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Estimation of Non-Energy Impacts from Energy Efficiency

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ACEEE 2022 Summer Study On Energy Efficiency in Buildings

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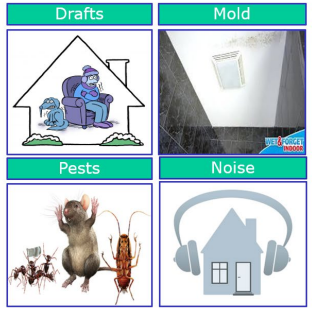

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1. OVERVIEW OF NON-ENERGY IMPACTS

Non-Energy Impacts

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Background

Societal Benefit Example

Reduced emissions positively impact the environment

- Economic
- Environmental
- Health & Safety

Ratepayer Benefit Example

Reduced usage improves affordability and may reduce collections costs

- Affordability
- Collections Costs
- System Reliability

Participant Benefit Example

Air sealing increases comfort

- Health & Safety
- Affordability
- Indoor Air Quality
- Noise
- Water Usage
- Maintenance

- NEIs accrue to participants, utility ratepayers, and society
- May be included in cost-effectiveness tests

Non-Energy Impacts

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Typical Approach to Estimation

Review Past Studies

Select Benefits for Inclusion

Average of Past Study Impacts

Challenges in the Literature

Past Estimates

- Out of date
- Applicability

Research Quality not Assessed

- Approach
- Sample Size
- Statistical Significance

Documentation Lacking

- Methodology
- Assumptions
- Limitations

NEI Valuation Methods

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Survey-Based Approaches	
Contingent Valuation	• Respondent assigns a dollar value
Direct Scaling	• Respondent values NEI as a % of energy savings
Labeled Magnitude Scaling	• Respondent values NEI on a scale relative to energy savings

Non-Survey Estimation Examples
• Health – Lit Review: Use estimates of weatherization impact on asthma
• Economic – Calculation: Multipliers applied to expenditures
• Water – Analysis: Estimate savings by analyzing water bills
• Maintenance – Projections: Estimate reduction in lighting replacement labor cost

Contingent Valuation

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Method

Survey Question

- Asks respondents to assign a dollar value associated with the NEI

"Could you put a *positive or negative dollar value* on the change in winter comfort? *What is that dollar value* from the change in winter comfort?"

Calculation

- Outliers dropped
- No other adjustment

Advantages

Most Direct Method	Answers provide a direct dollar value
No Scaling Assumption	Other methods apply scaling with energy savings
Wide Use in Literature	Method is well demonstrated in many fields

Disadvantages

Unbounded Responses	Respondents provide extreme values
No Point of Reference	Hard to assign values without a reference
Low Response Rate	Many are unable to answer the question

Direct Scaling

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Method

Survey Question

- Asks respondents to value an NEI as a % of their energy savings

"How does the dollar value from the change in winter comfort compare to the energy savings — *10% of energy savings, 20%, 30%, etc*.?"

Calculation

- Apply % to program savings
- Use reported or analyzed bill savings

Advantages

Quantitative Analysis	No need to translate from a qualitative response
Familiar Point of Reference	Mental anchor value helps orient respondents
Consistent Results	Within and across studies

Disadvantages

Difficult to Comprehend	Conceptualizing percentages can be difficult
Difficult to Answer	Some do not understand

Labeled Magnitude Scaling

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Method

Survey Question

- Asks respondents to value an NEI as more or less than energy savings

"Would you say [the value of the NEI] is *more value, less value, or the same value* to you as any [program savings]?"

Calculation

- Develop multiplier corresponding to each response
- Apply response to program savings

Multiplier Example

Response	Multiplier
More Value	1.35
Same Value	1.00
Less Value	0.65

Advantages

Easy to Answer	More are comfortable answering this question
Consistent Results	Within and across studies
High Response Rates	Higher than other survey-based methods

Disadvantages

Restricted Responses	Responses are limited to a few options
Qualitative Data	Answers must be translated to quantitative values

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2. ENERGY EFFICIENCY PROGRAMS & DATA SOURCES

Programs & Data Sources

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Market Rate Program
Assessment /No Measures
Thermostat Only
Water Heater Only
Heating System (with or without air conditioning)
HPwES (air sealing & insulation; may include HVAC)

Low Income Program
Electric Baseload
Air Sealing and/or Insulation, no HVAC
With HVAC Measures

Source	Method	Inputs	Use
Usage Analysis	• Weather Normalized • Pre/Post • Comparison Group	• Monthly Energy Usage • Weather Data	• Reality Check
Bill Analysis	• Pre/Post • Comparison Group	• Monthly Energy Cost	• Direct Scaling • Labelled Magnitude Scaling
Participant Survey	• Web/Phone	• Participant Contact	• Contingent Valuation • Direct Scaling • Labelled Magnitude Scaling

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3. USAGE & BILLING ANALYSIS

Usage Analysis Results

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Market Rate Program

	Program Services	#	Annual Energy Savings (therms)	% Change
Natural Gas	Thermostat Only	280	7	0.6%
	Water Heater Only	1,085	-10	-0.9%
	Heating System	1,261	39**	3.1%
	HPwES	1,197	202**	16.8%
	All Programs	**2,714**	**53****	**4.3%**

Low Income Program

	Program Services	#	Annual Energy Savings	% Change
Electric (kWh)	Electric Baseload	4,773	817**	7.9%
	Electric Heat	378	1,449**	7.7%
Natural Gas (therms)	Gas Heat	698	43*	4.2%

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level.

Billing Analysis Results

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Market Rate Program

	Program Services	#	Annual Bill Savings	% Change
Natural Gas	Thermostat Only	277	$38**	8.4%
	Water Heater Only	350	$29*	7.0%
	Heating System	1,651	$46**	9.7%
	HPwES	374	$104**	22.8%
	All Programs	**2,957**	**$50****	**10.7%**

Low Income Program

	Program Services	#	Annual Bill Savings	% Change
Electric & Natural Gas	Electric Baseload	4,903	$63**	6.4%
	Air Sealing and/or Insulation, no HVAC	135	$33	2.1%
	With HVAC Measures	350	$32	2.2%
	All Job Types	**5,388**	**$60****	**5.9%**

**Denotes significance at the 99 percent level. *Denotes significance at the 95 percent level.

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4. PARTICIPANT SURVEYS

APPRISE NEI Surveys

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	Market Rate	Low Income
Response Rate	67%	60%
Completed Surveys	393	258

Mixed Mode Web/Phone Breakdown of Completed Surveys

	Market Rate	Low Income
Web	59%	5%
Phone	41%	95%

Advance letters with $5 incentive

- Three e-mails to selected sample
- At least 9 phone contacts

Non-Energy Impacts Included

- Same for both surveys
  - Winter Comfort
  - Summer Comfort
  - Safety
  - Health
  - Noise

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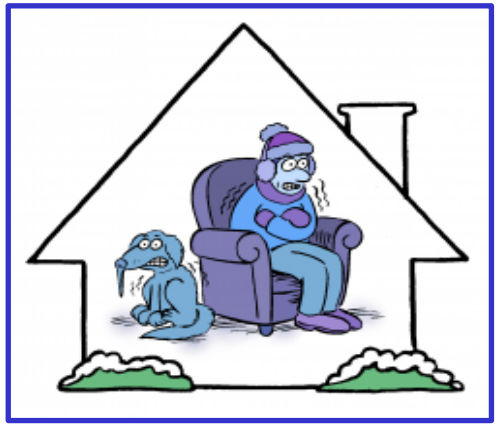
Drafts



Mold

Pests

Noise

5. NEI ANALYSIS

Key Analysis Issues

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Method	Process	Survey Question	Energy Savings Value	Scaling for More, Less, & Same Value	Common Steps
Contingent Valuation	Assign a $ value	"*What is that $ value* from the change in X?"			*Outliers dropped *Valuation of $0 assigned to respondents who had no change in the NEI
Direct Scaling	Value NEI as a % of energy savings	"How does the $ value from X compare to the energy savings — *10% of energy savings, 20%, 30%, etc*.?"	*Billing analysis $ savings or respondent reported $ savings *Negative reported and actual savings set to $0		
Labeled Magnitude Scaling	Value NEI on a scale relative to energy savings	"Would you say the value of X is *more value, less value, or the same value* to you as any program savings?"		*Two sets of multipliers *Previous study values *Direct scaling values (in-sample multipliers)	

Weighting

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All NEI Values are Weighted Means

Two Levels of Weighting → **Participant Level** → **Response Level**

Description	Sample Frame (3,953)	Completed Survey (393)	Participant Level Weight	Completed Question (201)	Response Level Weight
Thermostat Only	9%	25%	0.347	27%	0.313
Water Heater Only	11%	20%	0.566	28%	0.401
HVAC	66%	26%	2.558	21%	3.146
HPWES	14%	30%	0.484	23%	0.611

Weights are used to ensure that results represent measure combinations in the sample frame.

Response level weights differ for each NEI and method (example in table: market rate, winter comfort, CV method)

Reported & Actual Bill Savings

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Market Rate Program

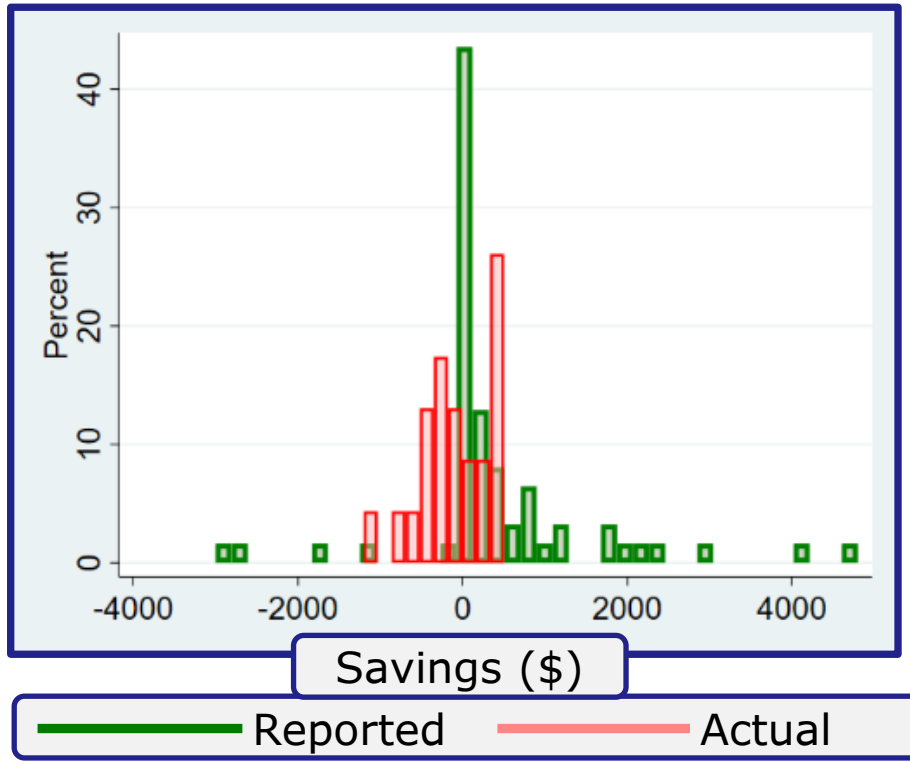
Bill Savings	#	Distribution of Values			
		Mean	P25	Median	P75
Reported	180	$195	$0	$10	$240
Actual	300	$58	$14	$51	$92

Low Income Program

Bill Savings	#	Distribution of Values			
		Mean	P25	Median	P75
Reported	172	$242	$0	$80	$420
Actual	107	$52	-$143	$28	$211

Low Income Program HVAC Participants

Reported vs Actual Bill Savings ($)



Reported savings are overestimated and more likely to be exactly $0. But respondent NEI valuation relates to respondent's perceived savings.

LMS Multiplier Values

Previous Study (PNNL)*	Multiplier Value	APPRISE Scale	Multiplier Value
Much More	1.55	More	1.35
Somewhat More	1.18		
Same Value	1	Same	1
Somewhat Less	0.82	Less	0.65
Much Less	0.475		

Examples of in-sample multipliers from market rate program

LMS Response	Safety Direct Scaling Values		
	Thermostat	HVAC,DHW	HPwES
More Value	0.30	0.68	0.44
Same Value	0.20	0.70	0.40
Less Value	-	0.30	0.15

Example: Of those who said that the value of improved safety resulting from HPwES was more than the energy savings.
The value compared to energy savings was on average 44% of energy savings.

*Pacific Northwest National Laboratory Study of NEIs for LED lights (Ledbetter et al. 2019)
Five-point scale with energy savings as an anchor. Derived multipliers from chemistry literature

Winter Comfort NEI Values

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Market Rate

Participant Group	Weighted Annual Mean NEI Value							
	Contingent Valuation	Direct Scaling		LMS – PNNL Multipliers		LMS – In-Sample Multipliers	
		Energy Bill Savings		Energy Bill Savings		Energy Bill Savings	
		Reported	Actual	Reported	Actual	Reported	Actual
Thermostat Only	$38	$9	$6	$23	$23	$9	$8
Water Heater Only	<$1	$0	$1	$1	$12	<$1	$2
HVAC	$75	$89	$18	$207	$44	$76	$17
HPwES	$78	$120	$29	$273	$91	$100	$34
All	$64	$76	$16	$177	$45	$65	$17

What is the $ value from the change in winter comfort?

How does the $ value from the change in winter comfort compare to the energy savings: *10% of energy savings, 20%, 30%, etc*.?

Would you say the value of the change in winter comfort is *more value, less value, or the same value* to you as any program savings?

HPwES customers had the highest estimates, as expected for winter comfort.

Health NEI Values

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Low Income

Participant Group	Weighted Annual Mean NEI Value							
	Contingent Valuation	Direct Scaling		LMS – PNNL Multipliers		LMS – In-Sample Multipliers	
		Energy Bill Savings		Energy Bill Savings		Energy Bill Savings	
		Reported	Actual	Reported	Actual	Reported	Actual
Electric Baseload	$1,382	$39	$20	$31	$52	$11	$21
Air Seal & Insulate	$68	$56	$3	$84	$12	$28	$4
HVAC	$2,157	$110	$11	$195	$28	$97	$14
All	$1,413	$50	$18	$57	$47	$24	$19

What is the $ value from the change in health?

How does the $ value from the change in health compare to the energy savings: *10% of energy savings, 20%, 30%, etc*.?

Would you say the value of the change in health is *more value, less value, or the same value* to you as any program savings?

- CV method skewed by extreme responses for Baseload and HVAC customers.
- Air Sealing and Insulation NEI values relatively low compared to expectations.

NEI Method Assessment

Method	Process	Survey Question	Advantages	Disadvantages
Contingent Valuation	Assign a $ value	"*What is that $ value* from the change in X?"	• No restrictions on response	• Low response • Extreme values
Direct Scaling	Value NEI as a % of energy savings	"How does the $ value from X compare to the energy savings — *10% of energy savings, 20%, 30%, etc*.?"	• Easier to answer than contingent valuation	• Clustering at low, mid, and extremes (0%, 100%) • Maximum allowed response was 100%
Labeled Magnitude Scaling	Value NEI on a scale relative to energy savings	"Would you say the value of X is *more value, less value, or the same value* to you as any program savings?"	• Easiest for respondent to provide answer • Direct scaling, in-sample multiplier derived from program experience	• Need additional information to value the response

Reported bill savings may yield more accurate response than actual savings because that is the respondent's reference.

Selected NEI Method

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Method	Process	Survey Question	Energy Savings Value	Scaling for More, Less, & Same Value	Common Steps
Contingent Valuation	Assign a $ value	"*What is that $ value* from the change in X?"			*Outliers dropped *Valuation of $0 assigned to respondents who had no change in the NEI
Direct Scaling	Value NEI as a % of energy savings	"How does the $ value from X compare to the energy savings — *10% of energy savings, 20%, 30%, etc*.?"	*Billing analysis $ savings or respondent reported savings *Negative reported and actual savings set to $0		
Labeled Magnitude Scaling	Value NEI on a scale relative to energy savings	"Would you say the value of X is *more value, less value, or the same value* to you as any program savings?"		*Two sets of multipliers *Previous study values *Direct scaling values (in-sample multipliers)	

Main Findings – Market Rate

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Market Rate | **NEI Valuations Using LMS with Reported Savings and In-Sample Multipliers**

Participant Group	Non-Energy Impact					Total NEI
	Winter Comfort	Summer Comfort	Safety	Health	Noise	
Thermostat Only	$9	$5	$3	$1	$1	$19
Water Heater Only	<$1	$6	$8	<$1	$6	$21
HVAC	$76	$38	$62	$31	$66	$273
HPwES	$100	$126	$23	$44	$39	$332

NEI Values

- As expected, thermostat only customers had low values for each NEI.
- Water heater only customers also had very low values for each NEI
- HVAC customers had highest NEI value for noise, second-highest for all others.
- HPwES customers had highest NEI value overall, and for most of the NEIs.

Main Findings – Low Income

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Low Income	NEI Valuations Using LMS with Reported Savings and In-Sample Multipliers

Participant Group	Non-Energy Impact					Total NEI
	Winter Comfort	Summer Comfort	Safety	Health	Noise	
Electric Baseload	$72	$40	$34	$11	$39	$196
Air Sealing and Insulation	$72	$58	$36	$28	$34	$228
HVAC	$74	$88	$82	$97	$45	$386

NEI Values

- Winter comfort estimates were similar for all three groups
- Summer comfort estimates were high for HVAC, as expected
- Safety estimates were high for HVAC
- Health estimates were high for HVAC and low for baseload
- Noise estimates were similar for all three groups
- Total estimates were very high for HVAC; baseload not much lower than air sealing/insulation

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6. RECOMMENDATIONS

Improving NEI Valuations

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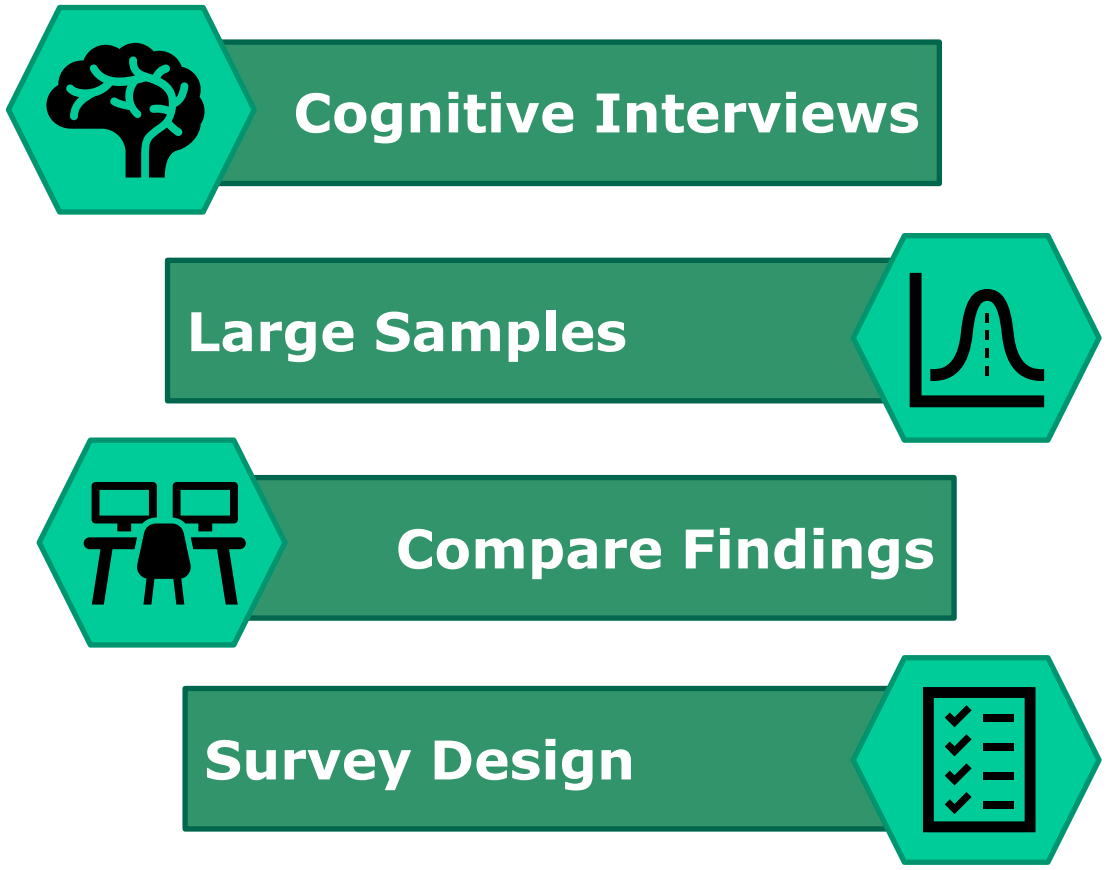

Conduct in-depth interviews

□□□

Use survey of specific program

□□□

Collect a large sample

□□□

Achieve high response rates

□□□

Weight results

□□□

Be transparent

□□□

Compare to expectations

□□□

Compare to other studies

Summary

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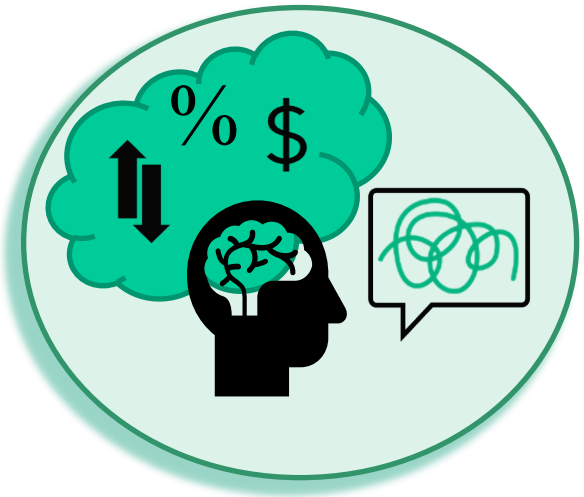


NEIs are difficult for participants to value

Anchors and qualitative labels may help

Cognitive interviews and research needed

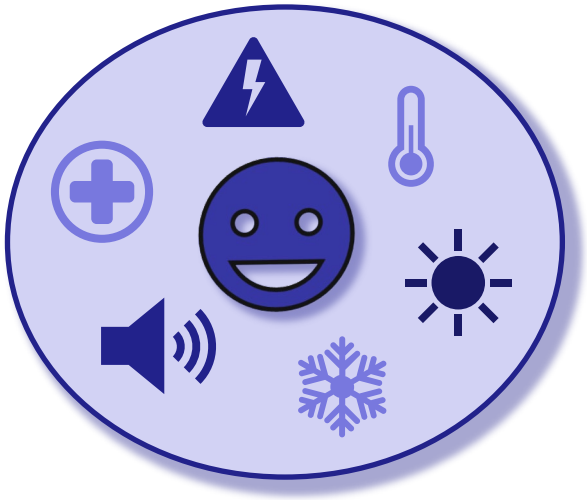
Participant NEIs are difficult to measure

Surveys may be the best approach

Total NEI benefits can be large for some

But many experience no impact

Analysis should account for measurement uncertainty



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