Achieving the Potential for Decarbonization in The Household Sector (USA)

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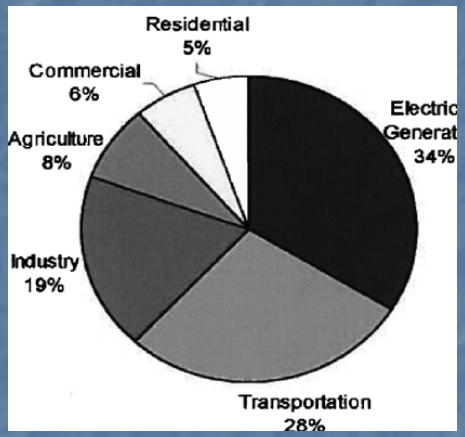
Note: This presentation reflects my views and does not necessarily reflect views of the National Research Council.

Topics for Today

- How large is the potential for reducing GHG emissions in the household sector?
- How can it be achieved?
- Where do major opportunities lie today?

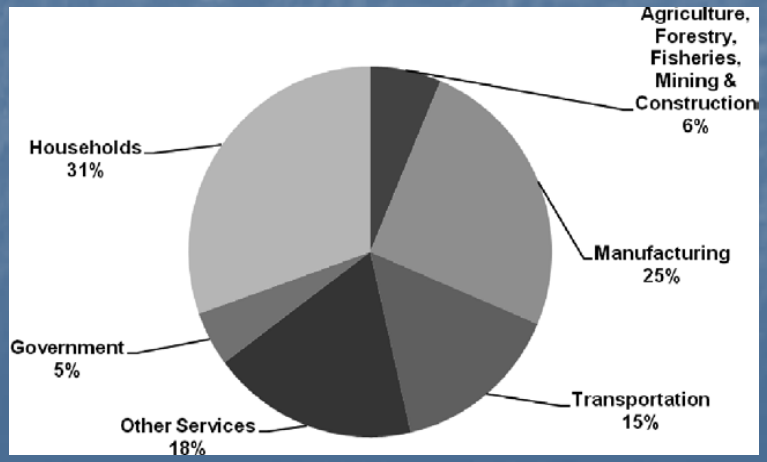
How large is the household sector of energy use?

- Energy use, or the consequent emissions, are most commonly disaggregated this way:



- Households appear to be roughly equivalent to the "residential sector" (about 5% of the total)

- But when disaggregated by decision makers, households look much more important:



Source: Vandenbergh et al., 2010; data from USEPA for 2005 and 2006.

How large is the technical potential for emissions reduction?

Potential carbon emissions reduction from full cost-effective adoption and use of existing technology, U.S. households (Dietz et al., 2009)

	MtC	Percent
Technology adoption		
Building shells	25.2	
Home heating and cooling efficiency	12.2	
Efficient home appliances	22.8	
Vehicle efficiency	63.7	
		19.5
Technology maintenance and use		
Home equipment adjustments, maintenance	15.1	
Daily in-home actions	25.3	
Auto maintenance	8.6	
Driving behavior	24.1	
Carpooling, trip chaining	36.1	
		17.1
TOTAL	233.1	36.6 (of sector)

How large is the practical potential? The concept of behavioral plasticity

- Technology isn't all that matters
- Regulations and financial incentives influence behavior
  - Price elasticity is a common measurement unit
- But consumers do not always do what is in their economic self-interest
  - Behavioral plasticity concept includes all determinants of variation in behavior
  - These include information, informal social influence, transaction costs of action, etc.
  - *These factors can make a huge difference*
  - Plasticity estimates are empirically determined from most effective past practices

Large variation in household action with constant incentives: Findings from three utility programs from the early 1980s

Source: Stern et al. (1986)

Program	Incentive	Median Adoption (%/yr)	Lowest Adoption rate	Highest Adoption rate	Highest/ Lowest ratio
NY program (1978-84)	Modest loan subsidy	0.12	0.01	0.51	51.0
BPA pilot program	Long-term 0% loan	4.4	0.8	10.4	13.0
BPA interim program	Grant of ~93% of cost	8.6	1.4	19.3	13.8

Implications

- Huge variability in responses across utilities offering identical incentives (more than tenfold variation in each program)
- The most effective programs do far better than average
- With small incentives, variation was mainly due to getting households to act on energy audit recommendations
- With a very strong incentive, variation was mainly due to getting homes audited

Overall conclusions: Program success depends on both households and organizations; getting homeowners' attention to the program is a major part of this

What are reasonably achievable reductions?
(% of U.S. national household share, year 10)

Source: Dietz et al., 2009

Weatherization, HVAC	5.1	
Other Equipment	9.0	Total: 14.1
Equipment adoption: weighted plasticity = 0.72		
Maintenance	1.5	
Adjustment	0.4	
Daily Activities	3.8	Total: 5.7
Equipment use: weighted plasticity = 0.33		
TOTAL	19.8 of sector (123 MtC)	

Based on most effective interventions; omits:

- mandated phaseout of incandescent lighting in <5 yr, preempting behavioral interventions and adding 4-5%
- technologies not yet at mass market penetration as of 2009 (residential PV, heat pump HVAC, electric vehicles, LED lighting)

How can the potential be achieved? Some conclusions from research on households

- **There is large untapped potential for reducing household energy use** without changing regulations or financial incentives
- **Multiple factors explain household action/inaction** (including available technology, knowledge, money, convenience, trust in information, personal situations and capabilities, transaction costs of taking action, market factors)
- **Limiting factors vary** with the household and its situation, across action types and decision contexts, and over time
- **Limiting factors can affect each other**
- **The hassle factor is particularly important** especially in technology adoption

How can the practical potential be achieved? Some design principles

1. Prioritize High-Impact Actions (Consider both *technical potential* and *behavioral plasticity*)

2. Provide Sufficient Financial Incentives

3. Strongly Market Programs to get people to notice opportunities and to convey to them that they are attractive enough to be worth consideration. Informal marketing through social networks can be as effective as mass marketing for getting people's attention, and more effective for getting them to believe what they hear.

4. Provide Valid Information from Credible Sources at the Points of Decision

5. Keep it Simple (Minimize hassle: people economize on cognitive effort, not only on money)

6. Provide Quality Assurance

Source: Stern et al (2010)

Recent programs vary greatly in how well they implement the design principles

Design Principle	Cash for clunkers	Energy efficiency tax credits	Residential PV incentives
High impact	Excellent	Excellent	Good
Financial incentives	Good-Excellent	Good-Excellent	Variable
Market effectively	Excellent	Fair	Poor
Point of decision	Excellent	Fair	Poor
Keep it simple	Good-Excellent	Fair to Poor	Poor
Quality assurance	Not an issue	Poor	Poor

Source: Vandenbergh et al. (2010).

Where do major opportunities lie today?

- Adoption of residential PV (DOE SEEDS research, including at NREL)
  - PV+EV as an emerging opportunity
  - Regulatory restrictions can be an issue with these
- Proposed EPA rule under Clean Air Act Section 111(d) would enable states to meet federal emissions targets via electricity demand reduction (Carrico et al., 2015)
  - States can become laboratories for innovation
- Opportunities for companies to serve pre-primed market segments
  - Could be assisted by research to support carbon footprint labeling of goods and services (Shewmake et al., 2015)

Sources

Carrico, A.R.,Vandenbergh, M.P., Stern, P.C., and Dietz, T. (2015) US climate policy needs behavioural science. *Nature Climate Change 5,* 177-179.

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Shewmake, S., Cohen, M.A., Stern, P.C., and Vandenbergh, M.P. (2015) Carbon triage: A strategy for developing a viable carbon labeling system. *Handbook of Research on Sustainable Consumption,* L. Reisch and J.Thøgerson, eds. Edward Elgar Publishing.

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Stern, P.C., Gardner, G.T., et al. (2010) Design principles for carbon emissions reduction programs. *Environmental Science & Technology 44,* 4847–4848.

Vandenbergh, M.P., Stern, P.C., Gardner, G.T., Dietz, T., and Gilligan, J. (2010) Implementing the behavioral wedge: Designing and adopting effective carbon emissions reduction programs. *Environmental Law Reporter*, *40*, 10545-10552.

Other relevant slides

Some Other Policy Examples

Source: Stern et al., 1986

The Residential Conservation Service

- National program of the early 1980s that offered free home energy audits and recommendations for retrofits
- Penetration varied greatly between neighboring states:

VT – 12%	WI – 19%	WA – 20%
NH - <1%	MN – 4%	OR – 8%

- **Possible implication:** *Marketing* of programs accounts for much of this large variation.

Financial Incentives in the USA Versus Other Countries

Source: Stern et al., 1986

- 3 grant programs in USA

  Median subsidy – 77% of retrofit cost

  Median penetration – 4%/yr
- 5 grant programs in CA, DK, UK, NL

  Median subsidy – 50% of retrofit cost

  Median penetration – 8%/yr

Possible implication

One striking difference:

- All the US programs required home energy audits before retrofits
- In the foreign programs, householders only had to purchase recommended goods and services and send a receipt to the government

Convenience may have made a large difference in the penetration of these programs.

How large is the potential for reducing energy use/emissions from household actions?

- 20% or more of total household emissions, or ~7% of total US emissions
- Vast bulk of potential comes from equipment adoption, not use

Reasonably achievable carbon emission reduction (RAER) from 17 household actions in Year 10 after introduction of interventions (Source: Dietz et al., 2009)

Equipment adoption	Plasticity	RAER	*Equipment Use*	Plasticity	RAER
Weatherization	90	3.39	Change HVAC air filters	30	0.59
HVAC equipment	80	1.72	Tune up air conditioning	30	0.22
Low-flow showerheads	80	0.18	Routine auto maintenance	30	0.66
Efficient water heater	80	0.86	Laundry temperature	35	0.04
More efficient appliances	80	1.87	Water heater temperature	35	0.17
Low rolling resistance tires	80	1.05	Standby electricity	35	0.52
Fuel-efficient vehicle	50	5.02	Thermostat setbacks	35	0.71
			Line drying	35	0.35
			Driving behavior	25	1.23
			Carpooling and trip chaining	15	1.02
Subtotal (% of household emissions)		14.09			5.51
Total					20

Note: Plasticity is % of households that might undertake action; RAER as % of total household emissions