Thinking Outside the Box: Why Social-Psychological Factors are Important in the Interdisciplinary Research of Energy and Technology

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What is Sociology?

Sociology is:

- the study of society
- a social science involving the study of the social lives of people, groups, and societies
- the study of our behavior as social beings, covering everything from the analysis of short contacts between anonymous individuals on the street to the study of global social processes
- the scientific study of social aggregations, the entities through which humans move throughout their lives'
- an overarching unification of all studies of humankind, including history, psychology, and economics

From American Sociological Association

Sociological Imagination (C. Wright Mills)

- The ability of understanding the intersection of one's own biography and other biographies with history and the present social structure you find yourself and others in. In essence, it is understanding the private in public terms.
- One person does not have a job - individual problem; 1 million people do not have jobs – a societal problem.

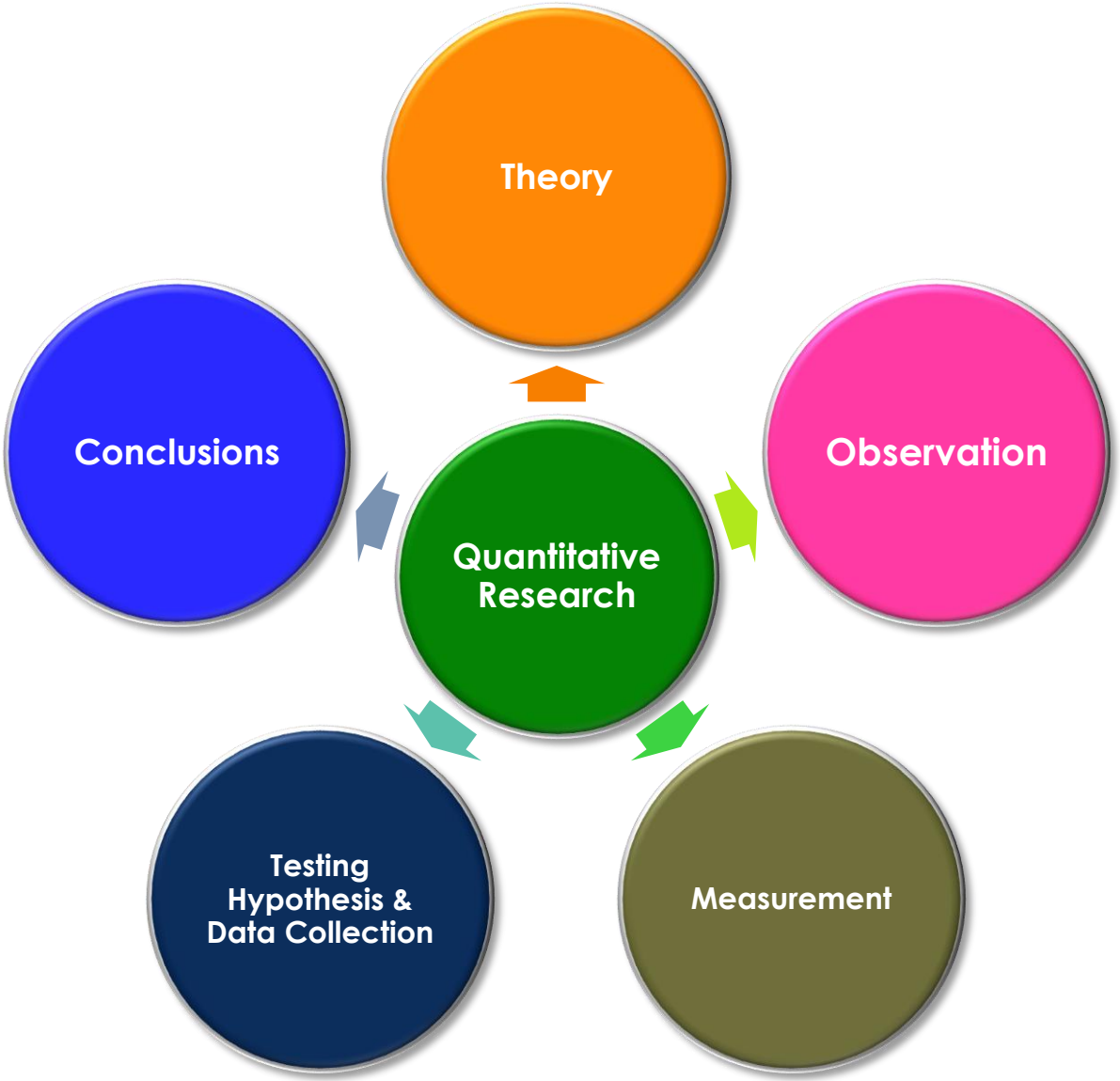
- http://www.cabrillo.edu/~lroberts/Sociological%20Imagination.pdf

Sociological Imagination: Thinking Outside of The Box

- A quality of mind that allows one to grasp "history and biography and the relations between the two within society.
- A different perspective
- Difference between personal troubles and public issues; **look beyond individuals**
- Different solutions
- Freedom to see the world in a new way
- Can be Frightening—makes you uncomfortable "things are not what they seem"

http://www.cabrillo.edu/~lroberts/Sociological%20Imagination.pdf

Cycle of Social Science Research



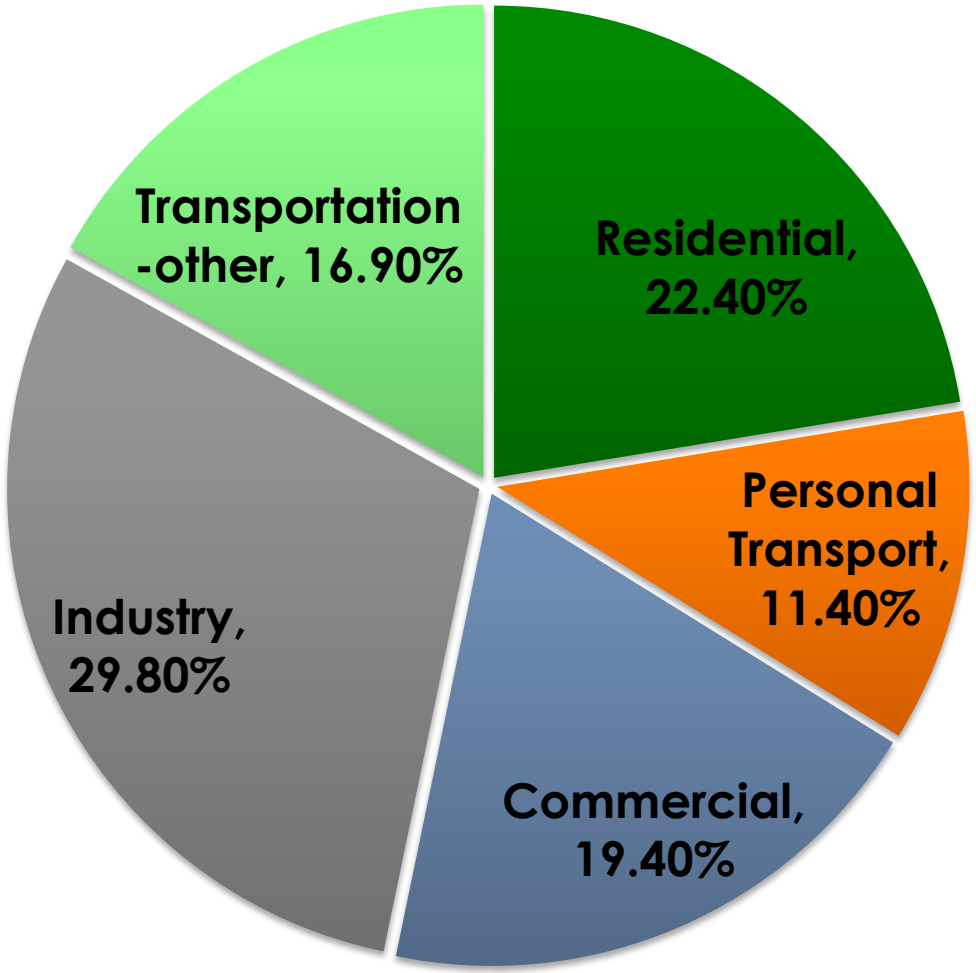
Examples of Social Psychological Factors and Energy Issues

Area	Project
Renewable Energy Technology	• Acceptance of smart meter technology • Acceptance of solar hot water heaters, EVs and support of renewable energy policy
Demand Response	• Social-psychological and demographic factors influencing DR programs (normal, critical and emergency) • Customer segmentation
Behavioral Change	• Effects of message framing on individual energy saving behavior change • Social-psychological related factors on short and long-term behaviors
Commercial Buildings	• Social-psychological and demographics factors affecting energy saving and building control options

Current CURENT Research

- DR programs, incentives and critical time behavioral change (New Mexico)
- DR programs and EVs (Waseda, Japan)
- DR programs and smart home management Management (Waseda, Osaka)
- International occupant behavioral survey in commercial buildings (Hungary, China, U.S. Italy, Portland, Norway, etc.)
- Energy saving intentions among low-income households (with U of M)
- Smart community research (several universities)

U.S. Energy Consumption in 2010



Residential & personal transport account for 34%

Source: EIA

Traditional Economic & Engineering Models

Typical responses to energy crisis:

- Find new energy resources
- Develop technologies – engineers' job
- Provide financial incentives for people to reduce consumption, to adopt more efficient technologies

Assumption of rationality

✓ People are instrumental and self-interested, consistent, cost-benefit based.

But it is often not true.

Creating an Energy Revolution

"A revolution doesn't happen when society adopts new tools, it happens when society adopts new behaviors" (Glay Shirky, Digital Guru).

"Mitigate future climate change will be made by energy consumers, rather than suppliers… not a straightforward and easily achievable goal" (EIA, 2009).

Nudging Behaviors Matter

Behavioral Change	Potential Savings:
Various types of household behaviors	***22% reduction*** in household & personal transportation energy use over a ***5-8 year*** period *(Laitner & Ehrhardt-Martinez, 2009)*
In crisis situations	Community-level electricity savings could be ***25%*** in ***6 weeks*** & post-crisis savings of ***8-10%*** *(Leighty & Meier, 2010)*
Feedback programs & devices	Save electricity ***4-12%*** *(Ehrhardt-Martinez, et al. 2010)*
Real-time feedback with smart programs + social science insights	Save electricity ***20-35%***

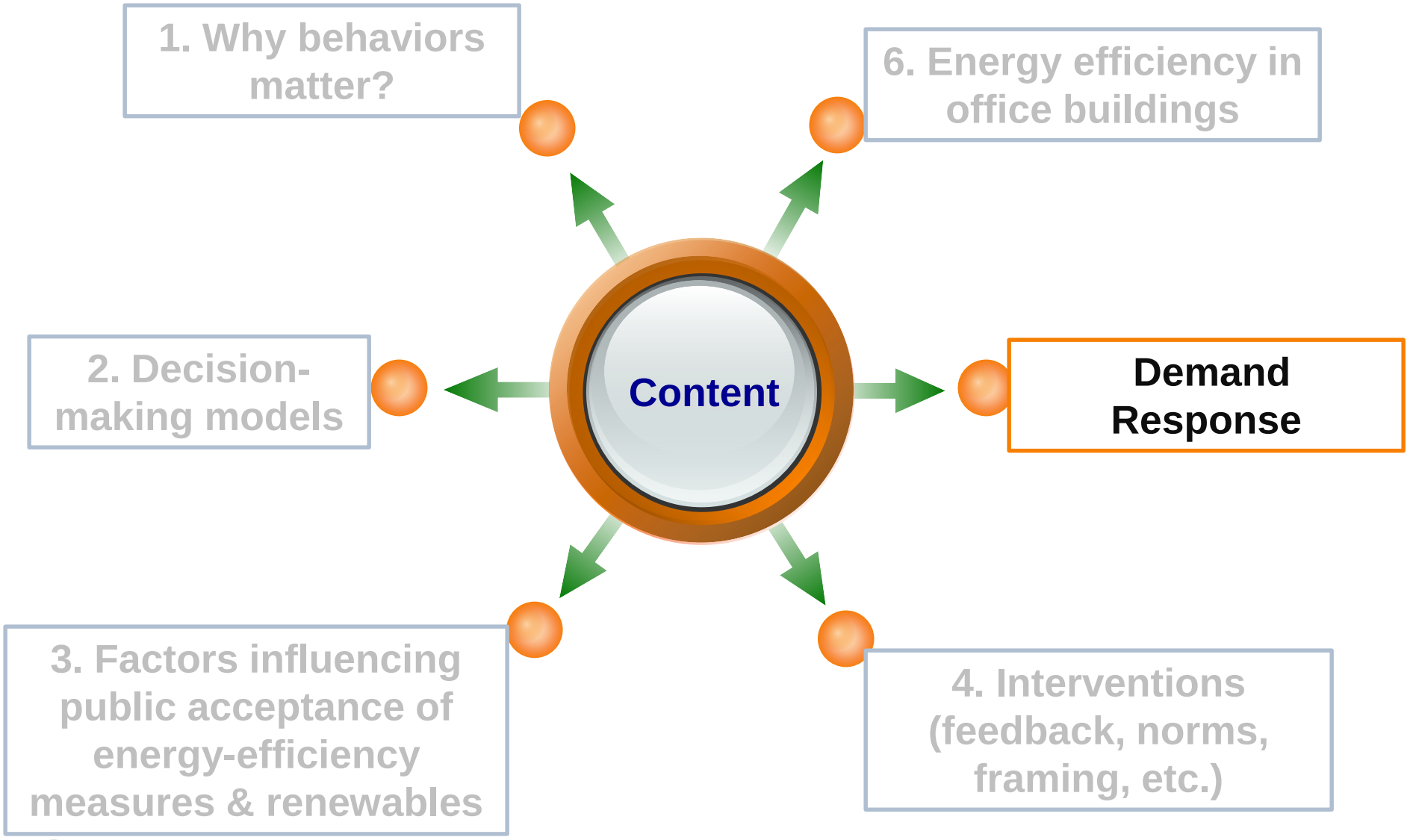
Assumptions of Human Behaviors

Without Deliberation	With Deliberation
• In-output model • Behaviors controlled by environment	• Emphasize human agency • Mindful or cognitive process
Not Empathizing: • Internal judgments • Cognitive process • Interpersonal relationships (Asch, 1951, Sherif, 1935)	Empathizing: • Attitudes • Perceptions • Motivations

Actors are mindless robots

Actors are mindful

Social Psychological Factors and Energy Behaviors



Demand Response (DR) Programs

- DR program provide an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. DR programs are being used by electric system planners and operators as the options for balancing supply and demand. DR can lower the cost of electricity in wholesale markets, and in turn, lead to lower retail rates.

Social-Psych Factors, Segmentation and Demand Response (DR)

- Traditional approach to promoting DR programs: peak & off-peak pricing, dynamic pricing, additional financial incentives, etc.
- Our questions:

1) To what extent the financial incentives help customers to accept DR programs? Is the effect same for everyone?
2) How to predict acceptance from energy use habits, demographic variables, and social-psychological factors?

Individual-level Factors

Category	Factors/Variables
Behavioral Patterns	Heating/cooling, lighting, electronic devices usage and other curtailment habits, etc.
Awareness & Knowledge	Appliances & devices (items, types and ages), awareness of energy efficiency technologies and energy assistance programs, etc.
Social-psychological Factors	Motivation, attitudes, behavioral control, energy concern, social norms, sense of community, thermal comfort, money consciousness, trust, privacy concern, willingness to adopt new technologies, etc.
Demographics	Gender, income, race, education, political orientation, household size, number of children and seniors, household dynamics, regions, etc.

Financial Incentives and HVAC-related DR Behaviors

- **Goal:** More accurate estimation of adjustable loads as a function of financial incentives and individual (social-psych) household characteristics
- **Method:** Two online surveys across 48 states in the U.S.
  - 711 and 754 valid responses collected

Ex: How much monetary rewards do you expect in exchange for… ?

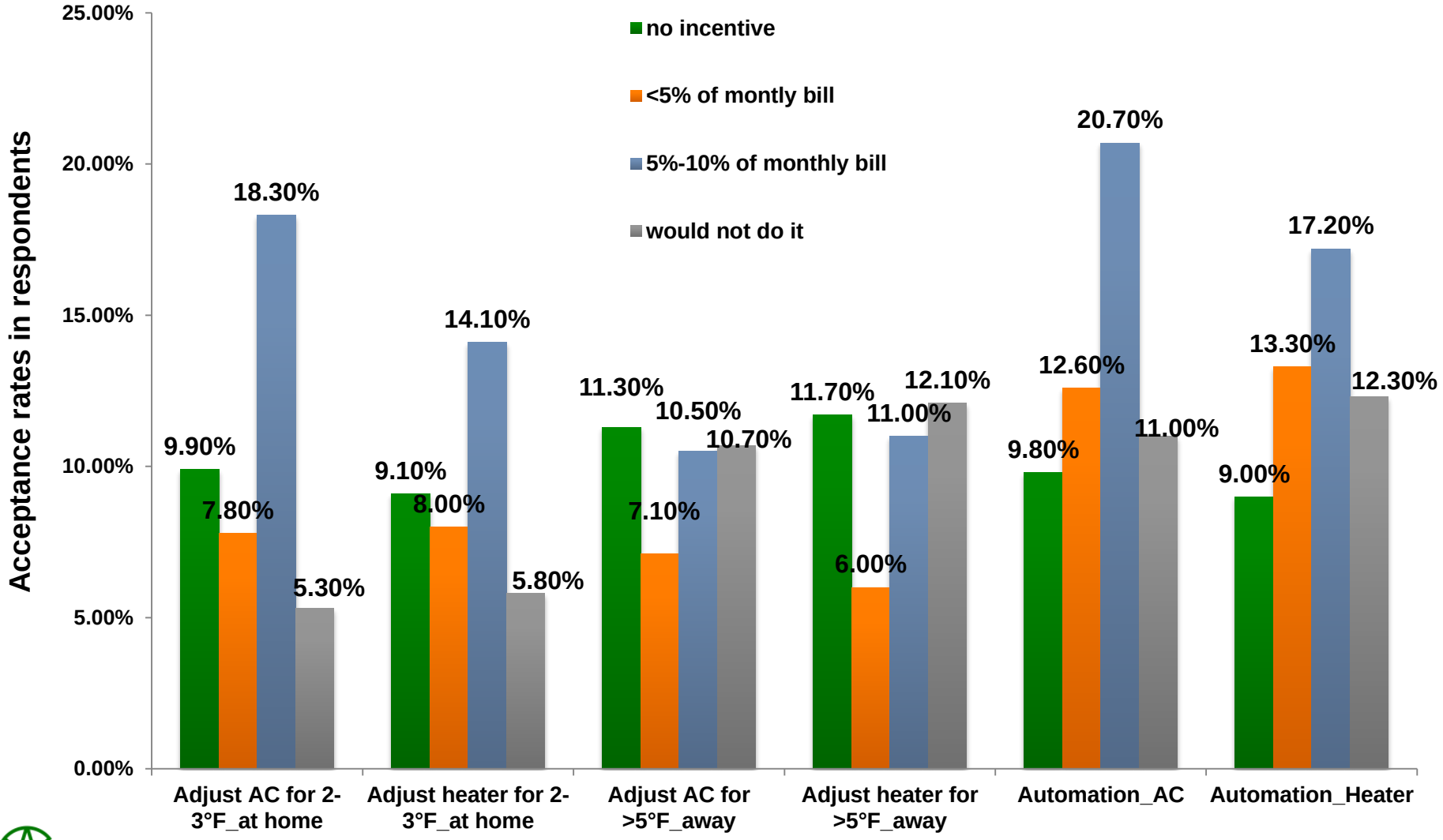
- Adjusting AC setting by 2-3^{o}F when at home
- Adjusting heater by 2-3^{o}F when at home
- Adjusting AC setting by > 5^{o}F or shutting AC down before leaving home
- Adjusting heater setting by > 5^{o}F or shutting heater down before leaving home

Predictors of HAVC-related DR Behaviors

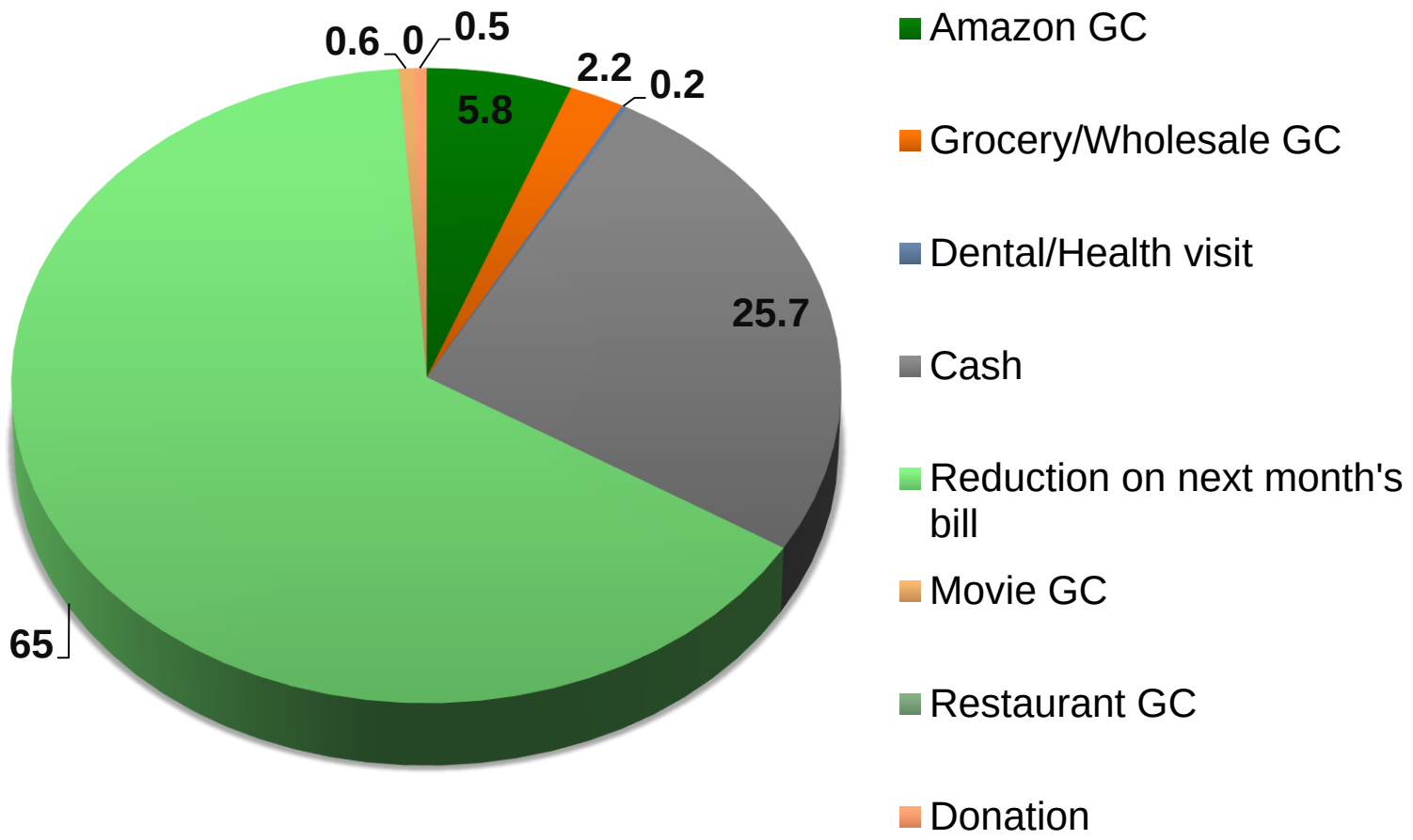
Energy Use Info	Demographics	Social-Psychological
Monthly Bill_Average	Age	Energy Concern
Stay Home (9am-5pm)	Gender	Bill Consciousness
Light Use	Income	Frugality
Computer Sleep Mode	Education	Need for Comfort
Thermostat Settings	Political Orientation	Need for Convenience
Night Adjustments	House Sqft	Need for Control
	Household Size	Trust
	Weather Region	Subjective Norm
		Perceived Control

Block 1 → Block 2 → Block 3

Categorizing Customers Based on Incentives and DR Behaviors



Preference on Incentive Type



Analysis of Customer Segmentation and DR Behaviors

To identify the demographics (i.e., income, education, household size and dwelling size) and social-psychological characteristics (i.e., environmental concern, money concern, comfort need, and trust in utility companies) that can categorize occupants into clusters varying in willingness to participate in different DR programs.

- **Model Selection and Model Checking**
  - ✓ Method: multinomial logistic regression model and Backward elimination.
  - ✓ The likelihood ratio test was applied.
  - ✓ Significance level: a=0.05.
- **Interpret the effect of parameter estimates**
  - ✓ Wald Chi-Square test was applied.
  - ✓ Significance level: a=0.05.
- **Odds ratio estimates**
  - ✓ Quantify the relative significance of each variable to the investigated DR behaviors.

Behavior 1: Adjusting thermostat settings for 2-3°F when someone is at home

❖ **Model selection and model checking**

Step	Removed Variables	DF	Wald Chi-Square	Pr > ChiSq
1	Income	6	3.222	0.781
2	Political orientation	6	3.903	0.689
3	MC bargain	6	3.884	0.692
4	Household size	3	2.541	0.468
5	MC future	6	6.775	0.342
6	Environmental concern	6	8.390	0.211
7	Education	6	9.127	0.166

7 variables having no significant impact were eliminated, and the likelihood ratio test with p-value <.0001 shows that the final model fits well.

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	**93.151**	**27**	**<.0001**
Score	87.856	27	<.0001
Wald	74.492	27	<.0001

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Behavior 1: Adjusting thermostat settings for 2-3°F when someone is at home

❖ Interpret the effect of parameter estimates

Variable	DF	Wald Chi-Square	Pr > ChiSq
Dwelling size	9	22.633	0.0071
MC bill	6	14.632	0.0233
Comfort need: summer	6	19.917	0.0029
Comfort need: winter	6	17.117	0.0089

Dwelling size, bill consciousness and comfort need in summer and winter have significant impact on the DR behavior 1

❖ Odds ratio estimates

Variable	Demanded Financial Rewards	Point Estimate
Dwelling size: small ***VS*** large	Reward < 10% monthly bill	8.932
MC bill: with ***VS*** *without*	Reward < 10% monthly bill	17.968
Comfort need summer: low ***VS*** high	No reward	3.478
Comfort need winter: low ***VS*** high	No reward	9.043

Behavior 2: Letting utility companies adjust thermostat settings for 2-3°F

❖ **Model selection and model checking**

Step	Removed Variables	DF	Wald Chi-Square	Pr > ChiSq
1	Household Size	3	0.600	0.896
2	MC future	6	3.900	0.690
3	Politics	6	4.322	0.633
4	MC bill	6	5.719	0.455
5	Dwelling size	9	9.636	0.381
6	Comfort need: winter	6	7.144	0.308
7	Environment awareness	6	7.189	0.304
8	Income	6	10.522	0.104
9	Education	6	12.271	0.056

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > Ch
Likelihood Ratio	61.342	18	<.000
Score	61.212	18	<.000
Wald	56.578	18	<.000

9 variables having no significant impact were eliminated, and the likelihood ratio test was significant show that the final model fits well.

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Behavior 2: Letting utility companies adjust thermostat settings for 2-3°F

❖ Interpret the effect of parameter estimates

Variable	DF	Wald Chi-Square	Pr > ChiSq
Comfort need summer	6	26.541	0.0002
MC bargain	6	12.642	0.0491
Trust level	6	19.931	0.0028

Comfort need in summer, interest in bargains and trust have significant impact on the DR behavior.

❖ Odds ratio estimates

Variable	Demanded Financial Rewards	Point Estimate
MC bargain: with ***VS*** without	Reward >=10% monthly bill	2.450
Comfort need summer: low ***VS*** high	No reward	5.513
Trust level: high ***VS*** low	No reward	3.211

Behavior 3: Shutting down HC devices for 10 min's after receiving emergency messages

❖ Model selection and model checking

Step	Removed Variables	DF	Wald Chi-Square	Pr > ChiSq
1	MC future	6	1.924	0.926
2	Household size	3	0.685	0.876
3	Political orientation	6	3.458	0.749
4	Dwelling size	9	8.540	0.481
5	Education	6	5.432	0.489
6	Income	6	7.635	0.266
7	MC bill	6	8.768	0.187
8	MC bargain	6	9.097	0.186
9	Comfort need: winter	6	9.666	0.139

9 variables having no significant impact were eliminated, and the likelihood ratio test with p-value <.0001 shows that the final model fits well.

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	69.026	18	<.0001
Score	70.163	18	<.0001
Wald	63.493	18	<.0001

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Behavior 3: Shutting down HC for 10 min's after receiving emergency messages

❖ Interpret the effect of parameter estimates

Variable	DF	Wald Chi-Square	Pr > ChiSq
Comfort need summer	6	20.031	0.0027
Environment concern	6	14.195	0.0275
Trust level	6	27.425	0.0001

Comfort need in summer, environment concern and trust have significant impact on the DR behavior.

❖ Odds ratio estimates

Variable	Demanded Financial Rewards	Point Estimate
Comfort need summer: low ***VS*** high	No reward	2.411
Environment awareness: with ***VS*** without	No reward	6.707
Trust level: high ***VS*** low	No reward	3.025

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Behavior 4: Shutting down HC devices for 10 min's after receiving emergency messages (1)

❖ **Model selection and model checking**

Step	Removed Variables	DF	Wald Chi-Square	Pr > ChiSq
1	MC future	6	1.924	0.926
2	Household size	3	0.685	0.876
3	Political orientation	6	3.458	0.749
4	Dwelling size	9	8.540	0.481
5	Education	6	5.432	0.489
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Testing Global Null Hypothesis: BETA=0

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Wald	63.493	18	<.0001

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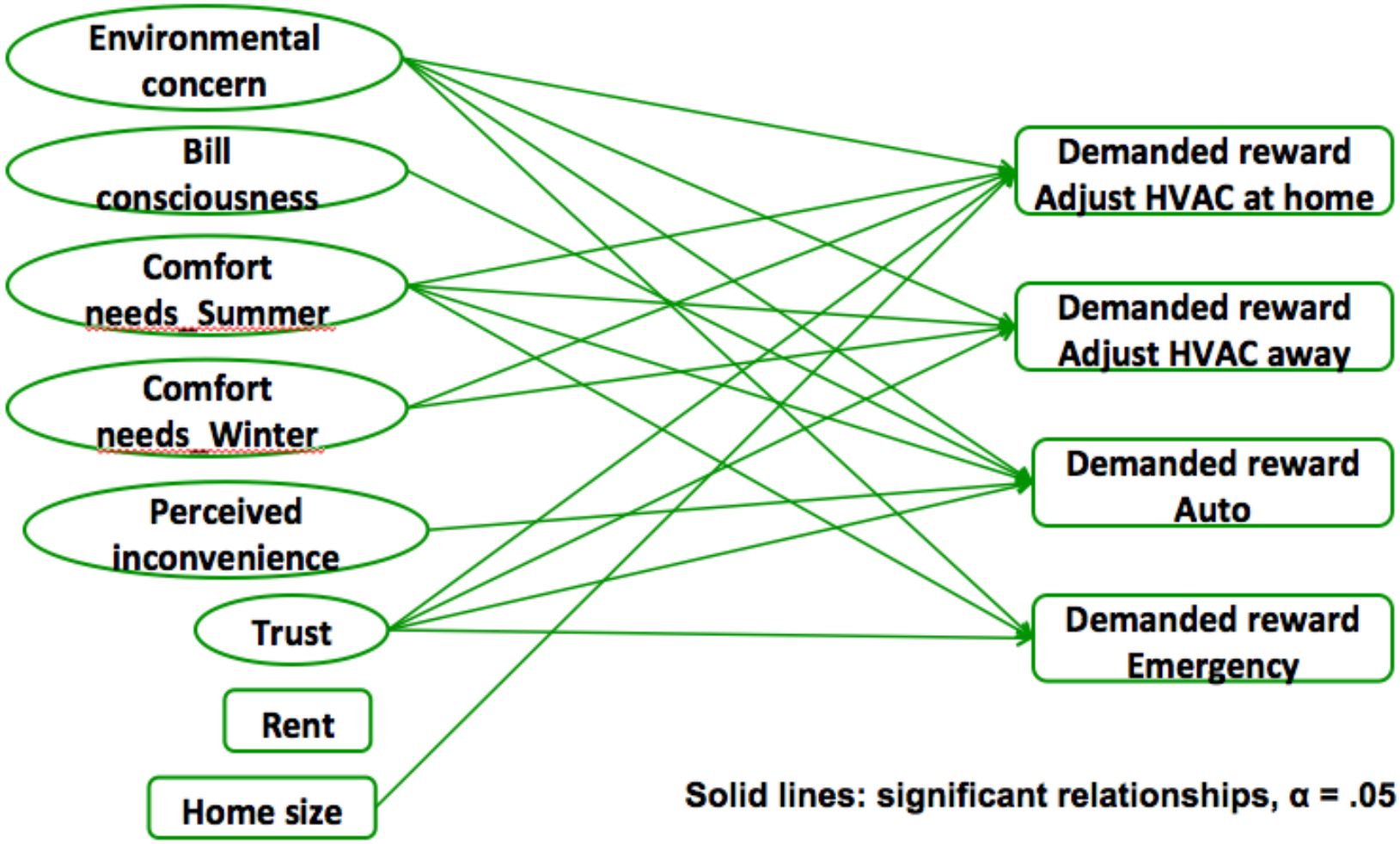
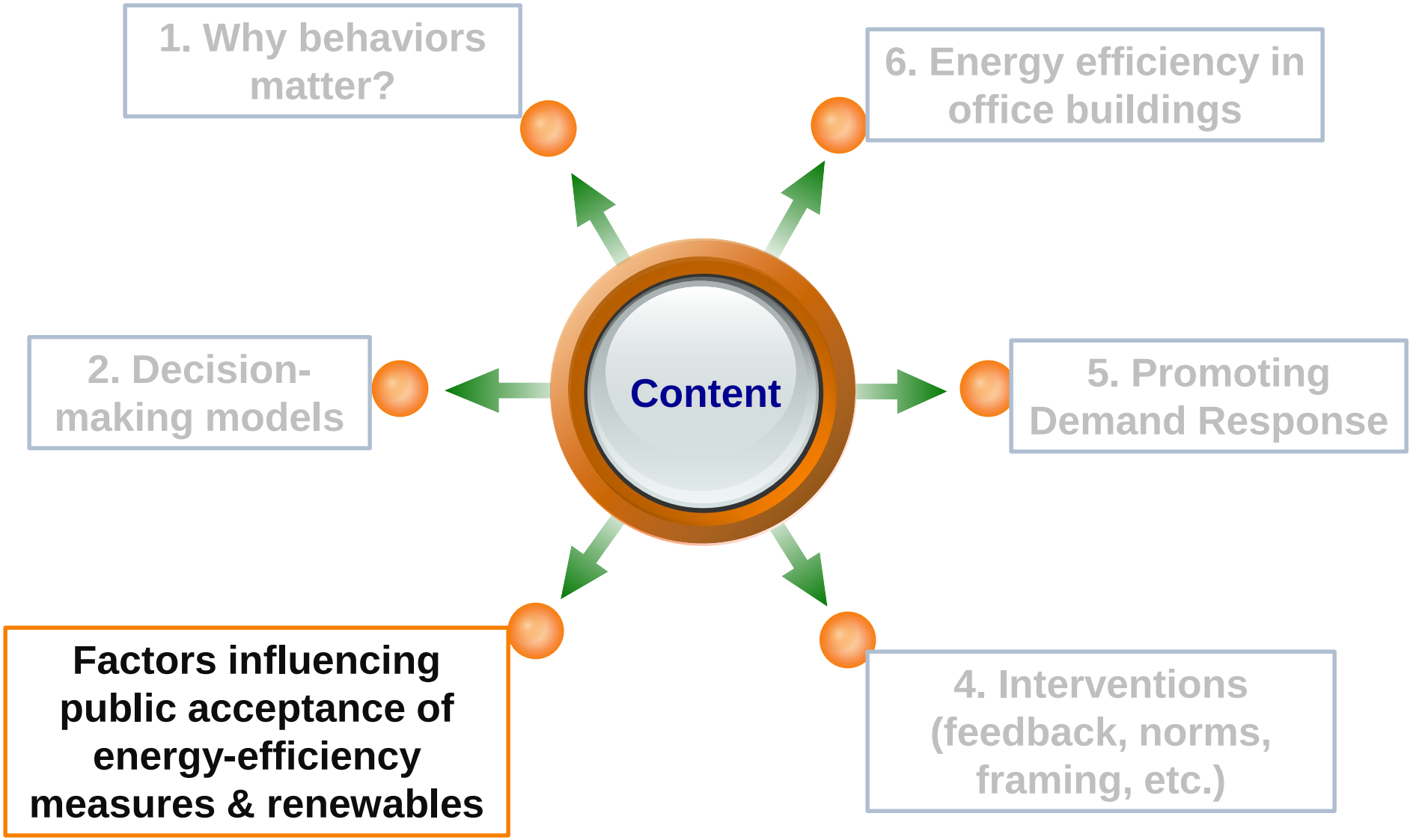
Social-Psych and Demographics Factors

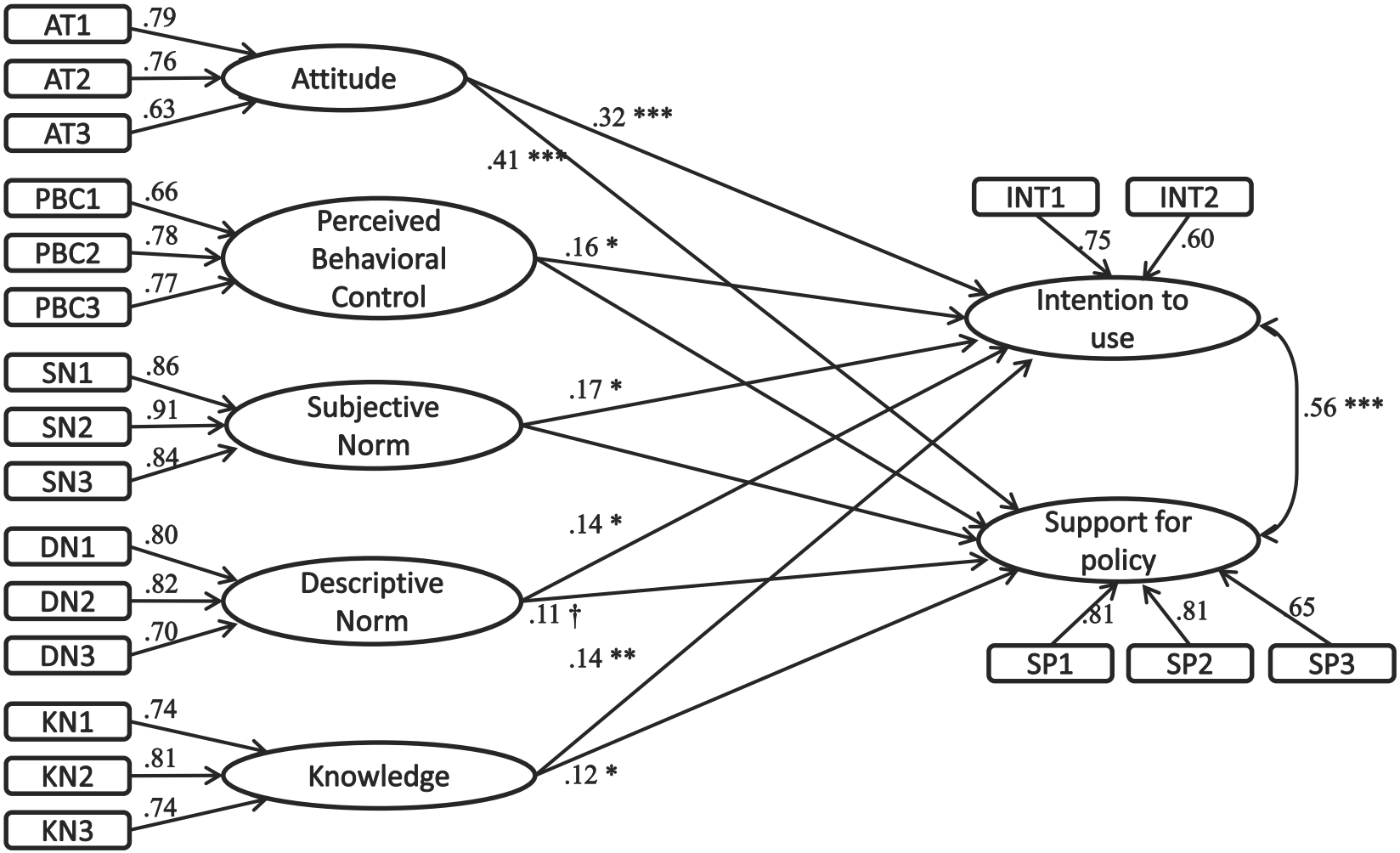
Structure Equation Modeling result:



Social Psychological Factors, Energy and Technology

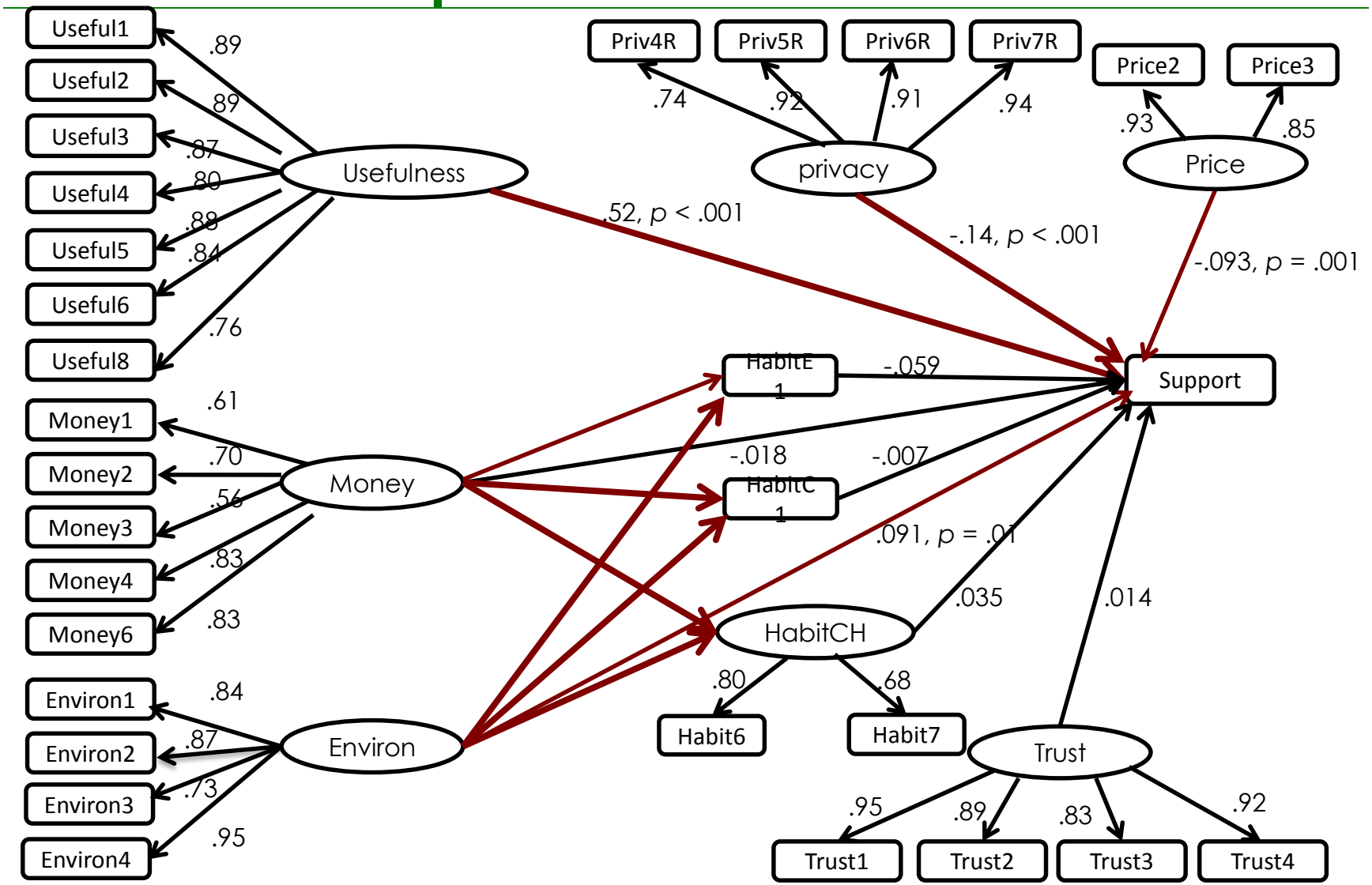


Social Psychological Factors Affecting Intention to Use Solar Hot Water Heaters and Electric Vehicles in China



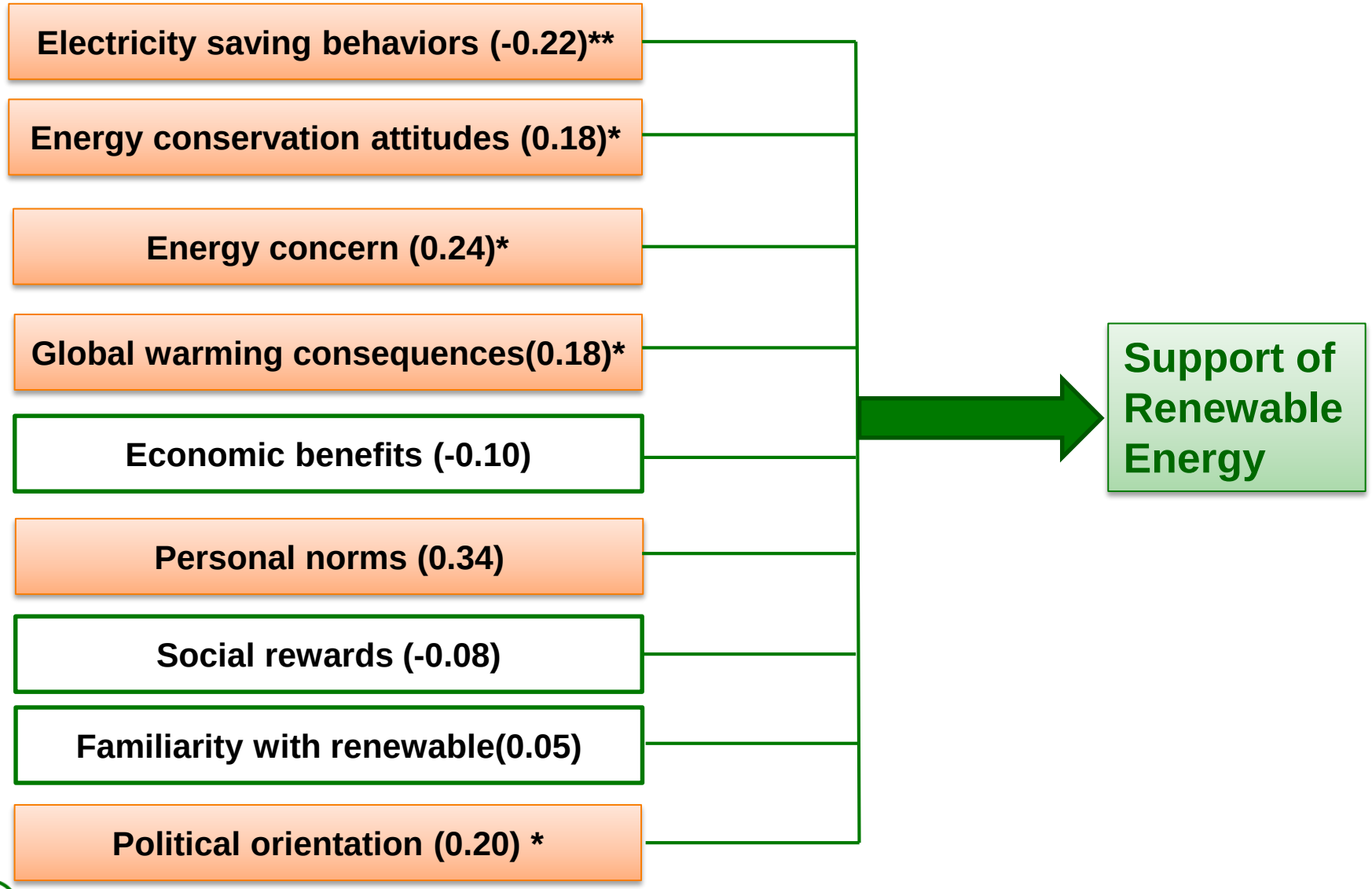
* $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$

Factors Influencing Acceptance of Smart Meters



- Sampled *817 U.S. residents* across the U.S.
- Based on the *Extended Technology Acceptance Theory*.

Social Psychological Factors Affecting Support of Renewable Energy in the U.S.



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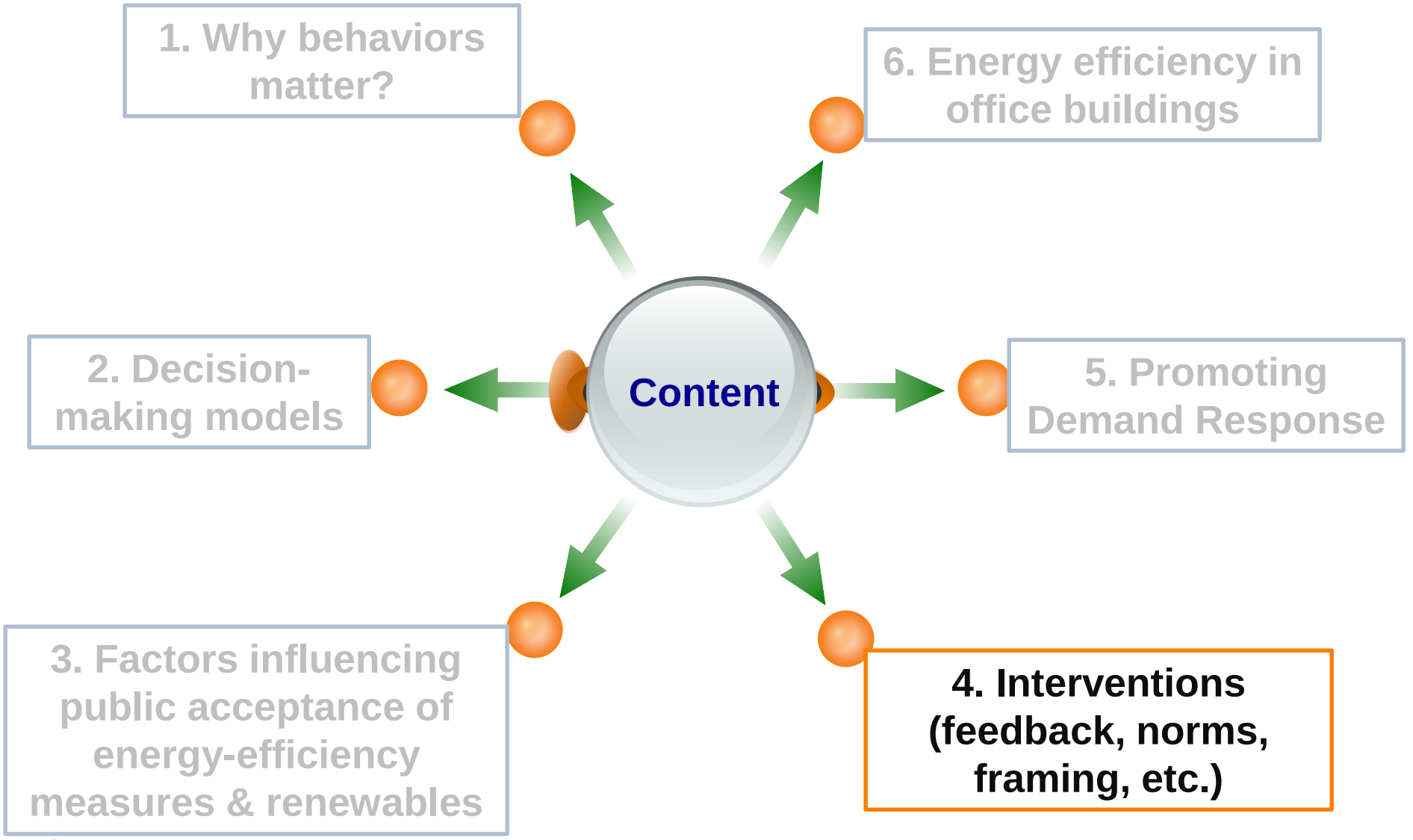
* *P*<0.05; ** p<0.01, green boxes on the left were not significant

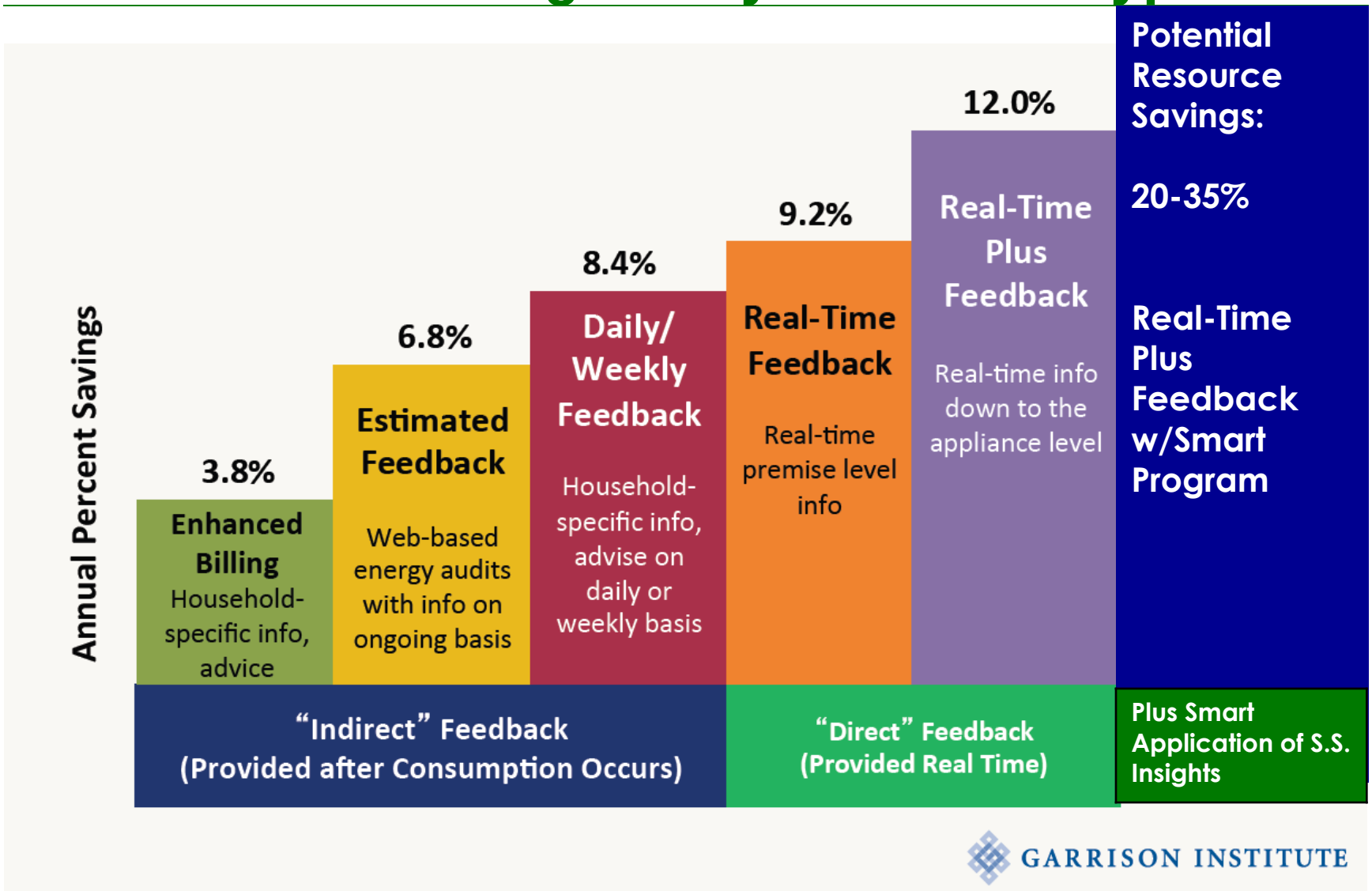
Social Psychological Factors and Energy Behaviors



Intervention/Strategies to Change Behaviors

- Feedback programs (direct vs. indirect)
- Social norms: descriptive and injunctive norms shape people's behaviors; developing strategies in a social context
- Goal setting: define what people are trying to attain and be able to evaluate their progress
- Message framing: emphasizing a particular aspect of an object/activity while limiting emphasis on other aspects
- Commitments: help people to sure their actions are consistent with their ideals

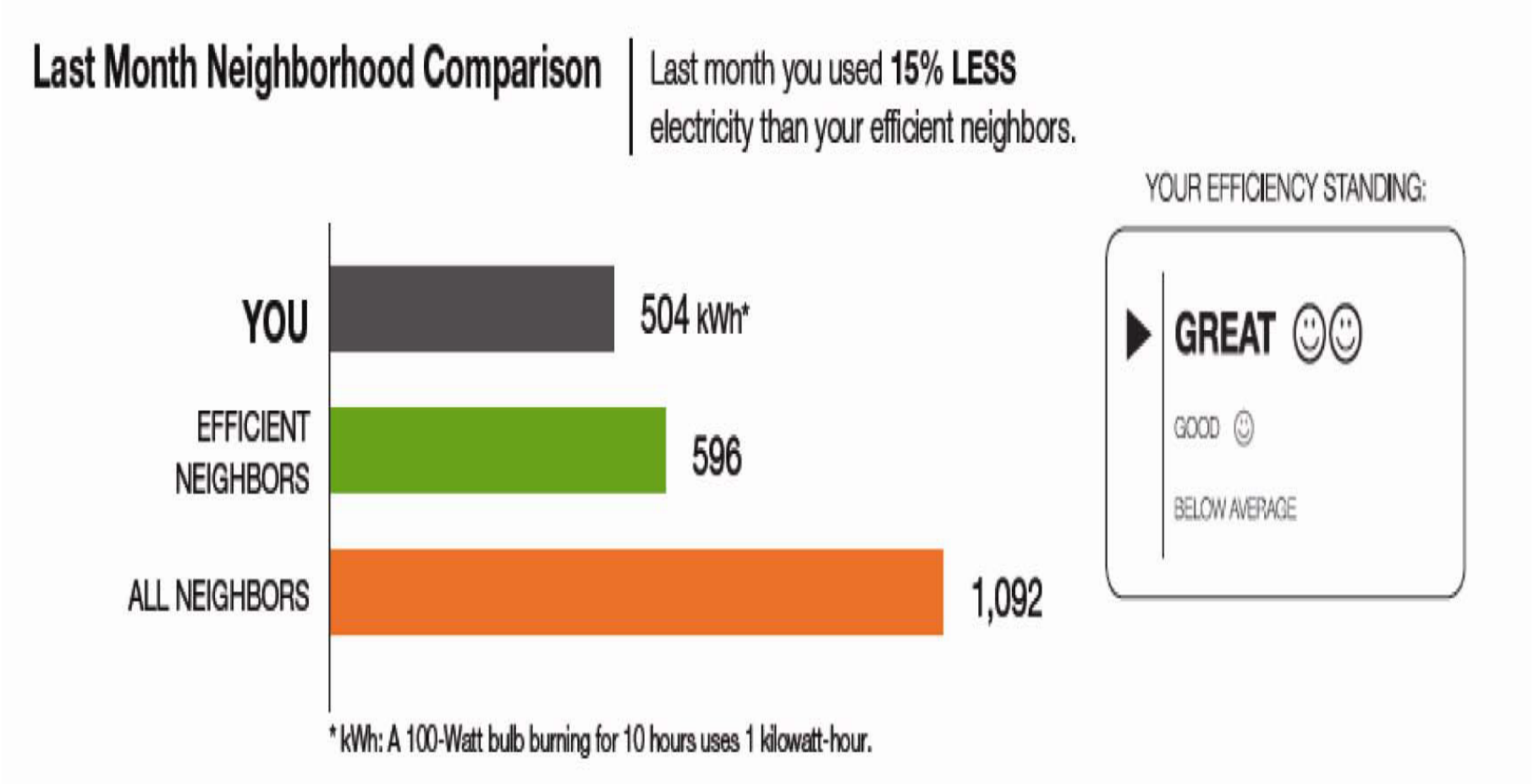
Average Household Electricity Savings of Historical Program by Feedback Type



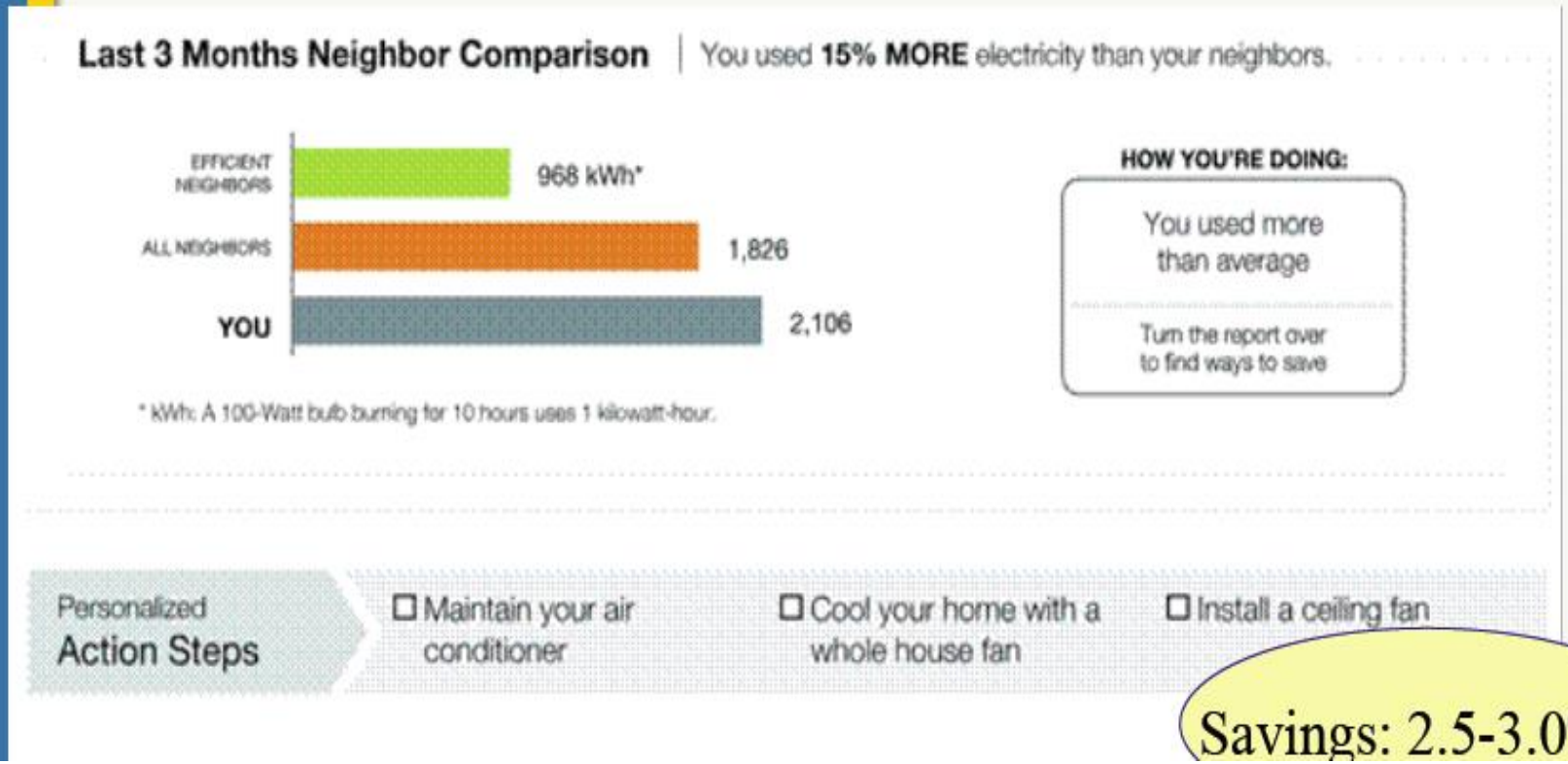
What are Social Norms?

- Social norms are an important solution to social dilemmas (Coleman 1990).
- Norms are rules about behavior that are socially enforced (Horne 2001) – social sanctions
- Social sanctions provide incentives (rewards and punishments) that encourage individuals to cooperate rather than free-ride. Therefore, when a norm exists, people have expectations about the behaviors others will see as appropriate and how others will react if someone deviates (Bicchieri 2006).

Social Norms Approach: Opower



Using Social Norms: Opower



Message Framing and Electricity Saving

- ***RQ1***: Which type of messages are effective to 1) change attitudes toward electricity saving? 2) to boost perceived efficacy ("whether can I make a difference") on saving electricity?

- ***RQ2***: Do individuals with difference on environmental concern react to messages differently?

- ***Design***: Four (2 x 2) manipulations on benefit message framing of saving electricity

Benefit framing: Environmental vs. Financial
Temporal framing: Long-term vs. Short-term

Condition 1/2: Financial, Long-term/Short-term

SAVING MONEY

According to the U.S. Department of Energy, an average household consumes 11,280 kWh in a year, leading to large electricity bills. There are a few ways proven to be effective in cutting down your bill, for example:

Saves $6 per bulb in a year by using CFLs

Saves $75-170 in a year by insulating your house

Saves $30 in a year by switching computers to sleep mode

Saves $40-85 in a year by increasing by 2°F during summer

SAVING MONEY

According to the U.S. Department of Energy, an average household consumes 940 kWh electricity in a month, leading to large electricity bills. There are a few ways proven to be effective in cutting down your bill, for example:

Saves $.50 per bulb in the next month by using CFLs

Saves $6-15 in the next month by insulating your house

Saves $2.50 in the next month by switching computers to sleep mode

Saves $3-7 in the next month by increasing temperature by 2°F during summer

Condition 3/4: Environmental, Long-term/Short-term

SAVING THE ENVIRONMENT

According to the U.S. Department of Energy, an average household produces 82,000 pounds carbon emissions per year, leading to polluted air and destructed ecosystems. There are a few ways proven to be effective in reducing your carbon emissions, for example:

Reduces 660 pounds of carbon emissions per bulb in a year by using CFLs

Reduces 2000 pounds of carbon emissions in a year by insulating your house

Reduces 3000 pounds of carbon emissions in a year by switching computers to sleep mode

Reduces 2000 pounds of carbon emissions in a year by increasing 2°F during summer

SAVING THE ENVIRONMENT

According to the U.S. Department of Energy, an average household produces 6,833 pounds carbon emissions per month, leading to polluted air and destructed ecosystems. There are a few ways proven to be effective in reducing your carbon emissions, for example:

Reduces 55 pounds of carbon emissions per bulb in the next month by using CFLs

Reduces 167 pounds of carbon emissions in the next month by insulating your house

Reduces 250 pounds of carbon emissions in the next month by switching computers to sleep mode

Reduces 167 pounds of carbon emissions in the next month by increasing temperature by 2°F during summer

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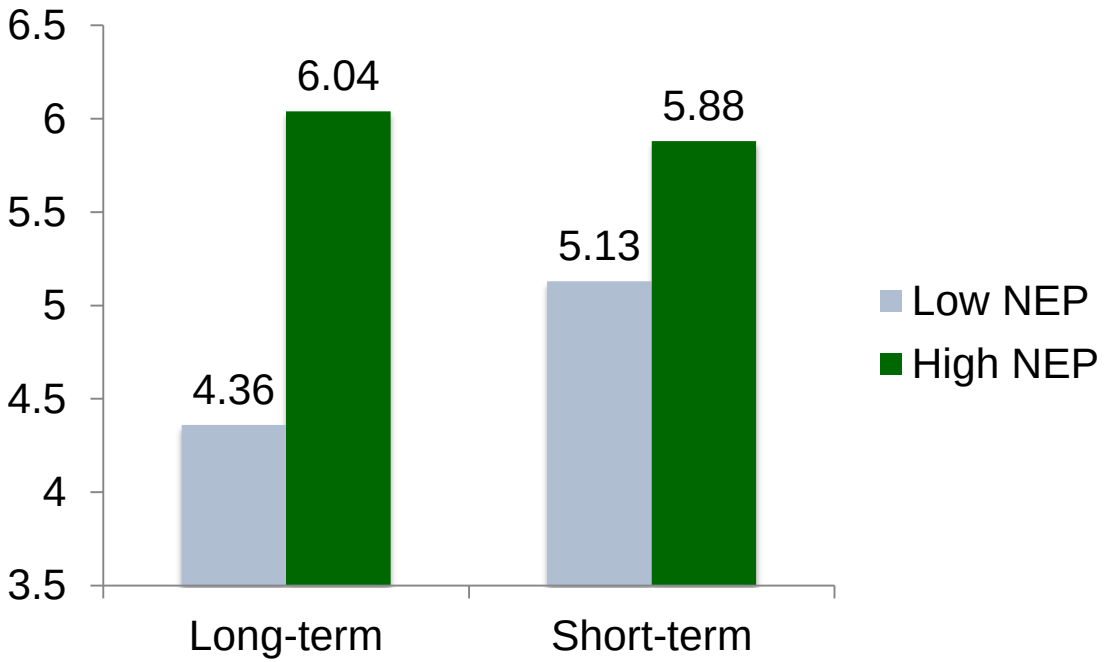
Results of Message Framing

- 292 US residents
- Environmental messages, in general, are more effective than the financial benefits in producing positive attitudes toward energy saving.
- Short-term benefits boost perceived efficacy among people with lower environmental concern.

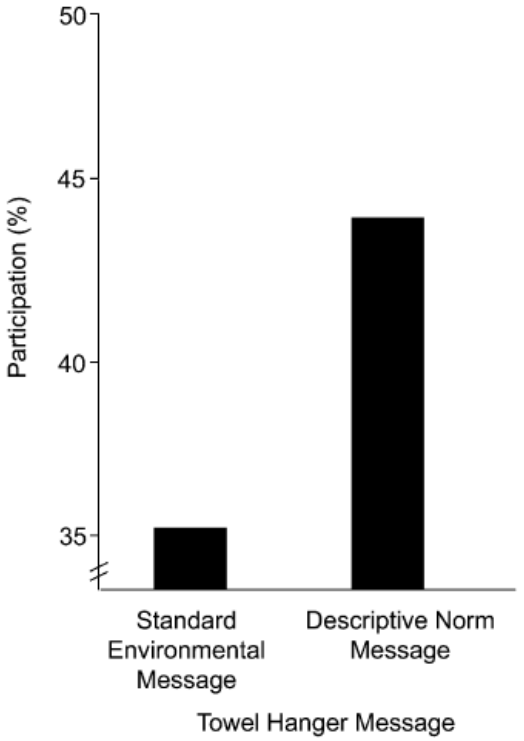


Recycling Towels in Hotels: Evidence of Descriptive Norms

Below "Please reuse your towels"

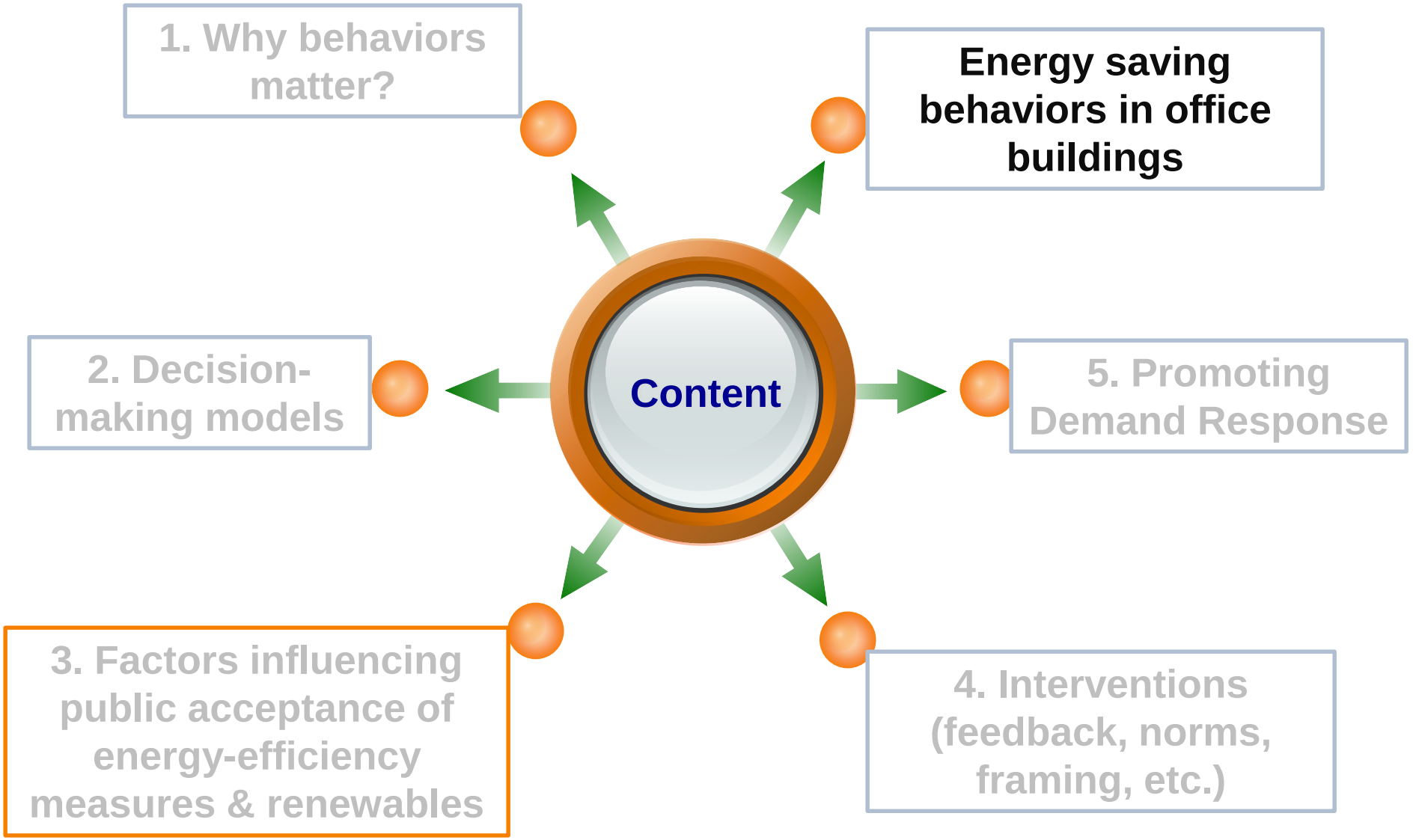
Control: HELP SAVE THE ENVIRONMENT. You can show your respect for nature and help save the environment by reusing your towels during your stay

Social Norm: JOIN YOUR FELLOW GUESTS IN HELPING TO SAVE THE ENVIRONMENT. Almost 75% of guests who are asked to participate in our new resource savings program do help by using their towels more than once. You can join your fellow guests in this program to help save the environment by reusing your towels during your stay.



Goldstein, Cialdini, & Griskevicius (2008, J of Consumer Research)

Social Psychological Factors, Energy and Technology



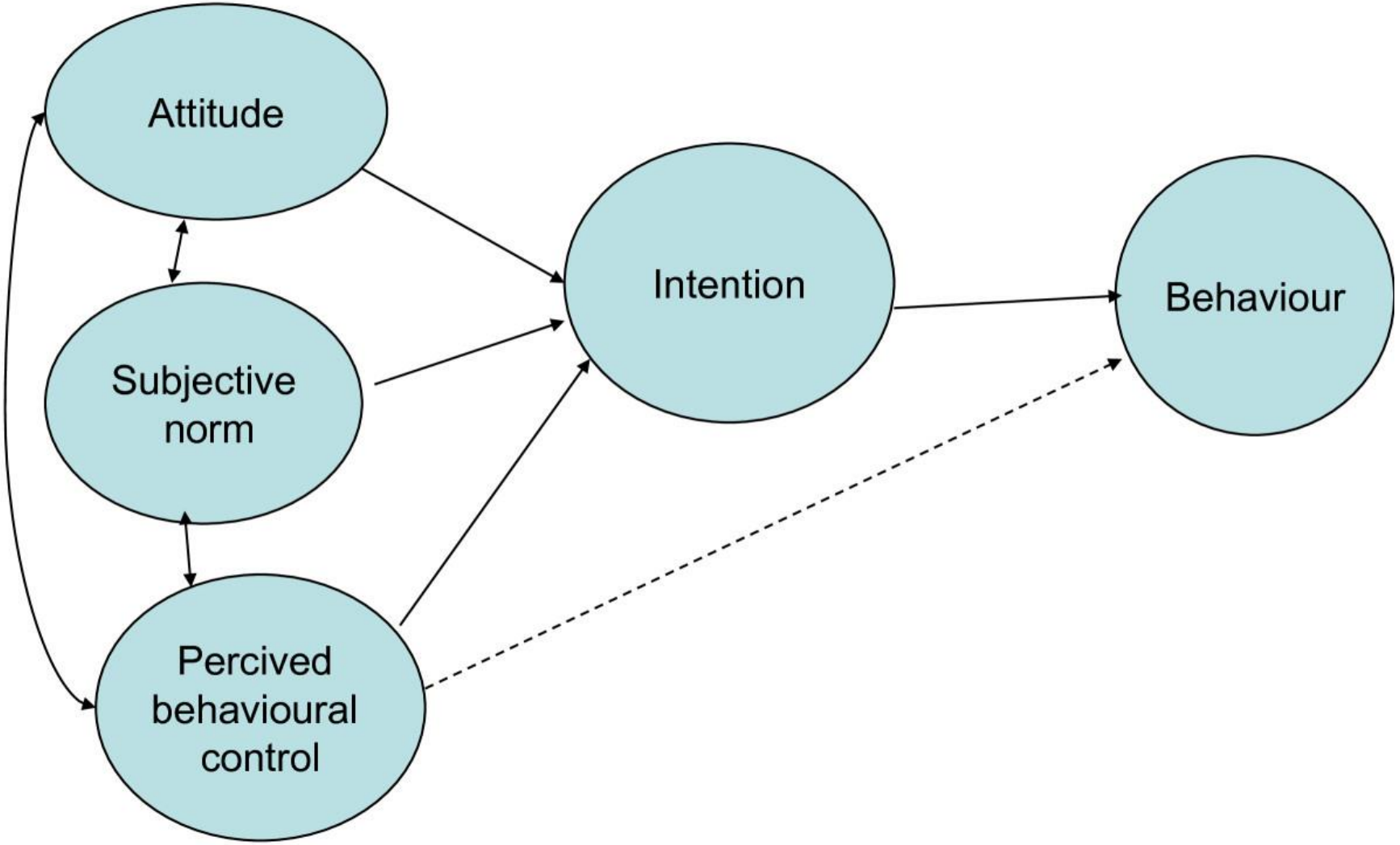
Social-psychological Factors Influencing Energy Saving at Workplace

- Sampled 584 employees from 9 electricity companies in Jiangsu Province, China.
- Investigated the relationships among social norms, behavioral control, attitudes, energy concern influence energy saving intention and energy behavior at workplace.
- Based on the Theory of Planned Behavior.

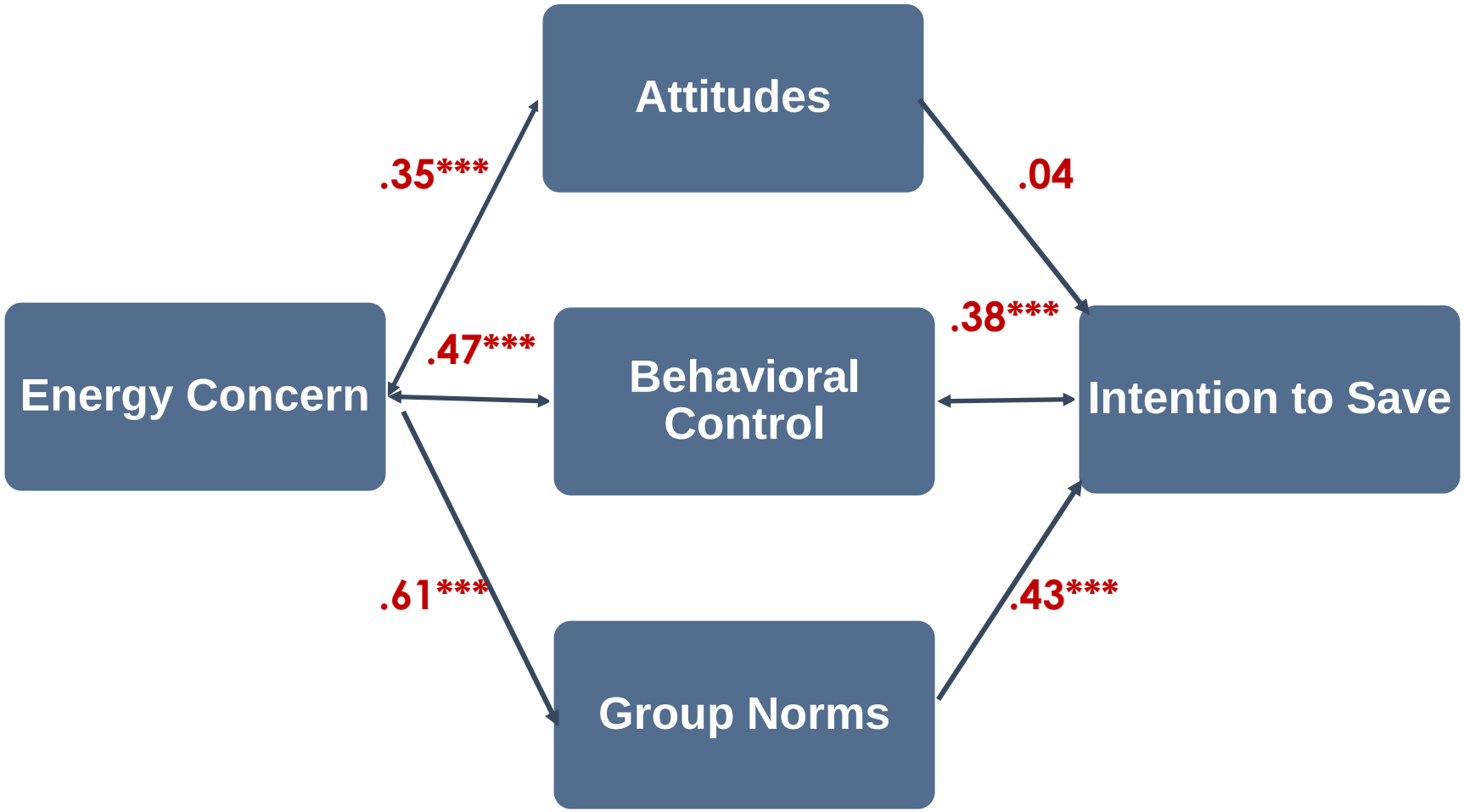
Chen, C.F., & Knight, K. (2014). Energy at work: social psychological factors affecting energy conservation intentions within Chinese electric power companies. *Energy Research & Social Science*, 4, 23-31.

Theory of Planned Behavior

(Icek Ajzen, 1991)



Social-Psychological Factors Affecting Electricity Saving Behaviors at Work in China

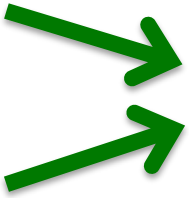


Energy Saving in Public Buildings

Research Questions:

Personal factors

Environmental factors

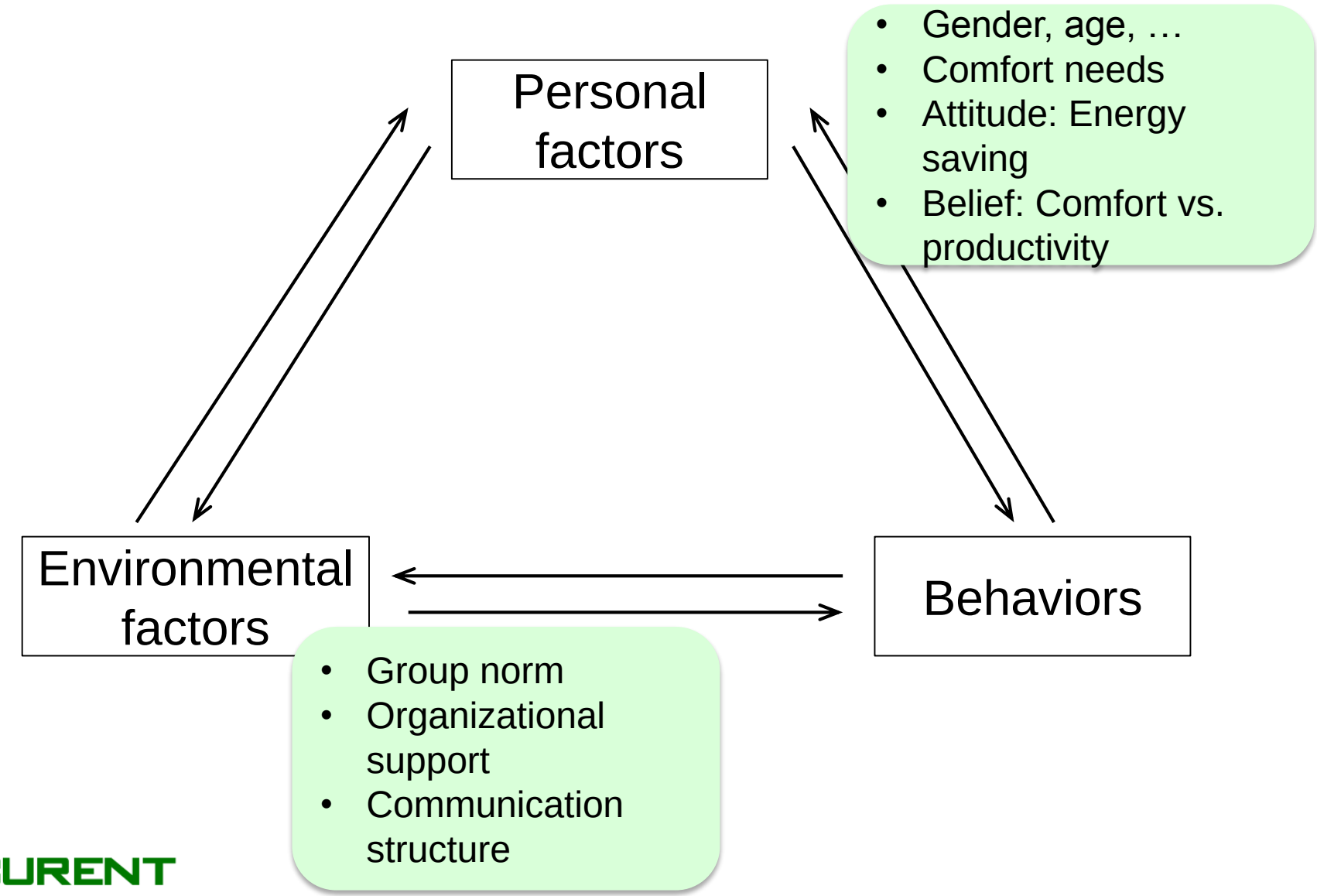


- Willingness to save energy at some cost of thermal comfort
- Ease to communicate with co-workers about saving energy

- Online survey across the States, 245 valid responses.
- 48.57% were female;
- 75.10% were White-Caucasian, 10.20% Asian or Asian American, 6.94% black or African American, 4.08% Hispanic or Latino;
- Age: 19 to 64 (*Mean* = 33.20);
- Spend at least 20 hours per week in an indoor office;
- Worked in accounting, engineering, sales, consulting, customer services, and many other areas.

CURENT

Social Cognitive Theory (Bandura, 1986)



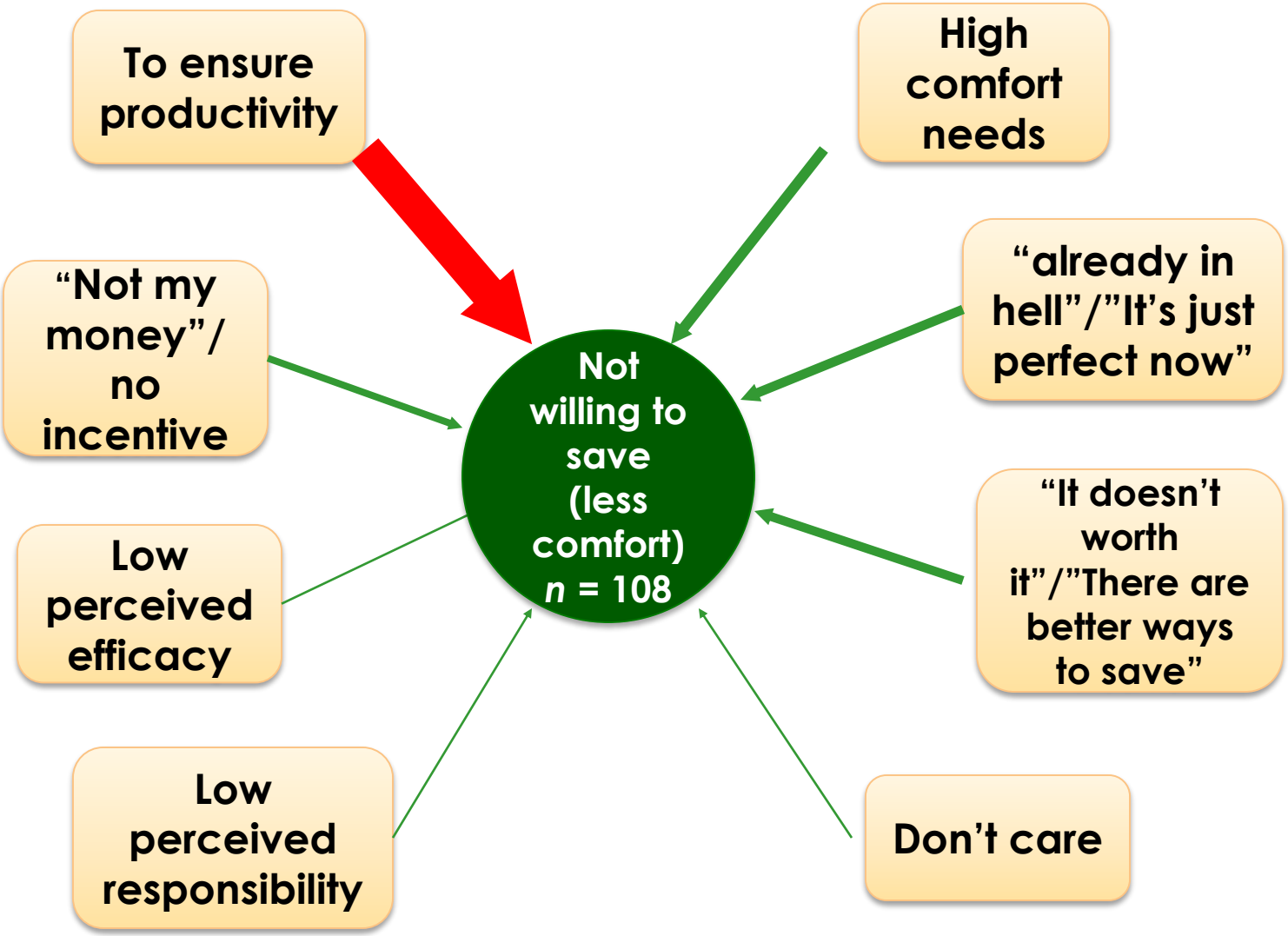
Predictors of Energy Saving Behaviors and Communication

Results from logistic hierarchical regressions

DV: Ease to communicate	Step 1	Step 2	Step 3
Demo-Biological factors:			
Gender	.82** (.31)	.79* (.31)	.83* (.33)
Age	.15 (.15)	.14 (.16)	.05 (.17)
Income	.03 (.06)	.05 (.07)	.03 (.07)
Ease to adapt to hotness	.22 (.12)	.17 (.14)	.14 (15)
Ease to adapt to coldness	.46*** (.13)	.45** (.13)	.41** (.14)
Personal factors:			
Energy-saving attitude		.46** (.17)	.41* (.18)
Comfort-productivity belief		-.11 (.17)	-.02 (.18)
Environmental factors:			
Energy-saving social norm			.52** (.15)
Organizational support			.37* (.16)
R^2	.15***	.19***	.29***
Correct categorization	67.80 %	67.37%	72.03%

DV: willingness to save	Step 1	Step 2	Step 3
Demo-Biological factors:			
			.17 (.32)
			.08 (.17)
			.07 (.07)
			.00 (.14)
			.14 (.14)
			.78*** (.20)
			-1.23*** (.23)
			.17 (.14)
			.22 (.14)
			.37***
			72.03%

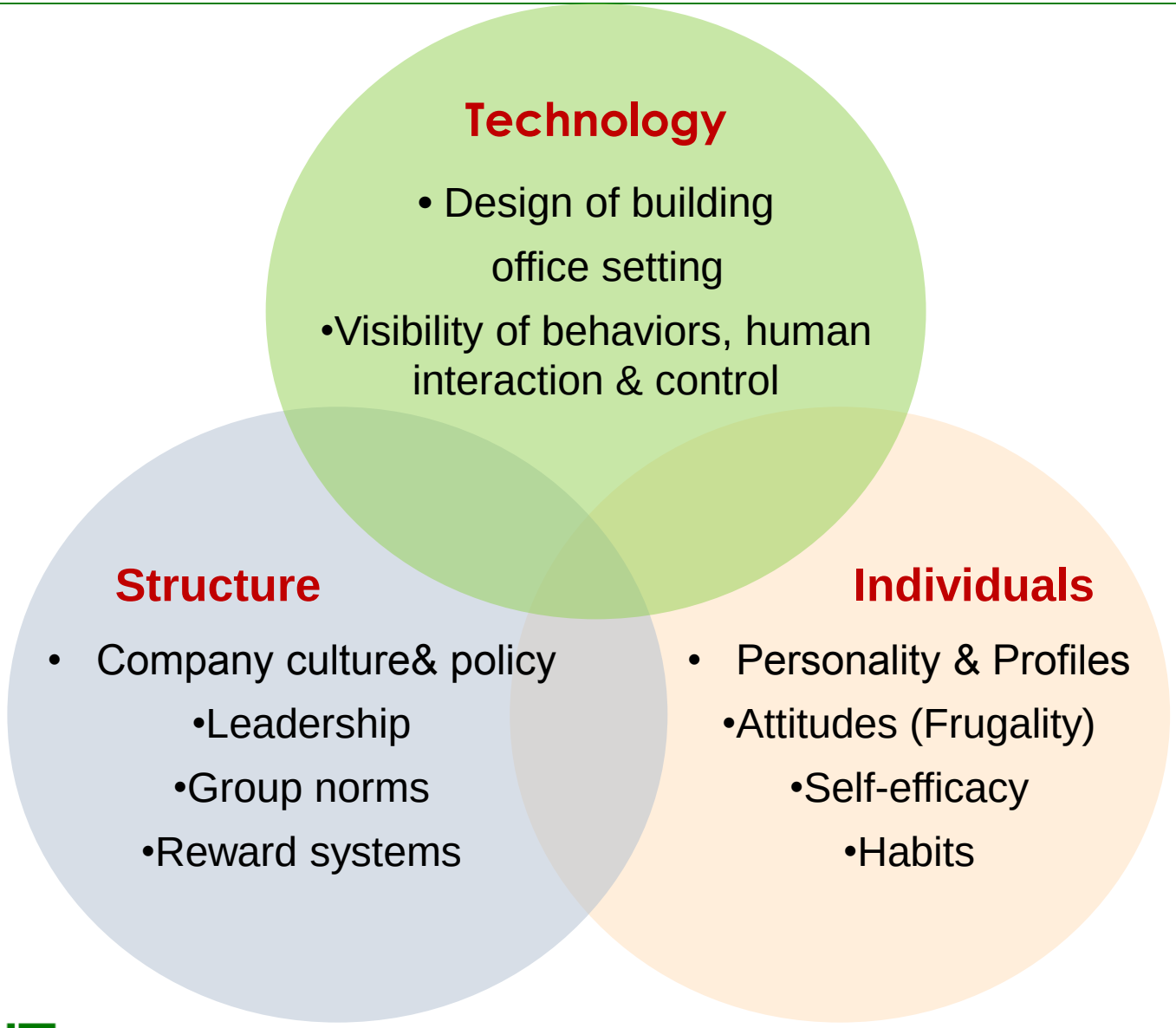
Reasons for NOT Saving Energy at Work



Barriers to Communication

Why is it difficult to communicate about energy saving with co-workers? What are the barriers? (*n* = 85)

Future Work: Triple Levels of Integration



Conclusions

- Human beings are not always rational.
- Behaviors are difficult to measure.
- The importance of social norms, networks and group dynamic factors.
- Energy use in public domain relates largely to social matters, not individual ones.
- Social-technological approaches are needed for persistent behavioral change and reducing free-riding.
- Recognize the challenge of integrating social-aspects and technology.