Identifying Promising Opportunities for Energy Savings in Residential Buildings

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Problems

- Climate change is worsening
  - Target: 60-80% GHG reductions below 1990 levels
- Energy demand is increasing

→ Need dramatic energy use reductions

Overarching Research Question

What options do we have for making dramatic demand side energy reductions while enabling people to achieve their needs with continued comfort and convenience?

Research Agenda

Project 1
Goal: Compile common energy saving actions into a list; create a taxonomy for selecting target actions for programs and for recommendation tools.

Project 2
Goal:
develop a method for identifying promising options for deep and widespread energy reductions.

Project 3
Goal: develop a methodology for testing and improving the most promising options with respect to behavioral barriers.

Project 4
Goal:
redesign product and service options for use in programs and potential development for commercial use at scale.

Theoretical Frameworks

- Resilience

Holling 1973; Berkes and Turner 2006; Carpenter et al 2001; Folke et al 2010; Gibbs 2009; Richardson et al. 2009; Kates et al. 2012

- Everyday practices

Holland and Lave 2009; Kempton and Holland 2009; Gram-Hanssen 2009; Kuijer 1022; Hargreaves 2011; Scott et al. 2009

  - Avoiding biases

Wansink 2002; Bourdieu 1977; McCray 1994; Ezell 1963; Eidelman et al. 2009; Samuelson and Zeckhauser 1988; Kahneman et al. 1991;Greenberg 1983; Deiner and Walbom 1976

- Design thinking

McKim, 1973; de Vere et al.; 2010, Clive et al. 2005; Gibb, 2002; Allan, 2011; Matthew, 2009; Arroyo-Vázquez et al., 2011; IDEO 2003

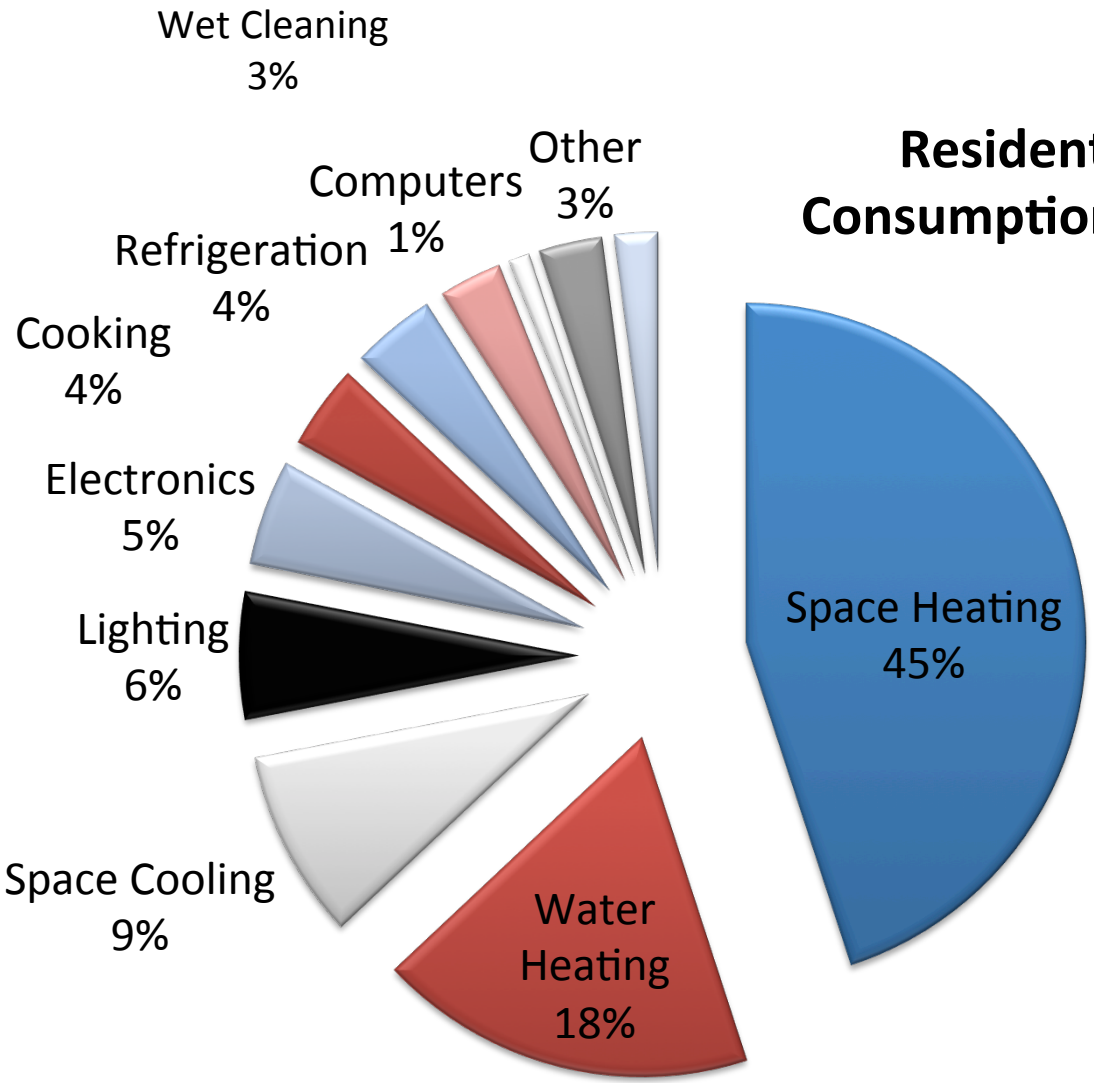
Study Design

- 20 semi-structured interviews
  - Iterative protocol design
  - Piloting for 1 year
  - Adaptive questioning
- Secondary research
  - Peer-reviewed articles, books, textbooks, blogs, DIY sites etc. on topics interviewees suggested

Sample

- Energy experts:
  - energy use (3), household & energy history (3), water heating (2), weatherization (1), device engineering (1), low-carbon cooking (1)
- Extreme users:
  - energy hacks/DIYers (4), seniors (3), culturally diverse subjects in harsh climates (2)

End Uses



Department of Energy 2008

Analysis

- Modified Grounded Theory Approach

Glaser and Straus 1967

- Coding by:
  - *a priori* end use e.g. heating
  - sub-category e.g. insulation
  - further sub-categories e.g. insulation of home (interior or exterior), insulation of body (clothing)
  - cross-cutting themes e.g. insulation & sealing; acclimatization & adaptation

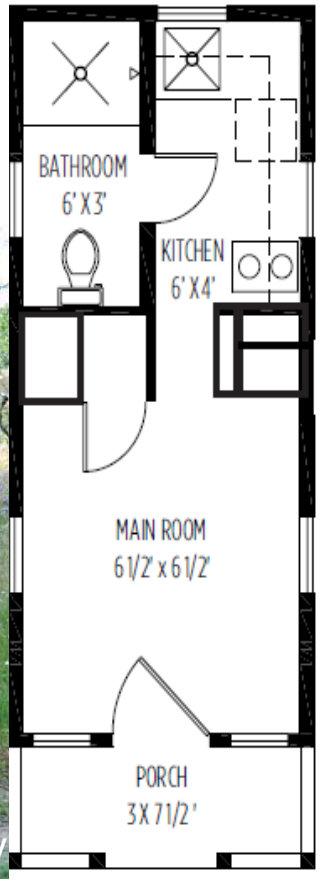
Thematic Framework

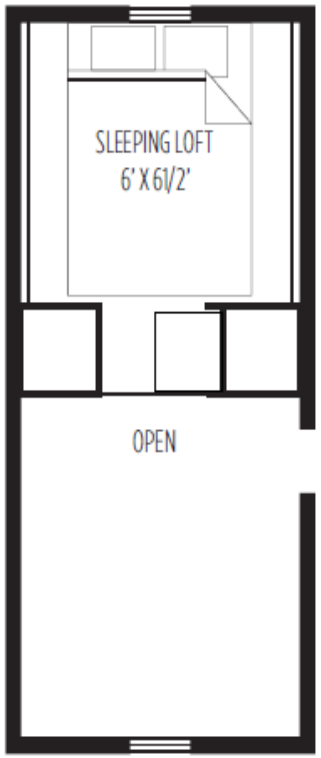
Themes / End Uses: (% of U.S. energy use)	Waste Elimination	Insulation & Sealing	Air flow & Evaporative Cooling	Reflection & Shading	Absorption, Storage & Thermal Mass	Alternative & Latent Energy	Acclimatization & Adaptation (biological & cultural)
HVAC (54%)							
Water Heating (18%)							
Refrigeration (4%)							
Cooking (4%)							

HVAC

Waste Elimination

Close off unused rooms





"You know you have perfection of design not when you have nothing more to add, but when you have nothing more to take away."
– Antoine de Saint Exupery

HVAC

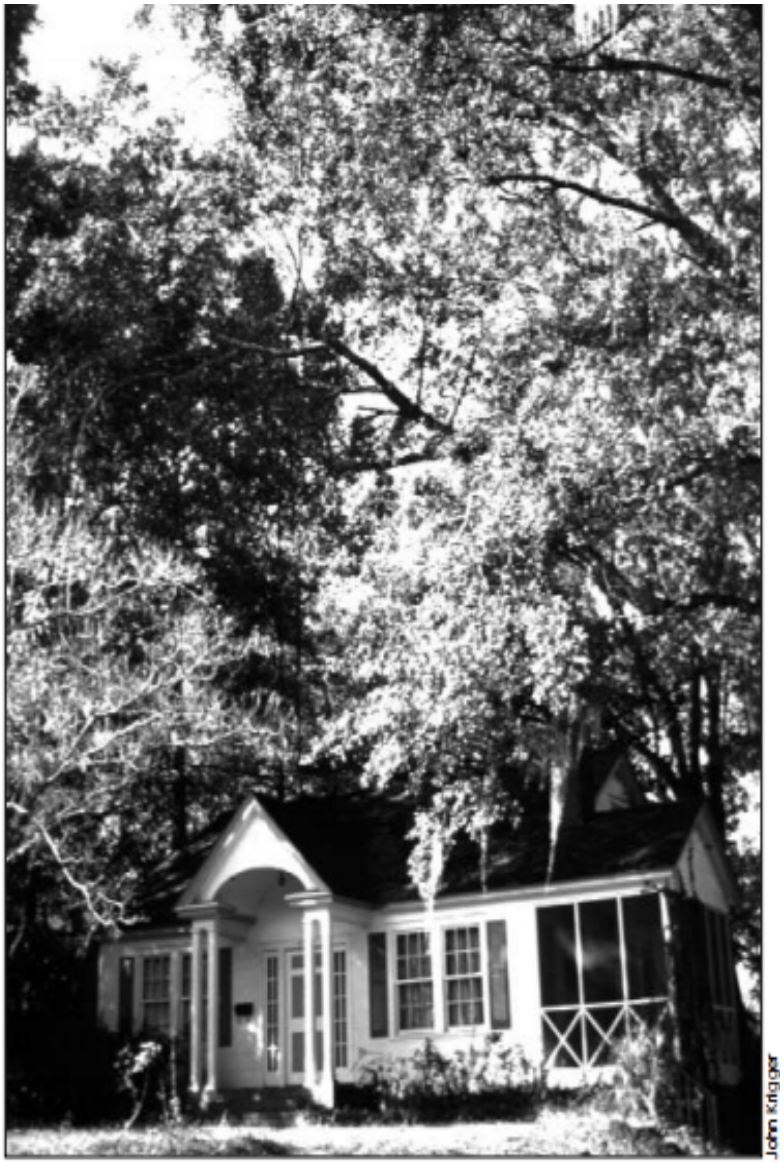
Waste Elimination	Insulation & Sealing
Close off unused rooms	Install indoor insulation

HVAC

Waste Elimination	Insulation & Sealing	Air Flow & Evaporative Cooling
Close off unused rooms	Install indoor insulation	Thawbs, wind towers, swamp coolers

HVAC

Waste Elimination	Insulation & Sealing	Air Flow & Evaporative Cooling	Reflection & Shading
Close off unused rooms	Install indoor insulation	Thawbs, wind towers, swamp coolers	Install awnings, deciduous trees



HVAC

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HVAC

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Close off unused rooms	Install indoor insulation	Thawbs, wind towers, swamp coolers	Install awnings, deciduous trees	Mimic *Yakhchals*	Use heat grabbers, Kotatsu

HVAC

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Close off unused rooms	Install indoor insulation	Thawbs, wind towers, swamp coolers	Install awnings	Mimic *Yakhchals*	Use heat grabbers, Kotatsu	Use pulse point heating & cooling devices

Refrigeration

Waste Elimination	Insulation & Sealing	Air Flow & Evaporative Cooling
Get rid of extra fridge	Use radiant barrier	Use botiijo or California Cooler

Refrigeration

Waste Elimination	Insulation & Sealing	Air Flow and Evaporative Cooling	Reflection & Shading	Absorption, Storage & Thermal Mass	Alternative & Latent Energy
Get rid of extra fridge	Use radiant barrier	Use botijos, or California Cooler	Place vegetables in shady indoor spots	Place containers of water in fridge or freezer	Cool or freeze items outside; vent fridge to outside

Refrigeration

Waste Elimination	Insulation & Sealing	Air Flow and Evaporative Cooling	Reflection & Shading	Absorption, Storage & Thermal Mass	Alternative & Latent Energy	Acclimatization & Adaptation (biological & cultural)
Get rid of extra fridge	Use radiant barrier	Use botijo or California Cooler	Place vegetables in shady indoor places	Place containers of water in fridge or freezer	Cool or freeze items outside; vent fridge to outside	Preserve food without a fridge

Summary

- Developed a methodology aimed at collecting and evaluating uncommon energy saving options to meet stringent targets
- Collected ~100 options and identified 7 emergent themes for residential buildings
- Future work: ethnographic study, seed product design

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ARPA-E

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Refrigeration

Insulation & Sealing

Use radiant barrier

Refrigeration

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