The Role of Energy Efficiency in Climate Policy: Insights from the Precourt EE Center Program

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Background

- Sketchy Vattenfall and McKinsey Studies
  - Lot’s of Potential *Maybe, That Might Be Realized*
- American Physical Society Study (September 2008)
  - 30% Reduction in Energy Use Through EE by 2030 Relative to Baseline at Little or Low Cost
- America’s Energy Future on EE-National Academy Study
  - To Be Released Soon
  - May Say Something Similar to the APS
- My View
  - Probably Even More Potential Than That
  - But Less Will Be Realized
- Obama Stimulus Program and Budget *Could Help Lots*
Interesting Observations About Energy Efficiency (EE)

- Buildings Often Designed With Little Attention to EE
- LEED Building Design Criteria Not Heavy on EE
- Energy Models Used in Design Typically Not Checked During Operation
- Principal Agent Problems Significant in Building Design
- Consumer Decision Making on Energy Neither Simple Nor Strongly Price Oriented, Products Designed to Fit
- Technologies for Making Building Materials Are 100 Years Old and Very Energy Intensive
- IT & Behavioral Studies May Be Our Biggest Hopes for the Future
Energy Efficiency:

Economically Efficient
Reductions in Energy Use Intensity
Increased Economic Efficiency

Decreased Energy Use

Reduced Economic Efficiency

Increased Energy Use
Economically Efficient Energy Intensification

Energy Efficiency Improvement

Waste

Inefficient Energy Saving

Decreased Energy Use

Increased Economic Efficiency
Decreased Energy Use

- Plug-In Hybrids (Now in US)
- LED General Lighting (Future)
- “Smart” Regional Land Development
- Energy Audits
- LED Traffic Lights
- Reformed CAFE Standards
- Gasoline Rationing
- Optimized Building Construction
- Compact Fluorescent Penetration
- Efficient AC-DC Converters
- Overly Strict Building Standards
- Appliance Efficiency Standards
- Old appliance replacement
- Energy Cost Labeling
- Hybrid Gas-Electric Vehicles
- Behavioral Change: Program Thermostat Lights, Tire pressure,
- Pigouvian Energy Tax
- Congestion Pricing
- Driving Patterns
- Internet Growth
- Personal Computer Penetration
- Increased Economic Efficiency
- Lead SUV Sales
- Many Rapid Transit Systems
- LED General Lighting (Now)
- Gasoline Price Controls
- Incan-descent Lighting
- LED Task Lighting (Now)
- Old appliance replacement
- High Definition TV
- Airline Deregulation
- Accessible Business Travel
- Old appliance replacement
- Economic development
- Increased commercial space

Behavioral Change: Program Thermostat Lights, Tire pressure,
Global cost curve of GHG abatement opportunities beyond business as usual

- ~27 Gton CO₂eq below 40 EUR/ton (-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities
Issues With MAC Curves for EE

• Dependence on Baseline Projection of GHGs
• Uncertainty About Baseline and Program Costs
• Aggregation Issues/Homogeneity Assumptions
• Insuring Consistency of Assumptions Across Individual Measures
• Can’t Look at General Equilibrium Effects
• Challenge of Identifying Policies to Achieve GHG Reductions
• Many of The Negative Cost Options Have Been Around for Awhile, But Not Implemented
PEEC California MAC Curve
A Lot of Low Cost Potential
Value of MACs for EE

- Identify Easy Options to Focus On
- Understand Where Barriers or Market Failures Might Exist
- Insights Into Non-Market Policies
- Springboard for Better Empirical Models
- Get Insights for Building Better Hybrid Models
- But Recognize EE May Be a Largely Non-Renewable Resource
- Modeling Can Extremely Useful Here
Why Do Negative Cost Options Continue?
### PEEC Research Matrix

<table>
<thead>
<tr>
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<th>Sectors</th>
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<tbody>
<tr>
<td><strong>Methods</strong></td>
<td><strong>Buildings</strong></td>
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<tr>
<td>Engineering</td>
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<td>Modeling</td>
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<td>Systems</td>
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<td>Behavior</td>
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<td>Policy</td>
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- **Green** indicates current emphasis.
- **Blue** indicates anticipated additions.

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**Precourt Energy Efficiency Center**
## Traditional View: Market Failures and Market Barriers

<table>
<thead>
<tr>
<th>Market failures</th>
<th>Market barriers</th>
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<tbody>
<tr>
<td>Unpriced costs and benefits</td>
<td>Low priority of energy issues</td>
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<tr>
<td>Distortionary regulatory and fiscal policies</td>
<td>Incomplete markets for energy efficiency</td>
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<tr>
<td>Misplaced incentives</td>
<td>Capital market barriers</td>
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<tr>
<td>Insufficient and inaccurate information</td>
<td>(Cognitive Skills)</td>
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</tbody>
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Externalities of Energy Use ("Unpriced Costs and Benefits")

– Global Climate Change
– Local/Regional Air/Water Pollution
– Excessive Burdens on the Disadvantaged
– Congestion
– Risks of Energy Price Shocks
– Limitations on Our Foreign Policy Options
– Terms of Trade Impacts (Pecuniary "Externalities")
– Automobile Risk Shifting by Purchase of Heavy Vehicles
Agency Problems

• Where is problem?
  • New Building Construction
  • Rental vs Owner-Occupied buildings
  • Consumer Product Design
  • Consumer Product Marketing

• Information/cognitive limitations generally central to agency problems
  • Automobile Design
  • Electricity Use by TVs, Passive chargers

• Incomplete markets for energy efficiency
  – Discrete nature of commodities Offered for Sale
  – Information Problems When Offering Energy Efficiency Services
Agency Problem: Market Penetration of Energy Efficiency Measures in Owner-Occupied and Rental Housing in California (CEC 2004)

- Insulated walls
- Insulated attic
- Double pane windows
- Programmable thermostat
- Compact fluorescent lamps
- Low-flow showerheads

Market penetration (%)

Owner occupied
Rental
Market Barriers: Agency/Cognitive

• Automobile purchase
  – Automobile purchase decisions
    • First cost bias
      – Failure to calculate operating costs
      – Belief that resale value will be independent of fuel economy
  – Automobile design decisions
    • Understand first cost bias
    • Don’t design optimally efficient cars
  – Consumers don’t have option to choose optimally efficient cars because they are not offered for sale
  – Market stays in equilibrium
  – Concept that consumers learn randomly is not applicable if there are no available options from which to learn randomly.
Example: Light Duty Vehicles

Since 1987 (CAFE standards constant since 1985) technological advances have been used to improve attributes other than fuel economy.

Car Data from EPA’s 2006 FE Trends Report

Fuel efficiency has increased by about 1.3% per year since 1987.

However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety.

Source: David Greene – Oak Ridge National Laboratory
Automobiles (Continued)

Price and Value of Increased Fuel Economy to Passenger Car Buyer, Using NRC Average Price Curves

\[ PV = \int_{t=0}^{L} P_t M_o e^{-\delta t} \left( \frac{1}{E_o} - \frac{1}{E_1} \right) e^{-rt} dt \]

Greatest net value to consumer at about 35 MPG

Assumes cars driven 15,600 miles/year when new, decreasing at 4.5%/year, 12% discount rate, 14-year vehicle life, $2.00/gallon gasoline, 15% shortfall between EPA test and on-road fuel economy.

Source: David Greene – Oak Ridge National Laboratory
Market Barriers

• Low Priority of Energy Issues
  – Generally means that energy costs are so small that it is not worth the effort to try to optimize
• Cognitive Issues
  – Probably very important for residential, small commercial, and individual transportation decisions
  – 2004 study. Only 20% of Americans own programmable thermostats. Of those, 70% don’t use programmable features because they're too complicated.
• Vehicle Purchase
  – Limited horizon of purchaser in calculating operating cost.
Systems Issues

• Learning by doing
  – Relevant particularly in unconcentrated industries
  – Individual decision making does not account for benefits of learning

• Chicken and egg problems
  – Non-convexity of problem
  – Individual competitive equilibrium does not get to global optimal

• Regional development
  – Local tax higher than cost for commercial development
  – Cost higher than tax for residential development
  – Incentives for communities to compete for commercial development and hope other communities have residential development (at least at margin)
  – May lead to more commuting
Levels of Interventions

- Interactions between levels
- Complementary interventions

Based on the socio-ecological model of health behavior

Thanks to Carrie Armel
What to Do Now

• Modeling
  – Disaggregate Strategically
  – Include Non-Price Policies and Measures
  – Learn From Behavioralists, States/Cities, and Other Countries
  – Be Clear About What’s In and What’s Out

• Policy
  – Do Not Be Afraid to Impose Standards if Appropriate
  – Do Behavioral Research to Learn More About What is Appropriate
  – Don’t Forget Prices Can Still Matter A Lot
  – Do Not be Dogmatic
The End

http://piee.stanford.edu/cgi-bin/htm/index.php?ref=home
The Rosenfeld Effect Project

Comparison of Per Capita Electricity Consumption in U.S. and California

- Starts Title 20
- Forms LBL Center for Building Science
- Founds ACEEE
- Receives Szilard Award
- Receives Carnot Award
- Instigates new era of CAEE
- Appointed CEC commissioner
- Reappointed CEC commissioner
- California
- Receives Fermi Award

Source: California Energy Commission, 2004
Residential and Commercial
Cumulative Conservation Savings 1980 - 2006

~19% of Residential and Commercial Electricity Use in California in 2006

Program, Price, and Market Effects
Title 20 Appliance Standards
Title 24 Building Standards
Decreased Energy Use

- Hybrid Gas-Electric Vehicles
- LED General Lighting (Now)
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- Energy Cost Labeling
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Increased Economic Efficiency

- Increased commercial space
- “Smart Buildings” Controls
- Energy Audits

Driving Patterns

- Behavioral Change: Program Thermostat Lights, Tire pressure, Driving Patterns
- Internet Growth
- Economic development
- Personal Computer Penetration
- Airline Deregulation
- Accessible Business Travel

Economic development

- Many Rapid Transit Systems
- Incandescent Lighting
- Gasoline Price Controls
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- Overly Strict Building Standards

Increased Energy Use

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