Residential Behavioral Savings:
An Analysis of Principal Electricity End Uses in British Columbia

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Introduction

- Energy Efficiency research more often an engineering economics paradigm
- Behavioral literature that examines the actions of economic agents in **specific and well-defined contexts** with a view to understanding **how** and **why** they make decisions
- Where substantial energy demand (consumption) reductions actually observed appeared to be due primarily to conservation behaviors promoted by mass media and by social marketing

Purpose

- To explicitly model the role of residential customers in securing conservation benefits
- To build a **conditions**, **capacity** and **commitment** model that will help understand why some customers adopt energy efficient technologies while others do not
- To estimate the potential impact of behavioral savings on residential electricity end use consumption in British Columbia households

Approach

- Estimate residential electricity consumption by end use
- Apply the **conditions**, **capacity** and **commitment** model to six residential energy end uses:

  (1) space heating,
  (2) lighting,
  (3) domestic hot water
  (4) washing appliances
  (5) refrigeration
  (6) consumer electronics

- Estimate potential electric behavioral energy savings

Study Objectives, Data and Methods

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Objectives	Data	Method
Estimate residential electricity consumption by end use	Customer survey (n = 1,126) Electricity billing data Weather data	Conditional demand analysis
Apply the conditions, capacity, commitment model	Customer survey (n = 1,437)	Cross tabulations Engineering algorithms
Estimate potential electric behavioral energy savings	Above information	Engineering algorithms

RESULTS

- Estimate unit energy residential electricity consumption by end use
- Survey responses (n=1,126) were weighted
  - by actual proportion of residential accounts in the population
  - penetration of each end use in (twelve) region-dwelling segments

Unit Energy Consumption (UEC)

- Estimated residential end use electricity consumption using a conditional demand analysis (CDA) model
- CDA assumes that total household consumption is the sum of consumption of various end uses plus an error term or residual .
- Appliance saturations are modeled by an indicator variable to indicate the presence or absence of an end use in a particular household or by a count variable

Saturation Rates and Unit Energy Consumption (UEC) for Electricity by End Use

End use	Saturation (no. per household)	Unit Energy (kWh/y)	Average Unit Energy (kWh/y)
Primary electric space heating	0.36	4,767	1,716
Secondary electric space heating	0.27	2,068	558
Central air conditioning	0.09	230	21
Room/portable air conditioning	0.16	34	5
Electric water heating	0.38	2,790	1,060
Refrigerator or freezer	2.00	1,120	2,240
Electric range, cook top, stove	1.05	347	364
Dishwasher	0.72	372	268
Clothes washer or dryer	1.81	256	463
Lighting	39.47	50.48	1,992
Television	1.88	409	769
Personal computer	1.25	415	519
Pool	0.004	1,597	6
Hot tub	0.03	2,881	86
Average kWh/y per household			**10,069**

Residential Behavioral Survey 2008

- A web-based, on-line survey of 1,437 residential respondents in 2008, developed by
  - Review of the literature, and
  - Workshops with & review by stakeholders (program staff and external experts)
- Survey addressed energy related attitudes, conditions and behaviors as well as detailed information on the respondent's home

Survey Questions

- For each end use area, the respondents were asked a series of scaled questions dealing with
- **Conditions** - their level of concern about the service level for the end use (such as lighting levels or temperatures)
- **Capacity** - their ability to modify or change service levels
- **Commitment** - the extent to which they performed energy efficient actions or behaviors
- **Behavioral Target** – calculated as the difference between capacity and commitment

Space Heating

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Night setback	69	100	67	33
Day setback	69	100	58	42
Keep part of house cooler	69	54	43	11
Draft proofing	45	100	53	47
Install storm windows	45	33	5	28
Average	59	77	45	32

Lighting

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Turn off lights – empty room	85	100	86	14
Use low wattage bulbs	85	100	68	32
Turn off outside lights	64	80	60	20
Average	78	93	71	22

Domestic Hot Water

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Check DHW temperature	46	100	43	57
Turn off DHW away/vacation	46	100	20	80
Average	46	100	32	69

Washing Appliances

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Cold water clothes wash	62	69	62	7
Dishwasher air dry/energy saver	62	100	43	57
Average	62	85	53	32

Refrigeration

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Check refrigerator temperature	41	100	59	41
Check freezer temperature	41	100	33	67
Defrost freezer more frequently	41	100	54	46
Average	41	100	49	51

Consumer Electronics

Conditions, Capacity, Commitment, Behavioral Target (%)

Behavior	Conditions	Capacity	Commitment	Behavioral Target
Unplug unused brick chargers	75	100	33	67
Turn off TV no one watching	81	100	80	20
Computer all components off	75	100	57	43
Computer monitor off	75	100	47	53
Computer power management	75	100	86	14
Average	76	100	61	39

Potential Behavioral Savings

Potential Behavioral Savings Per End Use Per Dwelling

End Use	Average Unit Energy (kWh/y)	Behavioral target share	Potential savings share	Potential savings (kWh/y)
Space heating	1,716	0.32	0.09	**49**
Lighting	1,992	0.22	0.14	**61**
Domestic hot water	1,060	0.69	0.15	**110**
Washing appliances	731	0.32	0.29	**68**
Refrigeration	2,240	0.51	0.12	**134**
Consumer electronics	1,288	0.39	0.04	**20**
Potential Energy Savings per Dwelling				**442**

Largest Potential Energy Savings

- Refrigeration (134 kWh/y per dwelling)
  - refrigerator and freezer temperature control
  - defrosting freezers
- Domestic Hot Water (110 kWh/y per dwelling)
  - checking the hot water tank temperature
  - turning off the hot water tank while away from home

Reasonable Potential Energy Savings

- Lighting (61 kWh/y per dwelling)
  - turning off lights when the room is empty
  - using low wattage bulbs and turning off outside lights.
- Washing Appliances (68 kWh/y per dwelling)
  - checking the temperature of domestic hot water (DHW) tanks
  - turning off hot water tanks while away or on vacation

Less Potential Energy Savings

- Space Heating (49 kWh/y per dwelling)
  - temperature setback at night
  - temperature setback during the day when no-one was at home
  - keeping part of the house cooler when unused
  - draft proofing
  - installation of storm windows.
- Consumer Electronics (20 kWh/y per dwelling)
  - unplugging brick chargers when not in use
  - turning off the TV when no one is watching
  - turning off all computer components
  - turning the computer monitor off
  - using power management software.

Conclusions

Refrigeration & domestic hot water actions were particularly effective means of saving energy

- Room to improve satisfaction
- High behavioral share indicating high potential to influence a large number of consumers
- Reasonable average unit potential energy savings

Conclusions - 2

Somewhat less, but still effective means of saving energy included lighting, washing appliances, space heating & consumer electronics actions

- Consumers are relatively satisfied with these services
- Relatively low potential energy savings shares for these services

Conclusions - 3

While all six end uses were found to be effective means of saving energy in residential buildings, the **conditions**, **capacity**, **commitment** model helped to

- identify leading energy savings opportunities, and
- Identify challenges that may well arise in developing messaging and programs to achieve the identified energy savings.

Thank you

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