



# Attributes of Energy Reduction Behaviors

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# Rationale

- ❑ Research on energy behavior focuses on people and environments.
- ❑ Utility, NGO and Government programs are designed to encourage energy efficiency behaviors.
- ❑ Yet, knowing which behaviors to target is often challenging.



# Research Questions

- Could we gain insights from rating behaviors on their attributes?
  - Do energy efficiency behaviors cluster into meaningful categories based on their attributes?
  - Do statistically determined clusters replicate categorization schemes as this in Dietz, Gardner, Gilligan, Stern, Vandenberg (2009)?
  - What is the behavioral plasticity of behaviors within clusters?

# Project Goal

Create a database of behaviors that can be used by intervention designers and policy makers

# Project Description

- ▣ Generate a comprehensive list of **residential** energy reduction behaviors
- ▣ Rate behaviors according to behavior change theory attributes
- ▣ Cluster behaviors into meaningful categories
- ▣ Gather population ratings of behaviors

# Attributes

# Categorical Attributes

Household Function	Appliance Topography	Home Topography	Locus of Decision
Thermal comfort	Large electrical/gas appliance	Shell/Envelope	Primarily Men
Food/ Nourishment	Small electrical/gas appliance	Kitchen/dining	Primarily Women
Hygiene	Electrical Tools	Office	Either or Both
Lighting	Craft and Rec	Entertainment space	Adults & Teenagers
Housekeeping	Electronics and computers	Bedroom	Adults & Teenagers & Kids
Outdoor recreation	Electrical Lighting	Storage spaces	
Entertainment and communication	No appliance, device or tool	Multiple Locations	
		Outside of home	
		Bathroom	

# Ordinal Attributes

Behavioral Frequency	Skill Demand	Household Observability	Energy Savings	Fiscal Cost
One-time	No Skill	To everyone	< 250 kWh/year	< \$5
Irregular	Low	To adults	250-750 kWh/year	\$5 - \$20
Regular	Medium	Only to the person who performed it	> 750 kWh/year	\$20 - \$100
Frequent (Weekly)	High			\$100 - \$1000
Very Frequently (Daily)				> \$1000

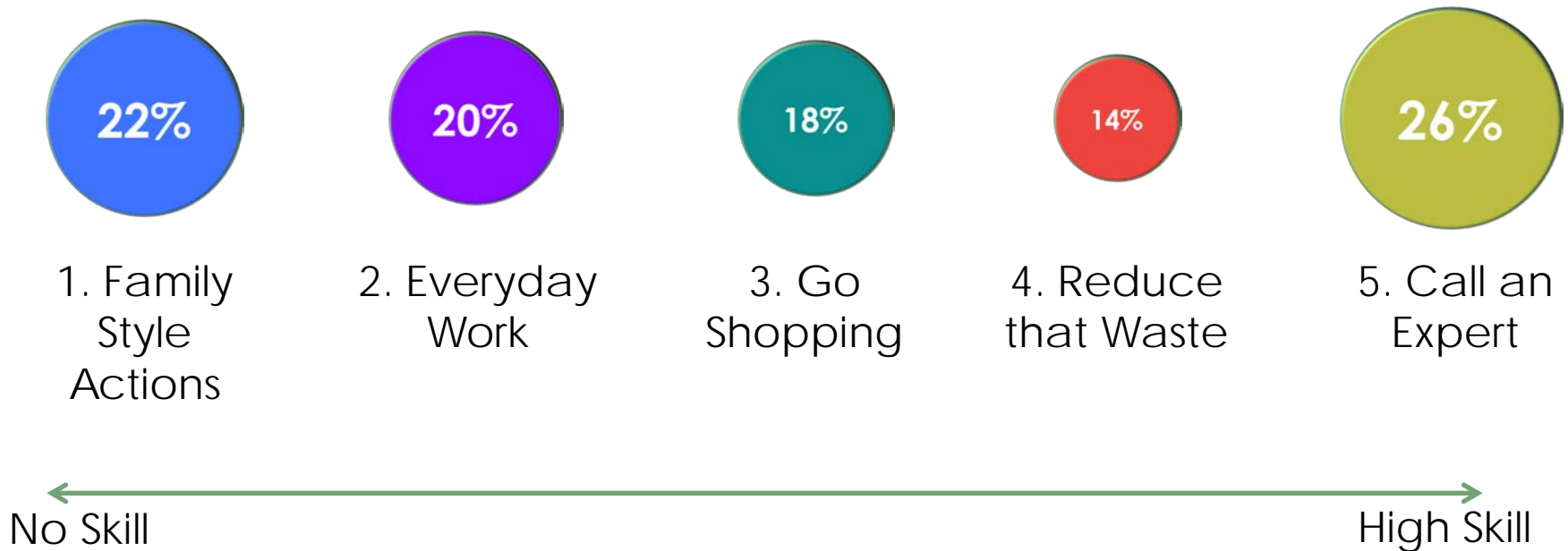


# Skill Demand

Functional Category	Definition	Percent
<b>No Skill</b>	Behaviors that can be intuitively adopted even without previous experience	<b>34</b>
<b>Low Skill</b>	Need to look at/ask for instructions, but fairly easy to perform and repeat when needed	<b>20</b>
<b>Medium Skill</b>	Some people prefer to hire professionals, while others perform the behaviors on their own. In the later case, individuals should carefully follow instructions. In addition to the information found in the instructions sheet, the performance of the behavior requires <i>practical/physical skill</i> , and in most of the cases the use of tools.	<b>19</b>
<b>High Skill</b>	Almost always need professional help, hire someone to do the task	<b>27</b>

# Behavior Groups

# Behavior Groups by Skill Level



# Behavior Groups by Fiscal Cost and Skill Level

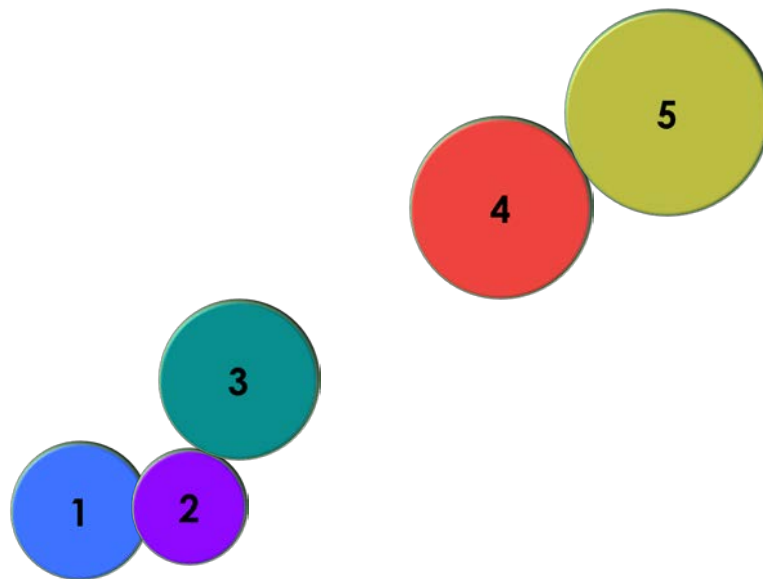
Fiscal Cost

High

Low

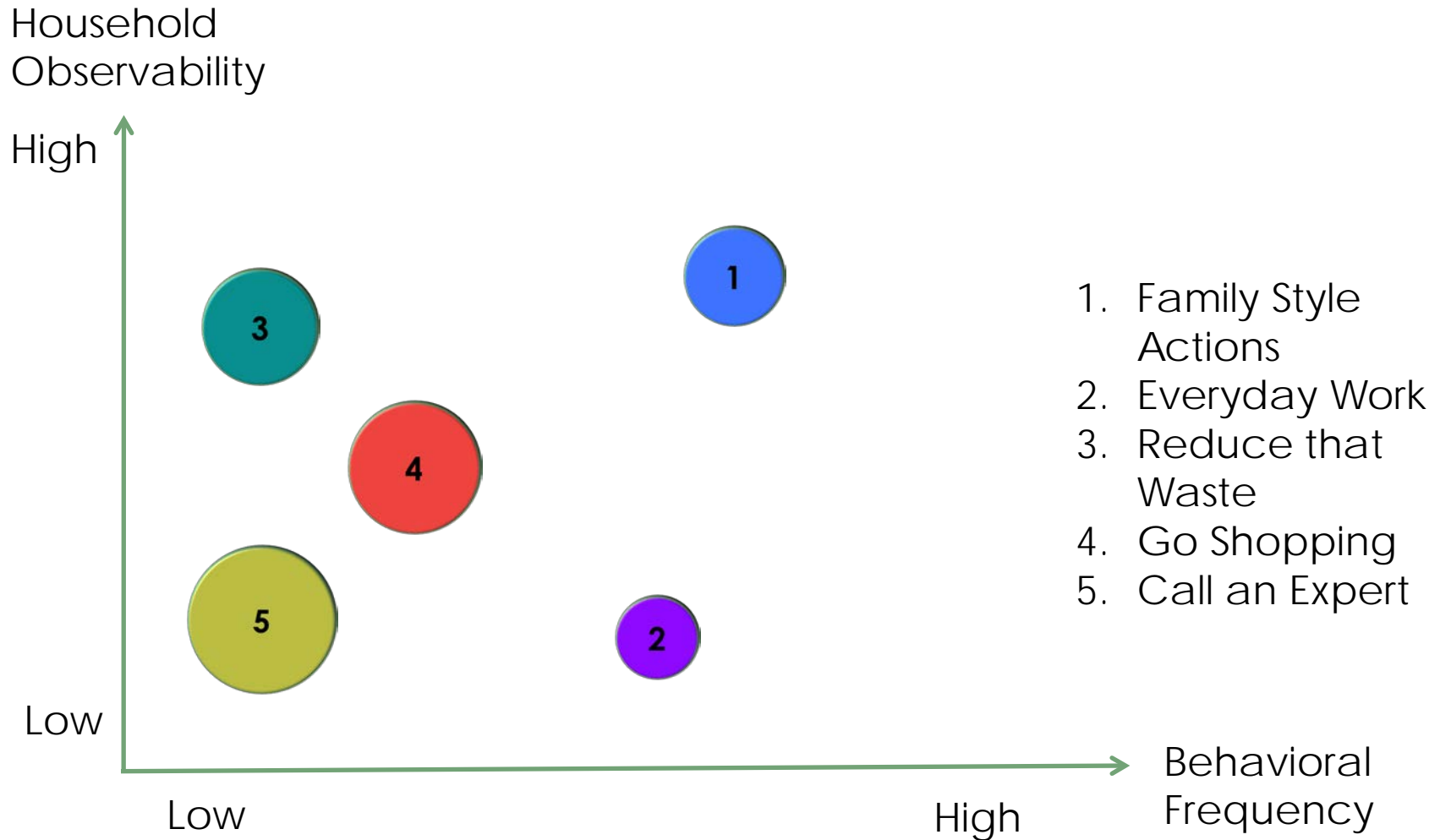
Low

High Skill Demand



1. Family Style Actions
2. Everyday Work
3. Reduce that Waste
4. Go Shopping
5. Call an Expert

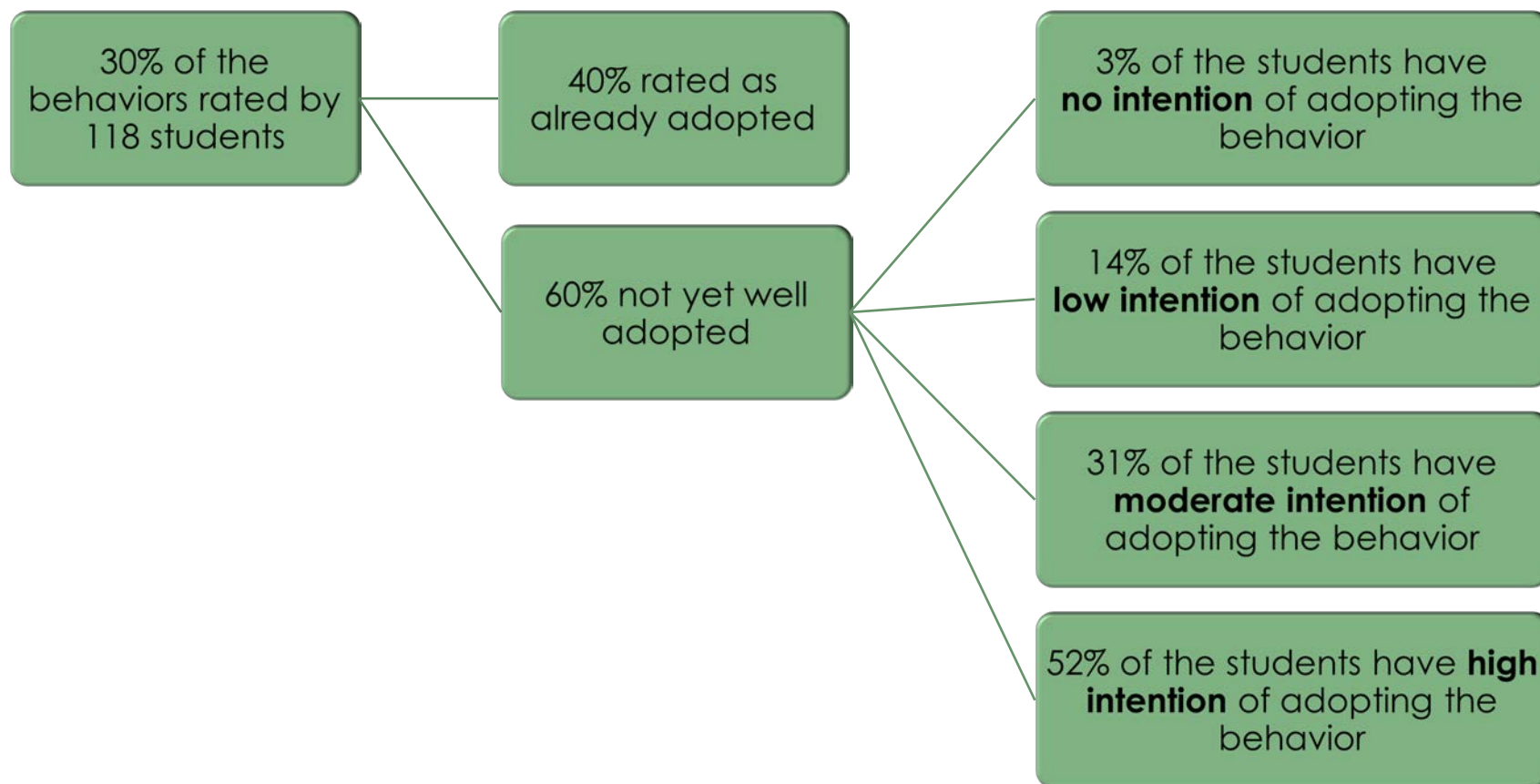
# Behavior Groups by Frequency and Observability



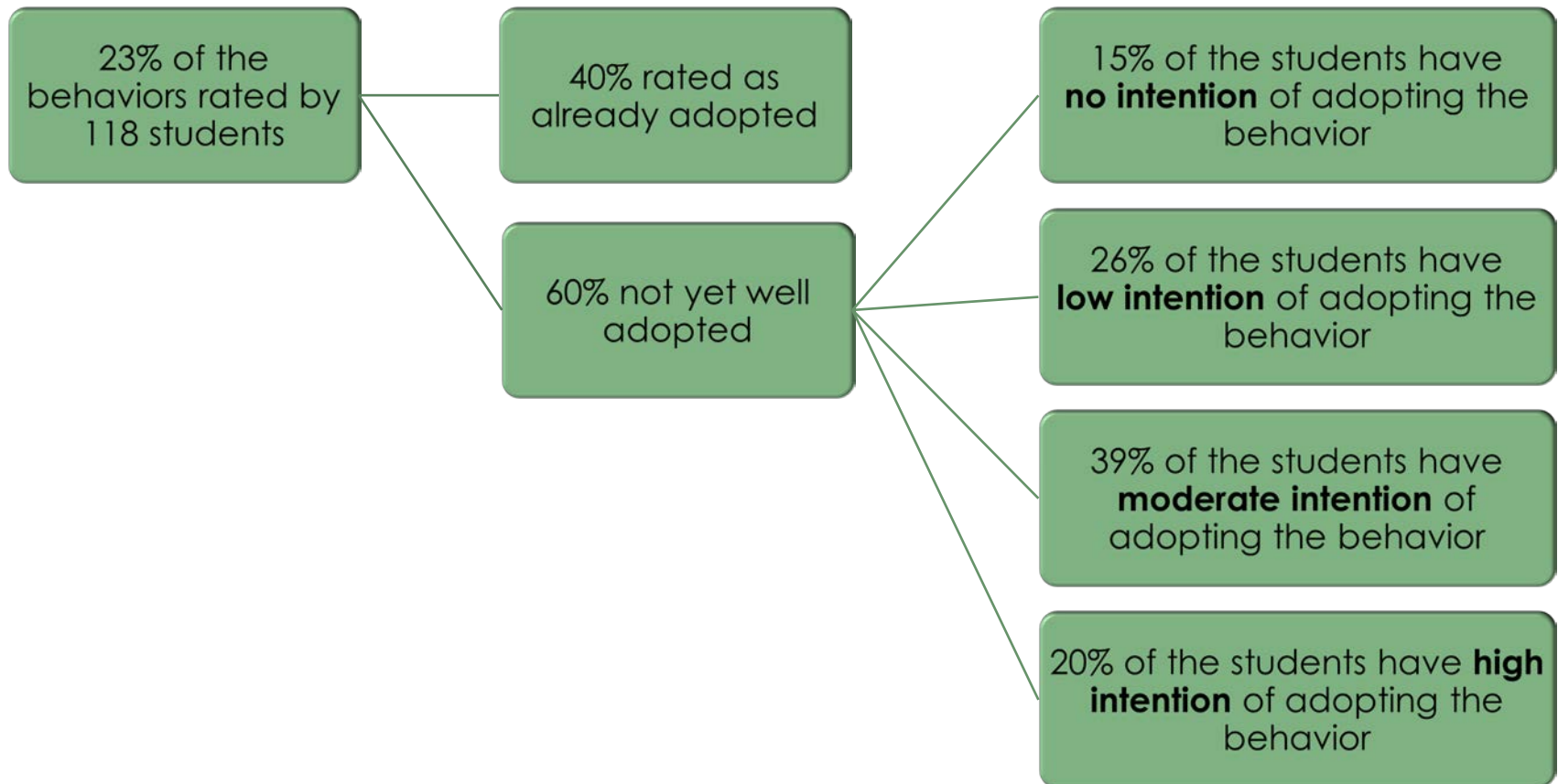
# Population Ratings

- Demographic
- Current Behavior (perform or not the target action)
- Likelihood of Adoption (intend to do)
- Confidence of Performing the Action

# Cluster 1: Family Style Actions

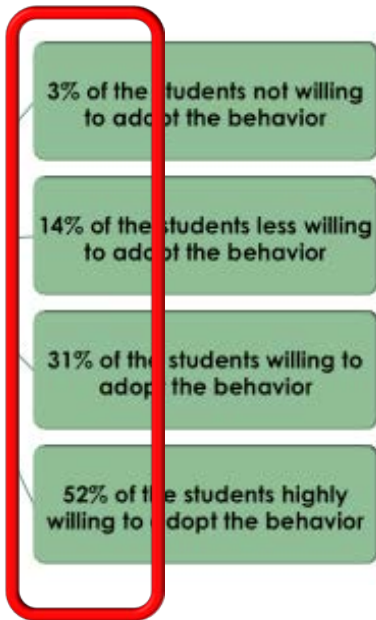


# Cluster 2: Everyday Work



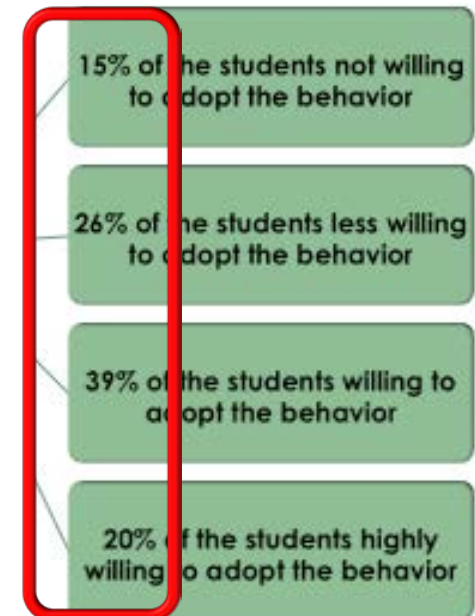


# Population Ratings



- *Open windows at night, turn off your cooling system and open your windows while sleeping*
- *When you wake in the morning, shut the windows and blinds to capture the cool air*
- *Unplug your cell phone charger after your phone is fully charged*

- *Decide what you want from a refrigerator before opening the door*
- *Adjust your refrigerator temperature settings*
- *Take shorter showers*



# Next Steps

- ▣ Extend List
- ▣ Revise Energy Savings Attribute
- ▣ Introduce Attributes
- ▣ Gather Population Ratings



Thank you

# Rationale

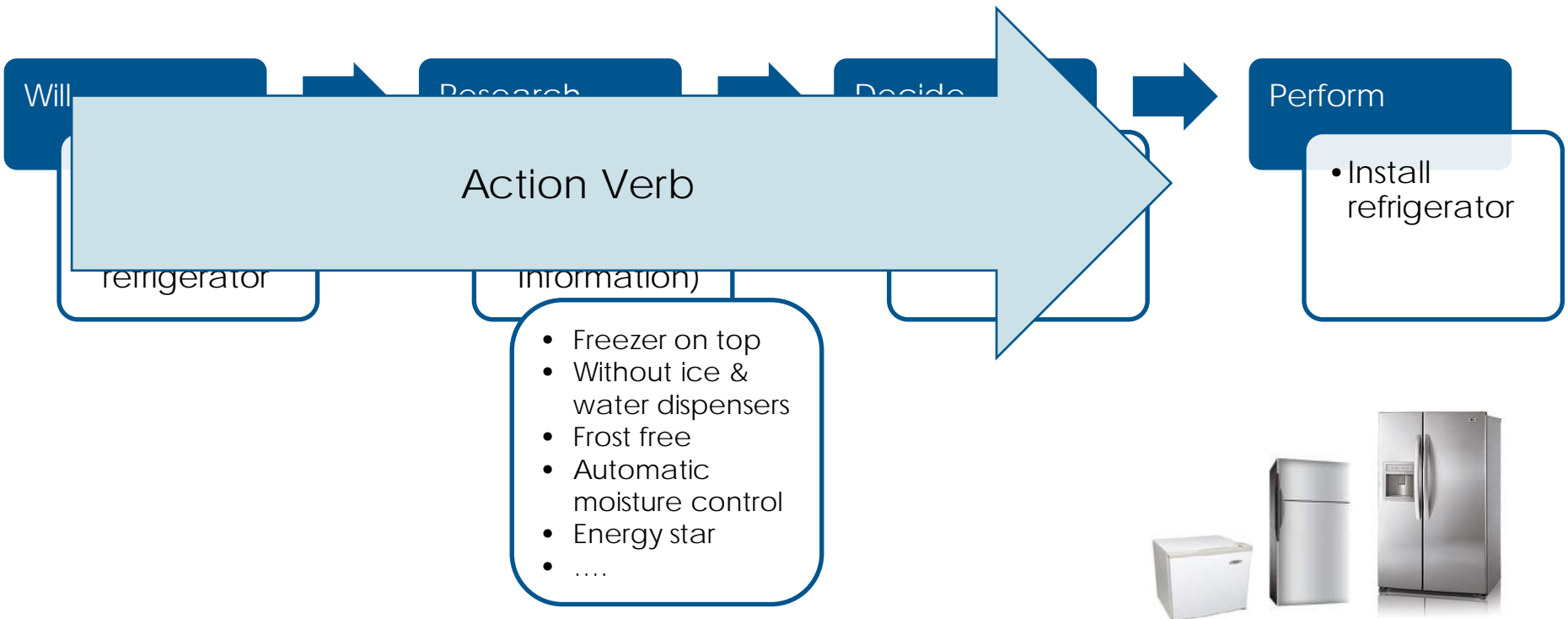
$$\text{Impact} = t p n$$

- ▣ t: technical potential
- ▣ p: behavioral plasticity of an action: proportion of people, households, organizations that could be induced to take the target action
- ▣ n: total number of actors that could possibly take the action

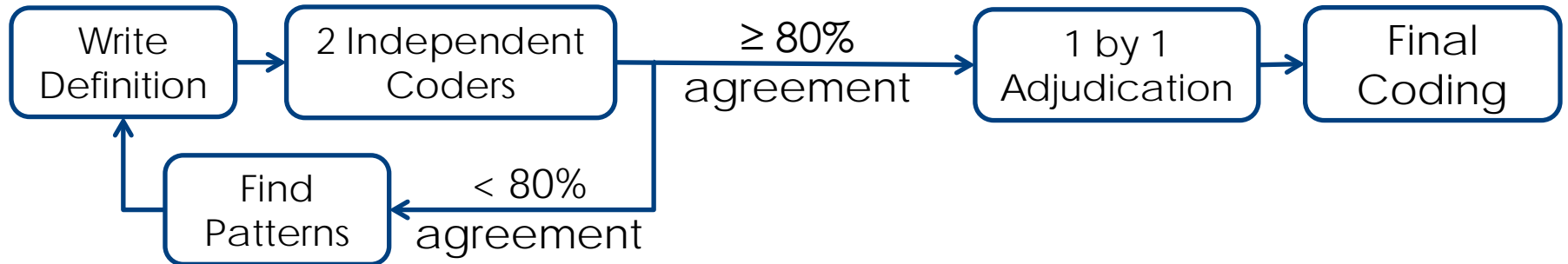


# Methodology

# Behavior Definition



# Attributes - Coding



# Attributes - Definition

- ▣ Definition:
  - ▣ Comprehensible Definitions
  - ▣ Mutually Exclusive Attribute Categories
  - ▣ Exhaustive Attribute Categories
  - ▣ Effort to avoid Perfectly Correlated Attribute Categories



# Attributes

- ▣ Household Function
- ▣ Appliance Topography
- ▣ Home Topography
- ▣ Locus of Decision
- ▣ Behavioral Frequency
- ▣ Skill Demand
- ▣ Household Observability
- ▣ Energy Savings
- ▣ Fiscal Cost

# Theories Guiding Attribute Selection

Attribute	Family system	Social cognitive theory	Social ecology	Diffusion	Energy/Economic
Function	x			x	
House Topography			x		
Appliance topography			x		
Skill demand		x			
Locus of decision	x				
Frequency		x			
Observability	x			x	
Energy Savings					x
Fiscal Cost					x

# List & Results

# Home Topography

Functional Category	Definition	Percent
<b>Shell</b>	Structure or framework of a house and products physically connected to it	35
<b>Kitchen/dining</b>	Anything located in the dining space along with the kitchen	20
<b>Office</b>	Office spaces located within a house	3
<b>Entertainment space</b>	Spaces commonly used for all the entertainment requirements of a family like TV theatre, music systems, etc	4
<b>Bedroom</b>	Spaces within a house that are used for the purpose of sleeping, taking rest, etc	1
<b>Storage spaces</b>	Places within a house used for the purpose of storing items	13
<b>Multiple Locations</b>	Products that do not have a specific location, and can be used anywhere in a house	14
<b>Outside of home</b>	Around a house like the lawn, patio...	7
<b>Bathroom</b>	Spaces within a house used for the purpose of personal hygiene	2

# Home Topography

Functional Category	Exemplars
Shell	<ul style="list-style-type: none"><li>• Caulk &amp; seal exterior walls</li></ul>
Kitchen/dining	<ul style="list-style-type: none"><li>• Install a freezer-on-top refrigerator</li></ul>
Office	<ul style="list-style-type: none"><li>• Install a desk lamp to use for task lighting</li></ul>
Entertainment space	<ul style="list-style-type: none"><li>• Install a 52" Projection HD TV instead of a 48" Plasma HD TV</li></ul>
Bedroom	<ul style="list-style-type: none"><li>• Use an under-blanket on your bed (instead of using a heater)</li></ul>
Storage spaces	<ul style="list-style-type: none"><li>• Set water heaters to 120° F</li></ul>
Multiple Locations	<ul style="list-style-type: none"><li>• Replace incandescent light bulbs with LED ones</li></ul>
Outside of home	<ul style="list-style-type: none"><li>• Set pool pumps to cycle less frequently</li></ul>
Bathroom	<ul style="list-style-type: none"><li>• Bathe via showers (instead of baths)</li></ul>

# Skill Demand

Functional Category	Exemplars
<b>No Skill</b>	<ul style="list-style-type: none"><li>• Turn off lights</li></ul>
<b>Low Skill</b>	<ul style="list-style-type: none"><li>• Appliance settings/timers</li></ul>
<b>Medium Skill</b>	<ul style="list-style-type: none"><li>• Paint rooms</li></ul>
<b>High Skill</b>	<ul style="list-style-type: none"><li>• Relocate hot water systems to minimize total pipe length</li></ul>

# Household Function

Functional Category	Definition	Percent
<b>Thermal comfort</b>	Actions that insure that household members are comfortable regarding heat, ventilation, and cooling. Excludes hot water.	<b>35</b>
<b>Food/ Nourishment</b>	Actions directly and indirectly related to nourishing family members; cooking, storage and serving of food	<b>16</b>
<b>Hygiene</b>	Actions related to hygiene of family members including hot water comfort, and other water actions related to personal hygiene, showering and bathing.	<b>8</b>
<b>Lighting</b>	Actions related to light; natural and electrical light	<b>10</b>
<b>Housekeeping</b>	Actions related to maintenance of cleanliness, comfort and orderliness of members.	<b>20</b>
<b>Outdoor recreation</b>	Actions and devices that are outside of home and associated with recreation; swimming, tubing, sports etc.	<b>2</b>
<b>Entertainment, computing and communication</b>	Household communication that is entertainment, work (includes school), public service, and community related	<b>9</b>

# Household Function

Functional Category	Exemplars
<b>Thermal comfort</b>	<ul style="list-style-type: none"><li>• Insulate exterior walls with high density insulation</li></ul>
<b>Food/ Nourishment</b>	<ul style="list-style-type: none"><li>• Cover pots &amp; pans when cooking</li></ul>
<b>Hygiene</b>	<ul style="list-style-type: none"><li>• Reduce the duration of your showers</li></ul>
<b>Lighting</b>	<ul style="list-style-type: none"><li>• Install CFL-compatible dimmer controls on lights</li></ul>
<b>Housekeeping</b>	<ul style="list-style-type: none"><li>• Empty and/or replace vacuum cleaner filter bags regularly</li></ul>
<b>Outdoor recreation</b>	<ul style="list-style-type: none"><li>• Reduce pool pump &amp; filter cycling frequency during cooler months</li></ul>
<b>Entertainment, computing and communication</b>	<ul style="list-style-type: none"><li>• Unplug mobile/cell phone chargers when not in use</li></ul>



# Appliance Topography

Functional Category	Definition	Percent
<b>Large electrical/gas appliance</b>	The following types of devices fit in this category; the crude definition is electrical or gas powered and larger than a breadbox: Refrigerators, stoves, ovens, dishwashers, AC, furnace, water heater	<b>34</b>
<b>Small electrical/gas appliance</b>	Electrical/gas powered and same size or smaller than a breadbox: Mixers, microwave, disposal, vacuum cleaners, dehumidifiers, air purifiers, battery chargers, fans, small heaters, iron, hair dryer, shavers	<b>11</b>
<b>Craft and Rec</b>	Pool pump, pool heater, spa heater, pottery wheel	<b>1</b>
<b>Electronics and computers</b>	TV, computers, games,	<b>9</b>
<b>Electrical Lighting</b>	CFLs	<b>7</b>
<b>Non-electrical Devices - Actions and not an appliance, device or tool</b>	Line dryer, drapes, pots and pans	<b>38</b>

# Appliance Topography

Functional Category	Exemplars
<b>Large electrical/gas appliance</b>	<ul style="list-style-type: none"><li>• Locate freezers in the coldest location possible</li></ul>
<b>Small electrical/gas appliance</b>	<ul style="list-style-type: none"><li>• Set timers on space heaters</li></ul>
<b>Craft and Rec</b>	<ul style="list-style-type: none"><li>• If a solar water heater cannot be installed, install an energy efficient swimming pool heater</li></ul>
<b>Electronics and computers</b>	<ul style="list-style-type: none"><li>• Turn off computer monitors when not in use</li></ul>
<b>Electrical Lighting</b>	<ul style="list-style-type: none"><li>• Replace incandescent light bulbs with LED ones</li></ul>
<b>Non-electrical Devices - Actions and not an appliance, device or tool</b>	<ul style="list-style-type: none"><li>• Install low-flow aerators in faucets</li><li>• Caulk windows</li><li>• Open windows &amp; louvers at night when cooling your home</li></ul>

# Locus of Decision

Functional Category	Definition	Percent
<b>Primarily Men</b>	Behaviors whose adoption is primarily <i>decided</i> by men	<b>31</b>
<b>Primarily Women</b>	Behaviors whose adoption is primarily <i>decided</i> by women	<b>16</b>
<b>Either or Both (Only Adults)</b>	Behaviors whose adoption is decided by either men or women, or both	<b>28</b>
<b>Adults &amp; Teenagers</b>	Behaviors whose adoption is decided by either adults (both genders) or teenagers (13-19 yrs) - Teenagers do not have purchasing power	<b>17</b>
<b>Adults &amp; Teenagers &amp; Kids</b>	Behaviors whose adoption is decided by either adults (both genders) or teenagers (13-19 yrs) or kids (7-12 yrs) - Teenagers and kids do not have purchasing power - Kids are not actively involved in housework and do not use cooking appliances (they can close doors, turn off appliances).	<b>8</b>

# Locus of Decision

Functional Category	Exemplars
<b>Primarily Men</b>	<ul style="list-style-type: none"><li>• Drain sediment from hot water storage</li><li>• Clean pool filters regularly</li></ul>
<b>Primarily Women</b>	<ul style="list-style-type: none"><li>• Clean ovens regularly</li><li>• Maintain clear freezer door seals</li></ul>
<b>Either or Both (Only Adults)</b>	<ul style="list-style-type: none"><li>• Install high efficiency windows</li><li>• Place tapestries on the walls</li></ul>
<b>Adults &amp; Teenagers</b>	<ul style="list-style-type: none"><li>• Wash laundry in cold water</li><li>• Cook with ceramic pans</li></ul>
<b>Adults &amp; Teenagers &amp; Kids</b>	<ul style="list-style-type: none"><li>• Turn off lights</li><li>• Close doors in unoccupied rooms</li></ul>

# Behavioral Frequency

Functional Category	Definition	Percent
<b>One-time</b>	Behaviors that occur only once in a year or longer	<b>48</b>
<b>Periodic, irregular low frequency</b>	Behaviors required irregularly typically when equipment breaks. These actions occur on an as needed basis	<b>5</b>
<b>Regular, Medium Frequency</b>	Behaviors that occur infrequently but regularly (monthly or seasonally). These behaviors are often related to the actions which keep energy equipment in safe condition and related to maintenance process of these equipment.  Hint: Maintain, Repair	<b>16</b>
<b>Frequent (Weekly)</b>	These actions occur several times a week but not every day of week	<b>11</b>
<b>Very High Frequency (daily)</b>	Stands for decision or behaviors that we should deal with over the course of a day. They are mostly related to changes in the use of energy equipment  <b>These actions occur 1 or more times every day of the week.</b>	<b>20</b>

# Behavioral Frequency

Functional Category	Exemplars
<b>One-time</b>	<ul style="list-style-type: none"><li>• Install an energy star appliance</li><li>• Install insulation in walls</li></ul>
<b>Periodic, irregular low frequency</b>	<ul style="list-style-type: none"><li>• Repair leaky ducts</li></ul>
<b>Regular, Medium Frequency</b>	<ul style="list-style-type: none"><li>• Maintain oven seals</li><li>• Set a programmable thermostat to intelligently control central heating/cooling</li></ul>
<b>Frequent (Weekly)</b>	<ul style="list-style-type: none"><li>• Use clothes dryer balls</li><li>• Wash only full loads of laundry</li></ul>
<b>Very High Frequency (daily)</b>	<ul style="list-style-type: none"><li>• Turn off lights</li><li>• Unplug power strips</li></ul>

# Cluster 1: Family Style Actions

<b>Behavioral Frequency</b>	Very High
<b>Skill</b>	No Skill
<b>Household Observability</b>	High
<b>Locus of Decision</b>	Everybody
<b>Savings</b>	Low
<b>Cost</b>	Very Low

They reside in:

- Kitchen/Dining
- Multiple Locations
- Shell

They are aimed for:

- Nourishment
- Thermal Comfort

# Cluster 2: Everyday Work

<b>Behavioral Frequency</b>	Medium
<b>Skill</b>	No/Low
<b>Household Observability</b>	No
<b>Locus of Decision</b>	Primarily Women
<b>Savings</b>	Low
<b>Cost</b>	Very low

They reside in:

- Kitchen/Dining
- Storage Space

They are aimed for:

- Housekeeping



# Cluster 3: Go Shopping

<b>Behavioral Frequency</b>	One-time
<b>Skill</b>	Medium
<b>Household Observability</b>	High
<b>Locus of Decision</b>	Adults
<b>Savings</b>	Medium
<b>Cost</b>	High

They reside in:

- Shell

They are aimed for:

- Thermal Comfort

# Cluster 4: Reduce that Waste

<b>Behavioral Frequency</b>	Irregular
<b>Skill</b>	Low
<b>Household Observability</b>	Adults
<b>Locus of Decision</b>	Adults
<b>Savings</b>	Low/Medium
<b>Cost</b>	Low

They reside in:

- Multiple Locations
- Shell

They are aimed for:

- Thermal Comfort
- Lighting

# Cluster 5: Call an Expert

<b>Behavioral Frequency</b>	One-time
<b>Skill</b>	High
<b>Household Observability</b>	Low
<b>Locus of Decision</b>	Primarily Men
<b>Savings</b>	Medium
<b>Cost</b>	High

They reside in:

- Shell

They are aimed for:

- Thermal Comfort