they are consuming at the time of consumption.

They have no idea what the price is, either, at the time of consumption.

(2) Their consumption of energy is mediated through the physical structure of the building they live in and the hardware in it.

Some of those things may not be under their control.

Even when they are controllable, those things won't be changed often or instantaneously.

Compare to other uses

- Household transportation
  - Rate of fuel consumption is visible – how often do you fill the car
- Industrial/commercial
  - Depending on the industry, decision makers may be highly aware of energy use.
    - E.g., fuel managers for trucking companies or airlines pay attention to achieving savings of 1-2% in fuel use – savings that are invisible to home owners

The question of policy tools

- A key question underlying policy:
  - Do we want to reduce energy use by moving along a given demand curve?
  - Or, do we want to reduce it by *shifting* the demand curve inwards?
- The conventional approach to policy focuses on the former – getting the price right (raising the price appropriately) so as to reduce demand.
- The strategy in California over the past 40 years has aimed more at shifting the demand curve inwards by non-price initiatives.
- The recent interest in "nudges" – for example, messaging electricity users on their use relative to that of others – aims at shifting the demand curve inwards.

The two issues converge

- How to shift the demand curve inwards
- How to conceptualize the demand curve and approach modeling it.

The question of market failure may be irrelevant

- If you think of a fixed demand curve resulting from conscious decision making, then market failure is a primary lens for examining questions relating to energy efficiency.
- If you think of a Lancaster-type model of demand with product characteristics, with the characteristics that are considered being subjectively determined and context-dependent, market failure is not the only lens that is relevant.
  - Behavior change is a separate lens.
  - Some -- not all -- of the phenomena discussed in the behavioral economics literature can be better explained in terms of a Lancaster model where salience plays a role, leading to changes in the wight on attributes.

- Some of the policy instruments may work primarily by increasing the salience of energy efficiency.
- Salience may be asymmetric
  - When the price goes up and you have to pay an unexpectedly large amount of money, salience may drive you to use less.
  - When the price goes down, using more may not become similarly salient.

There is no “representative consumer” for residential energy use.

- You live in a house, which you own or rent.
- It was built by somebody else.
- What could you possibly change about the house?
- Why would you do this?
- In any case, how long will you live there?
- Houses come in many shapes, styles, vintages.
- Arguably, at any point in time the houses are far more heterogeneous than the people living in them

- You use energy for many purposes.
- Some of these you may be conscious of
  - E.g., air conditioning
- Some of these may be invisible to you
  - E.g., heating water
- Some of these uses you can readily modify
  - E.g., changing light bulbs
- Others are hard, perhaps impossible, for you to modify
  - E.g., home heating

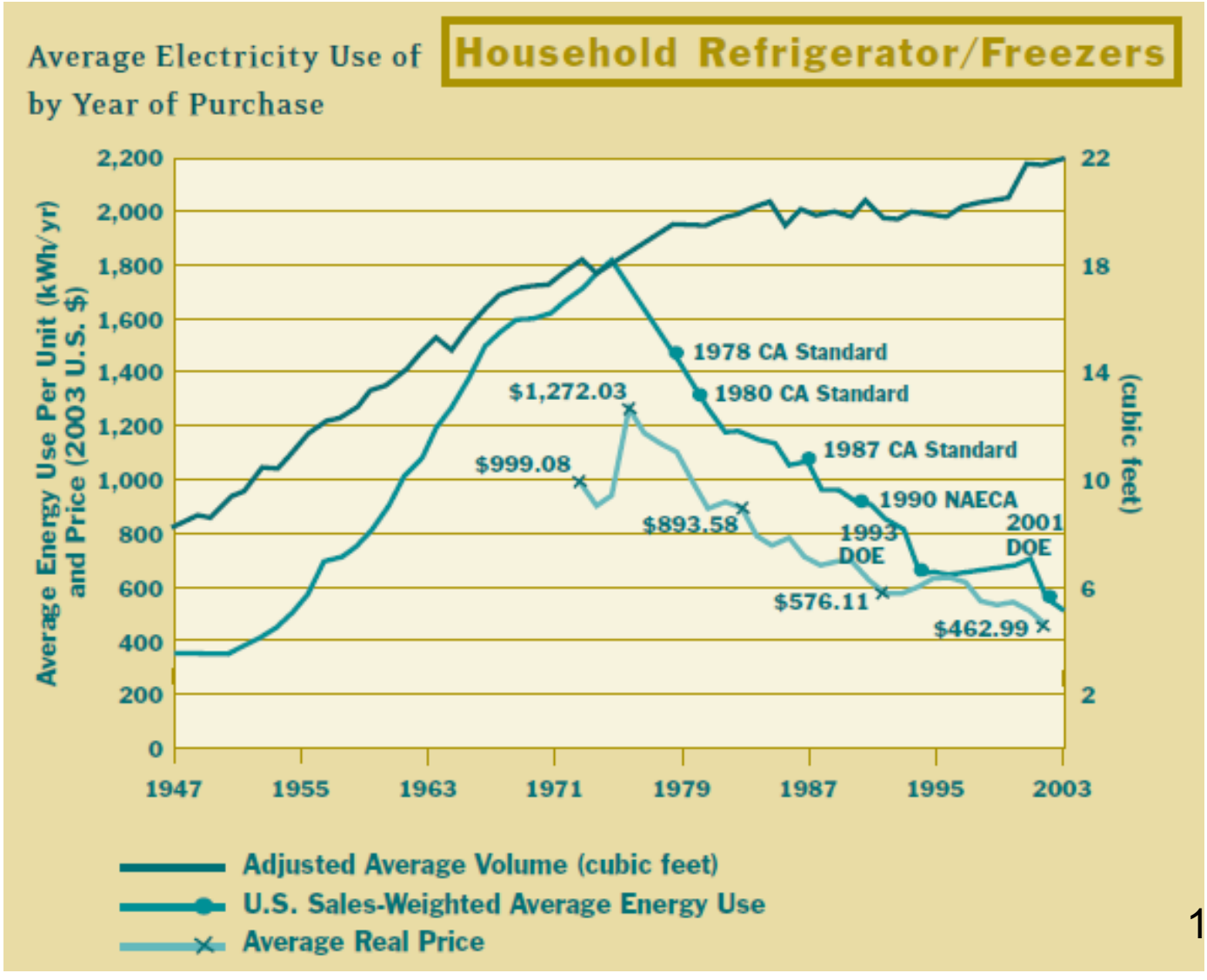
- The physical structure of the building has a huge effect on residential energy use

U.S. Residential Primary Energy Consumption by Building Type, 2001

	% Total Units (2001)	% Total Owned (2001)	% Total Rented (2001)	% Total Btu (1997)
Single-family detached	59.0	52.1	6.9	73.4
Single-family attached	9.9	7.0	2.9	9.2
Building of 2–4 units	8.9	2.0	6.9	5.0
Building of 5 or more units	15.9	1.7	14.2	7.5
Mobile home	6.3	5.3	1.0	4.9
Total	100	68.0	32.0	100

Sources: Energy Information Administration. 2004. *2001 Residential Energy Consumption Survey: Housing Characteristics Tables*, EIA, Washington, DC. Table HC1-2a. Energy Information Administration. 2000, *1997 Residential Energy Consumption Survey*, EIA, Washington, DC. table 2.1.2, 1.2.6.

Many actors are involved in determining my residential energy use. My refrigerator, for example.

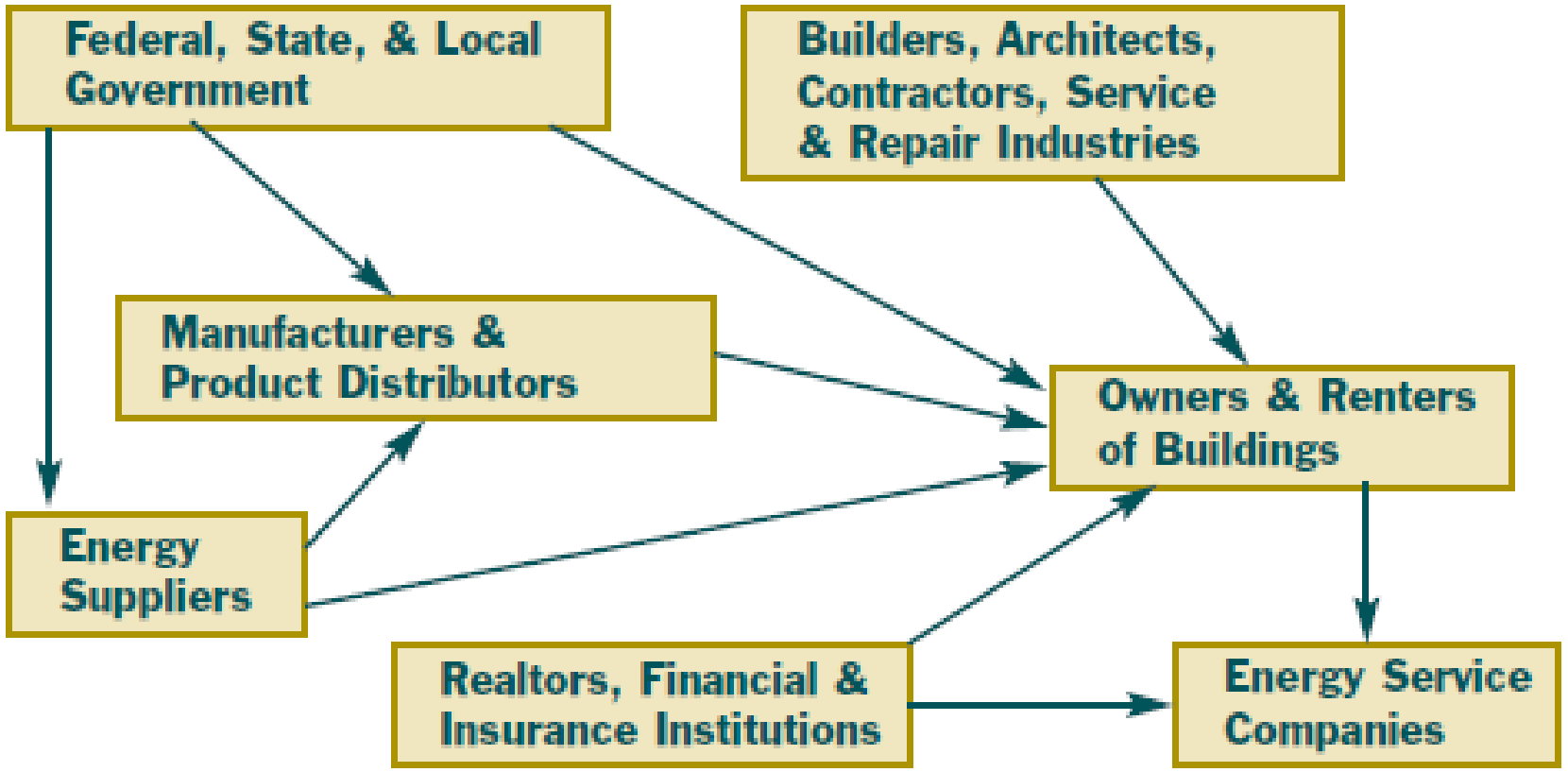


The locus of decision-making

- Who makes the decision?
  - What is the decision that they are making?
- Whose choice behavior do you want to influence?

Multiple Stakeholders and Decision-makers

in the Building Sector



Who is the decision maker, continued

The building construction industry, especially homebuilding, is dominated by small and medium-sized firms. This is problematic because it means that a large number of firms and individuals need to be influenced to have a significant collective impact on energy efficiency. There were 1.65 million new home closings in the United States in 2002, and nearly 500,000 homebuilders operated that year. The five largest of these homebuilders accounted for less than 7 percent of new homes, while the top 100 accounted for just another 7 percent.[44] However, there is a trend toward consolidation. According to

Is “the” demand curve static?

- How much of change in behavior is explained by change in prices and/or income over time?
- How much is explained by other changes, including changes in preferences?

requirements. According to the vice president of research at the National Association of Home Builders, “as family size decreased almost 25 percent over 30 years, the size of new houses increased about 50 percent, to slightly more than 2,300 square feet today, from 1,500 square feet.”[3] Second, the range of electric equipment provided in buildings has increased significantly, especially air conditioning in the South and electronic equipment, televisions, and other “plug loads” in buildings nationwide.[4] Central air conditioning is now a feature of 85 percent of homes in the United States, up from 34 percent in 1970.

- What fraction of these changes in house size, air conditioning, number of electricity using appliances, etc. was a conscious, deliberate choice by the current occupant of the home?

- The experience with nudges in the US suggests that they can reduce demand by 4-5%.
  - Should we see that as a large change, or a small change?
  - If it is a small change, how might we obtain large changes?
    - Will those come primarily from changes in energy intensity of appliances (e.g. LED bulbs)?

Rethinking demand modeling

The locus of decision-making

- Who makes the decision?
  - What is the decision that they are making?
- Whose choice behavior do you want to influence?

What is the choice?

- Conventional economics models the demand for a commodity as though the consumer is constantly re-optimizing his consumption to match current circumstances.
- An alternative approach would focus on modeling when and how demand changes.
  - The assumption is that most of the time, the consumer just repeats what he normally does. He has some existing pattern of demand – "habitual demand"
  - However, sometimes circumstances change sufficiently to attract his attention. He then considers whether to make a change.
  - In the latter case, there are two things to model:
    - If a change occurs, what change will be selected?

What energy uses do I control?
And why would I change them?

- If I get a more energy-efficient electric toothbrush, how likely is it that I will choose to brush my teeth longer? Why would I do that?
- If it is not likely that I brush my teeth for longer, there is no rebound effect.
- If I get an energy-efficient refrigerator, how likely is it that I will choose to utilize my refrigerator in such a sway that my consumption of electricity rises? How would I do that?
  - Is the rebound argument that I buy a larger refrigerator?
    - If so, how do I fit a larger refrigerator into my kitchen?

- Need to identify the users, the uses they control, and the time frame on which they might choose to change them.

An analysis framed around changes

- How many households confront change (participate in experiment, etc)?
  - What percent of total users?
- What is the possible nature of the response
  - Change in appliances (refrigerator, dishwasher,etc)
  - Retrofit part of house – air conditioning, heating, lighting, kitchen
  - Change in behavior – use appliances less

  - What percent of their usage might be changed
- The idea is to put an upper bound on how much change in usage could occur, over what time period.