Integrating Energy Efficiency and Consumer Behavior into the Energy Box Design

by
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Presentation for CERA Workshop: Energy Consumption Drivers
Dan Yergin, in 1979!!:

- Serious US conservation commitment
  - Consume up to 40% less
  - Maintain current lifestyle (or higher)
- Conservation is a quality source of energy
  - Can stimulate innovation, employment, and economic growth
  - May be cheapest, safest, most productive alternative
  - Readily available in large amounts.
- Does not:
  - Threaten international monetary system
  - Emit [much] carbon dioxide
Traditional Economics Assumptions

> Agents: rational, controlled, informed, selfish, and calculating; preferences are known, stable, and ordered; maximize their welfare

> Market: optimal market conditions

> Dan Yergin, in 1979!!: 
  - “If the US were to make a serious commitment to conservation, it might well consume 30 to 40 percent less energy than it does now, and still enjoy the same or an even higher standard of living.” (p. 136)
  - “Conservation may well be the cheapest, safest, most productive energy alternative readily available in large amounts. By comparison, conservation is a quality energy source. It does not threaten to undermine the international monetary system, nor does it emit carbon dioxide into the atmosphere, nor does it generate problems comparable to nuclear waste. And contrary to the conventional wisdom, conservation can stimulate innovation, employment, and economic growth.” (p.137)
Energy Efficiency
Dan Yergin & Amory Lovins

> Serious commitment
  – Consume 40% less

> Quality energy source
  – Stimulates employment, innovation, environment, economy
  – cheapest, safest, most productive alternative
  – readily available in large amounts

> Does not:
  – threaten international monetary system
  – emit [much] carbon dioxide
  – generate waste problems like nuclear
  – cause Geopolitical issues…
States Adopting Residential Building Standards (2008)
Blue=Previous
Green=New

States Adopting Energy Efficiency Portfolio Standards
Yet EE is not happening. Why?

Behavioral Economics

- Agents do not maximize welfare: They are reciprocating, trusting, and vindictive
- Agents follow suboptimal decision strategies
  - Solve local decisions/misunderstand implications
  - **Most customers have very high implicit discount rate (> 60%/year)** when buying energy efficiency (high time value of money, short-term view!)
- Succumb to different decision traps
  - Incoherent preferences/variable tastes
  - Impulsive, myopic
- Non-optimal market conditions
  - Unaccounted for **externalities** (oil is priced well below optimal **social costs**)
    - Military/security (about $10 to $25+/bbl), diplomatic/geopolitical/instability (?/bbl)
    - Climate ($2 to $5/bbl), other environmental ($1 to $15/bbl)
  - **Improper price signals**
    - Net subsidies ($1 to $3/bbl + ?$16/bbl to oil-using systems)
    - Lack of peak price signals (little real/time, time-of-use pricing)
  - **Information asymmetries**—Most customers, even sophisticated ones, lack good information on end-use efficiency and **renewables** alternatives
## Policy and Behavior Interventions

<table>
<thead>
<tr>
<th>Antecedents</th>
<th>Information or persuasive campaigns</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Information</td>
<td>Campaigns to promote conservation through information, such as pamphlets, letters, booklets, workshops</td>
<td>Mostly non-effective. However, research results are inconclusive since specific wording and messaging have not been studied. Need to study effect of Social Media Marketing (personalize the message, utilize Peer pressure and social norm principles).</td>
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<td>Prompts</td>
<td>Cues designed to elicit conservation through signs, posters, flyers</td>
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<td>Persuasion</td>
<td>Appeals to conserve by written or media-based persuasive communications</td>
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<tr>
<th>Consequences</th>
<th>Incentive and Feedback Techniques</th>
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<tbody>
<tr>
<td>Direct Feedback</td>
<td>Response contingent presentation of energy conserving information with written cards, notes, signals, bills, or meters</td>
<td>Immediate direct feedback from meter or associated display monitor saves from 5 to 15%. High energy users likely respond more than low energy users. (2006, Darby)</td>
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<td>Indirect Feedback</td>
<td>Feedback that has been processed in some way before reaching the user (normally via billing)</td>
<td>Usually more suitable than direct feedback for changes in space heating, household composition, and impact of investments in efficiency measures or high-consuming appliances; saves from 0 to 10% (2006, Darby)</td>
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<tr>
<td>Incentives</td>
<td>Response contingent monetary rewards, tokens, rebates, prices for conserving energy</td>
<td>Greatest consumption reductions in high-rebate conditions (up to 31%). However, the policy applicability is questionable since rebate schedules amount to price changes of several hundred percent. (1985, Ester)</td>
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<tr>
<td>Disincentives</td>
<td>Response contingent costs, inconveniences, and penalties for failing to conserve energy</td>
<td>Little research on the subject. However, there is some evidence that rising prices is inducing some conservation behavior (using transit ridership as an example).</td>
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<th>Social Influences</th>
<th>Change individual behaviors with group incentives, social diffusion</th>
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<td>Groups</td>
<td>Presentations of consequences for conservation contingent on group performance</td>
</tr>
<tr>
<td>Modeling</td>
<td>Exposure to live or videotaped presentations of models performing energy conserving behaviors</td>
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<tr>
<td>Commitment</td>
<td>Inducing individuals to conserve by social compliance procedures such as commitment and the foot-in-the-door technique</td>
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<th>Targetting Behaviors</th>
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<tr>
<td>Pay-as-you Go</td>
<td>Display allows customer to be in charge of electricity use</td>
</tr>
<tr>
<td>Real-time/Time of Use (TOU) pricing</td>
<td>Pricing strategies that charge higher rates during peak demand and lower rates in off-peak periods.</td>
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</table>

Most research has targeted specific behaviors. There are very few combinatorial studies. Positive consequences much more effective than negative consequences. Policy examples: monetary incentives for conservation, such as subsidies for insulation, tax credits for hot water or heating systems, rebates for efficient appliances and boilers, and pay-as-you-go pricing.
Effective EE Policy: Goal Setting
Commitment, Measurement, and Feedback

> Goal Setting: Proven as a successful behavior Δ strategy
  - Increases motivation, commitment, direction
  - Increases the adoption of sustainable and conservation behaviors
    • Performance best in a situation of a difficult goal combined with regular feedback on task performance (Ester, 1985; Katzev, 1987)

> Measurable and Significant Goals to Provide Feedback (Becker, 1978; Van Houwelingen and Van Raaij, 1989).
  - See progress and further progress needed, assess goals
  - Motivate to work harder, develop new strategies

> Feedback
  - 1. Learning – people can better understand how their behavior influences the amount of energy they use.
  - 2. Forming habits – people can use their new knowledge to alter their activities which may result in a change in routine.
  - 3. Internalization of behavior – new habits can change attitudes to suit the new behavior.
Do people know their preferences?

> Anchoring—**initial positions** affect each side’s perception of what outcomes are possible
  - Will inhibit people from rationally consuming electricity

> Context—**relative positions** affect each side’s perception of what outcomes are possible

> Frame of Reference—**relative situation** affects each side’s perception of what outcomes are possible

> The psychological value function. People are:
  - Risk adverse when confronting potential gains
  - Risk seeking when confronting potential losses

> Which means,
  - Losses are steeper (emphasize in information campaigns)
  - Diminishing returns (use strategies with biggest impacts)
  - Reference Point (set effectively)

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Applicability to Conservation Behaviors

> Rational decision making shaped by two factors
  – Abundance of raw data
  – Dearth of meaningful information

> Need to bridge the gap between economical, technological, and psychological approaches to understanding behavior.
  – Behavior and technology are closely interwoven throughout life

> Role of technology receives surprisingly modest attention in psychology and in policy making. (2007, Midden, C.)
  – Technology as an intermediary between behavior and conservation outcomes,
  – Technology as an amplifier of human performance and—as side effect—of environmental resource consumption,
  – Technology as a determinant of behavior—shaping and channeling behavior, and
  – Technology as a promoter of conservation motivation and/or behavior.
ESD Energy Box Project: What is it?

> Home computer running specially-developed software especially intended to achieve peak load shaving (load shape Demand Side Management)
  - controlling a combination of hardware that makes it possible to turn appliances on or off (and automation) according to supply conditions
  - With or without stand-alone display in house, with web-browser interface

> Users can download and install software (or write their own!)
  - onto their home computer.
  - Different algorithms for different appliances
    • Power Factor Signature (for individual appliance/room/floor monitoring)

> The following consumer behavior experiments contribution to the Energy Box:
  - Develop detailed user interface to influence consumer behavior
  - Test best supportive pricing policies (structure of time-of-use mechanism)
  - Gain a more detailed understanding of the behavioral economics of energy conservation
  - Bust the barriers of market failures and information asymmetries
Technologies and Issues for Load Shape Demand-Side Mgt

> Beyond Smart Metering…

– **Behavioral aspects**
  • Consider consumer comfort and preferences
  • Analyze socioeconomic conditions
  • Change attitudes (environmental, economic, geopolitical)
  • Modify consumption patterns
  • Take advantage of social marketing

– **Dynamic Demand Response** to offset distributed supply intermittency and storage issues

– Control and Communications
  • **Open source, modular** (lots of algorithms)
  • **Smart Grid** integration
  – Identify **Storage** Opportunities
  – **Smart Analysis**: Modelling and Forecasting
  – **Improved Market Coordination**
    • Pricing Structures (Esp. time-of-use)

Some information from: Nilsson, Hans, Chairman of the IEA DSM-Programme, Load Shape DSM, Retrieved from on February 9, 2008: mineco.fgov.be/energy/rational_energy_use/DSM_Workshop/special_LS.ppt

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### Future Study: Consumer Behavior Experiments (forthcoming)

#### Experiment One: Data Reporting Formatting
Test and apply: Goal Setting, Pain of Paying, Magic Number of Zero, Self-Control: Starting Over, Self-Control: What the Hell Effect, Thinking in Percentages

<table>
<thead>
<tr>
<th>Economic (Pricing)</th>
<th>Pricing Format</th>
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<tr>
<td></td>
<td>Count Up</td>
</tr>
<tr>
<td>Reset Monthly</td>
<td>Monthly, Count Up</td>
</tr>
<tr>
<td>Reset Daily</td>
<td>Daily, Count Up</td>
</tr>
<tr>
<td>Control Group</td>
<td></td>
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#### Experiment Two: Pricing Structures
Test and apply: Information Thresholds, "Pain of Paying"

<table>
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<tr>
<th>Real-Time (Continuous)</th>
<th>Time-of-Use (Hourly) (24 Levels)</th>
<th>Time-of-Use (Complex) (5 Levels)</th>
<th>Time-of-Use (Peak/Off-Peak) (2 Levels)</th>
<th>One-Rate (Control)</th>
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Future Study: Consumer Behavior Experiments (forthcoming)

### Experiment Three: Pricing Structures 2
Test: Self-Control, “Starting Over”,””What the Hell’” effect

<table>
<thead>
<tr>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Control</th>
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### Experiment Four: Establishing Norms
Test: Social Networking (Web 2.0 Technology)
“Peer Pressure”, “Consumer Greenerism”

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<tr>
<th>Self-Norm</th>
<th>Community Norm</th>
<th>None (Control)</th>
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> Consumer Behavior Surveys to get to know the attitude-behavior intention relationship. Learn about:

- Demographic variables, dwelling and energy use characteristics
- Energy price and usage knowledge
- Attitudes toward energy scarcity, energy conservation, energy efficiency, sustainability, mandatory or voluntary conservation
- What kinds of things can people do to save energy?
References