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NEBS / NEIS BEYOND LITERATURE REVIEW

New findings on Values, Updated Models / Tools, and Suggestions for Expanded Use Across the US

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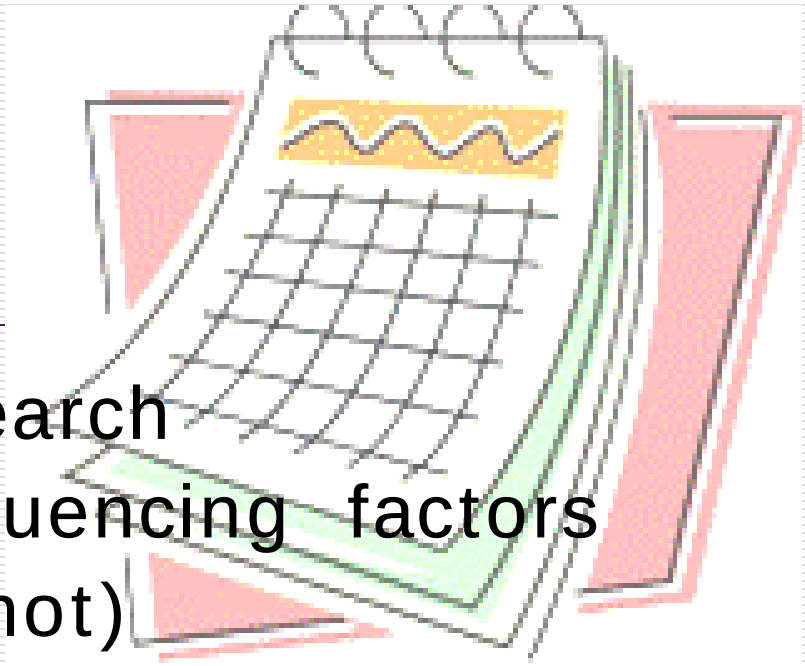
Lisa A. Skumatz, Ph.D.
Skumatz Economic Research Associates, Inc.
762 Eldorado Drive, Superior, CO 80027
303/494-1178 email: skumatz@serainc.com

TOPICS



- New NEB Values / Research
- Disaggregation and influencing factors
- Best approaches (and not)
- Conclusion

NEBs / NEIs

- Positive and negative, 3 perspectives
- 5 main applications of NEBs
- Serious quantification started mid-90s; in earnest 2001 and on.
- Primary work slowed about 2009; reliance on literature reviews.
- Lit reviews / borrowing results 2009-2016+
- Cost-effectiveness application revitalized 2014

KEY APPLICATIONS OF NEBS

MARKETING & ROI –

Sell what's valuable to customers; link to peers

B/C TESTS –

Refined C/E for program & portfolio; reduce bias in investment

PROGRAM REFINEMENT –

Positive & Negative NEBs for measures, barriers, incentives, and targeting

POLICY / GOALS

Quantifies Non-energy goals (e.g. Low income, jobs, etc).

TRAIN THE CHAIN –

Align / Educate Actors on NEB priorities

EXPANDING NEB CATEGORIES – H&S (~2013)

- Fewer missed days at work ($16-$201/hh/yr
- Aggregate “health” benefits, valued at $0.13-19/hh/yr
- Improved air quality: $156/ year
- Reduced asthma symptoms: $10-$15/yr participant, societal larger; others have varying units
- Reduced allergy symptoms: 5-13% reductions in various subgroups, symptoms
- Reduced medical costs: multiple values and units
- Carbon Monoxide: $6-37/hh/yr
- Reduced fires / safety: $37-93/hh/yr
- Improved safety, aggregate: $20-181/hh/yr plus other units and impacts.
- Participant and some societal – input improvements

EXPLORATIONS INTO OTHER H&S

- Formaldehyde, radon, moisture / mold, VOC, ventilation
- Hypertension and cardiovascular disease
- Mental health improvements,
- Scalding, wheezing, sinusitis
- Sleep improvements

- Top down / bottom up; watch overlaps / drivers

EXPANSIONS, IMPROVEMENTS – AND REMAINING GAPS

- Societal health effects – model
- Societal economic impacts – model
- Societal water - data

- Gaps
  - H&S
  - Utility perspective
  - Commercial / published
  - Societal
  - Lighting
  - Hardship

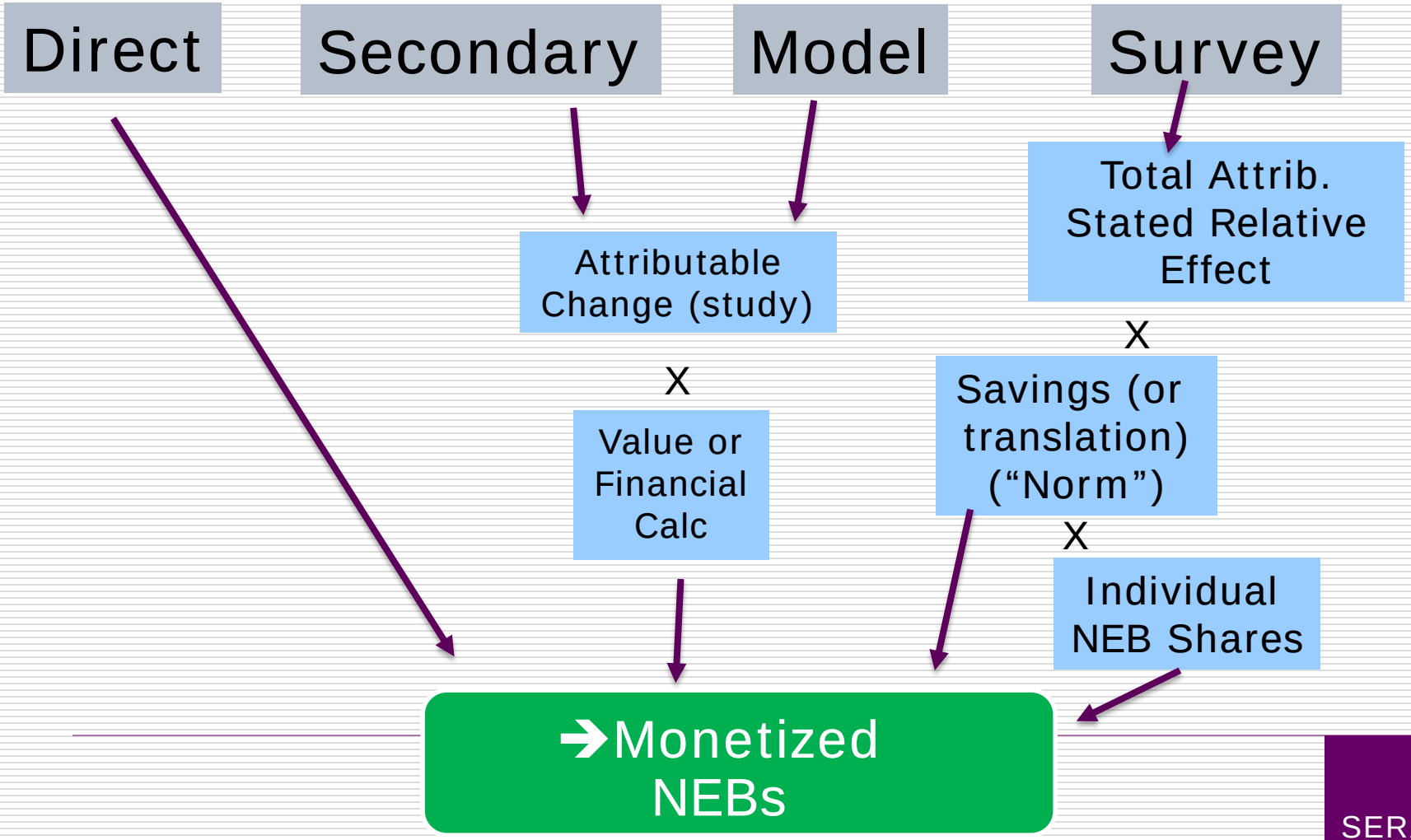
EXPANDING NEB CATEGORIES

- Paper lists 25 utility (4), 29 societal (2), 72 participant (3); 3 tiers
- Transferability / balancing new and existing research (cost)

TRANSFERABILITY -

- Literature reviews have gone too far
- Average of literature values - not looking beneath the curtain

HOW THE NEBs ARE MONETIZED



USING THE LITERATURE: NEBS TRANSFERABILITY – FOR SAVINGS, CONSISTENCY- VS RISK

Variability	Relevant NEB Categories
Program / measure invariant (suitable for "adder") **AGNOSTIC**	• Environmental / emissions – links to energy savings (varies with generation mix, and local air conditions, and time of day, but not primarily with measures / program)
Program / measure dependent **MEASURE-DEPENDENT**	• Economic – societal (depends on measures and local manufacture / installation) • Health and safety, health care, illnesses – societal and participant (measure) • Water / wastewater infrastructure and water bill savings – societal and participant • Participant benefits including: equipment operations, lifetime, O&M, comfort, noise, control / education, home-improvements. Note: if measure bundles are "similar" participant NEB multipliers are similar in different areas of country.
Climate dependent **CLIMATE DEPENDENT**	• Participant benefits including comfort, but when expressed as percent of energy savings, this variability may be mitigated. Note: if measure bundles are "similar" participant NEB multipliers are similar in different areas of country.
Residential Target dependent (low income or MF vs. SF) **PARTICIPANT DEPENDENT**	• Payment related – utility (arrearages, etc. stronger for low income targets) • Health and safety, health care, illnesses – societal and participant (higher with chronically ill, vulnerable populations) • Participant benefits related to hardship and payments • Initial information indicates non-low-income NEBs for occupant MFs are similar to SF

GEOGRAPHY **SIZE / INTENSITY** **FUEL TYPE** **RATE DEPENDENT** **OZONE DEPENDENT**

Source: Skumatz / SERA research

WHAT CAN YOU BORROW? / TRANSFERABILITY

- Weather-based dependencies

Ratios for Measure Savings

Measure	High Savings	Low Savings	Ratio High to Low
Furnace (kWh)	2.38	0.22	10.8
Furnace (therms)	0.78	0.0366	21.3
Air Conditioning (kWh)	326	8.12	40.1
Wall Insulation (kWh)	0.707	0.0408	17.3
Ceiling Insulation (kWh)	2.1	0.113	18.6

Need to be wary of just "transferring" NEB values

Issues with literature reviews

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WHAT CAN YOU BORROW? TRANSFERABILITY / GAPS

- Gas vs. Electric
  - May have similar order of magnitude multipliers
  - Not much research on fuel patterns – a gap / thin
- MF
  - Less-commonly-studied; poor response and complexity
  - Study provides some indicative results on occupants vs. owners (112% vs 71%); some comparisons to SF; Gap.
- Demographics (H&S, comfort, others)
- Weak –
  - Utility, arrearage, other – antique; calls in the age of email?

Do not need more literature reviews! Please spend the money on the gaps. Borrow methods, but not numbers!

BIGGEST ISSUE IN RESIDENTIAL NEBS - MEASURE-BASED NEBS

- Issue in residential primarily
  - NEBs vary with causal measures; program-wide estimates
  - Don't want estimates that don't vary with measures included – undermines confidence
- Options – increasing quality
  - Program-wide / across the board (measure invariant)
  - Savings-based (Negative & Zero problem)
  - Regression
  - Measure-stratified estimates

MEASURE-BASED NEBS ISSUE: 2 PARTS – CAUSAL & IMPORTANCE

Results Using Regression Analysis to Allocate Program NEBs to Measures

Measure Group	Measure	A. Comfort	B: Ability to Pay Bill	C: Light quality / quanitty	D: Noise inside (appliance)	E: Noise outside	F: Eqpt reliability	G Appearance/ ability to sell	H: Control over bill	I: Moving	J: Eqpt perfor-mance / features	K: Bill calls	M: Ability to Help Enviro	N. Health & missed days	O: Water bill costs /Savings	P: Home safety	# of NEBs/measure
HV	Furnace repairs	17%	17%				23%	9%	15%		14%		18%			14%	8
HV	Furnace replace	14%	21%				34%	7%	11%	16%	19%	55%	19%	21%		15%	11
HV	Fan		13%					5%									2
HV	Vents - fix / replace	8%	24%						7%				16%				4
AC	Air Conditioning									84%							1
Water	Hot water repair																0
Water	Hot water replace														70%		1
Shell	insulation	18%	25%			34%						45%					4
Shell	Tests for Drafts													27%			1
Shell	Caulk windows																0
Shell	Seal crawlspace	16%							21%								2
Shell	Fix doors	14%				22%		7%	9%							13%	5
Shell	Fix windows	13%				44%	43%	14%	10%							15%	6
Lighting	CFL bulbs			100%									48%				2
Appliances	Appliances				100%			59%	28%		67%				30%		5
CO&Smoke	CO / Smoke detectors													52%		43%	2
Number of Measures Contributing		7	5	1	1	3	3	6	7	2	3	2	4	3	2	5	

Source: Skumatz 2019, may be used with permission of author

Initial work 2005

BUT DEPENDS ON PROGRAM MEASURS & NEBS INCLUDED

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TWO STAGES FOR MEASURE ALLOCATION

- Causation
  - Regressions
  - Consistent lists
  - Measure groups / end uses
- Importance - logical
  - Variations on savings
  - Spending
  - Water, etc.
- Highest tends to be HVAC; depends on rates too

MEASURE-BASED NEBS – STRATIFIED EXAMPLE

Table 2: Estimates of Appliance NEBs as a Percent of Measure Savings (Skumatz 2006)

Household appliances	Refriger-ators	Dish-washers	Clothes Washer	Room Air Conditioner	CFL Bulbs	Lighting Fixture
NEB Multiplier as a percent of the measure's energy savings	29%	65%	27-54%	71%	45-90%	30%

Share of Total Appliance NEBs for Individual NEB Categories

Percent of Total Measure NEB by Category	O&M	Appear-ance	Perfor-mance	Lifetime	Noise	Satis-faction	Comfort	Lite Qual	Safety	Ability to Sell Home	Avoid Moves	Water Sav	Environmen-tal Ethic	Total
Refrigerators	9%	4%	13%	7%	10%	17%	9%	0%	2%	11%	3%	0%	15%	100%
Dishwashers	5%	4%	8%	8%	9%	11%	6%	0%	4%	8%	8%	12%	17%	100%
Clothes Washers	5%	4%	8%	10%	5%	10%	8%	0%	5%	6%	7%	14%	18%	100%
Room AC	6%	7%	10%	8%	11%	10%	9%	0%	8%	7%	8%	0%	16%	100%
Bulbs (CFL)	8%	3%	10%	13%	1%	13%	8%	11%	7%	4%	4%	0%	18%	100%
Lighting Fixtures (CFL)	6%	6%	12%	9%	4%	10%	8%	5%	7%	9%	9%	0%	15%	100%

Figure 4. Skumatz 2006: Share of Total Appliance NEBs for Individual NEB Categories
For NYSERDA / Meissner

But also think about it - transfer dollar or percent?!

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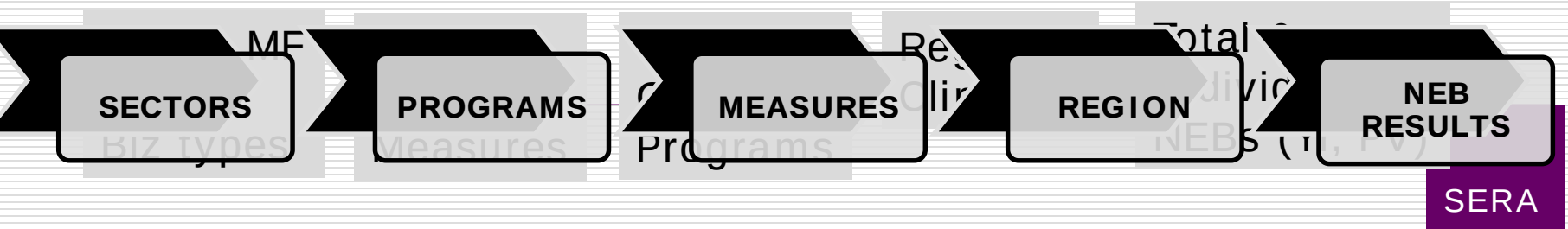
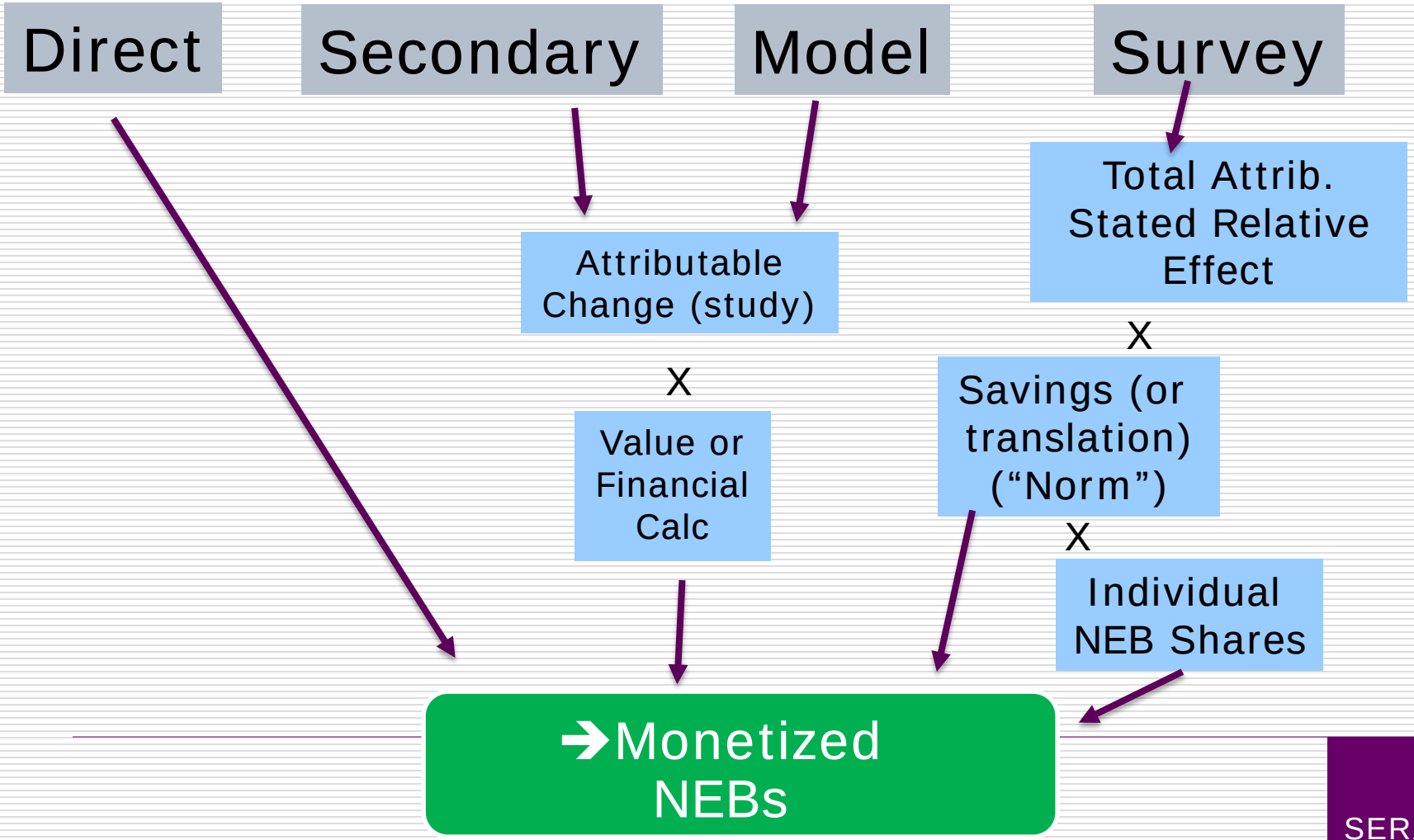
NEBs MODELING

- Continually-updated “NEB-It” model
  - >80 modeled
  - All data **elements**, not just values / allows mix & match; from hundreds of studies
  - 2 part allocation steps
  - Supports quick values, ranges, patterns, volatility for priorities, review of weakest inputs



HOW THE NEBs ARE MONETIZED



PRIORITIZE EFFORTS

Weatherization	Low NEBs Value	Medium NEBs Value	High NEBs Value
Easy to Estimate / Easily Adapted	• Payment-related (arrearages, etc. Utility and Participant	• Low income rate subsidy - Utility	• Water savings –Participant • Lifetime / deferred replacement – Participant • Emissions effects on public health - Societal
Moderate Estimation Ease / Transfer or adapt i(MAYBE local survey or local data)		• Individual illnesses – Participant & Societal • Survey-based NEBs - Comfort, Noise, Aesthetics, Ability to control bill– Participant • Avoided moves – Participant • Sick days from work or school – Participant	• Water savings –Societal • Economic impacts – Societal • Regression- or similar basis for allocating NEBs to measures
Hard to Estimate / Requires Tailored Data			• True work on measure-based NEBs

TAKEAWAYS

- Progress in values & methods, but stalled
- Not as transferable as literature reviews wish
  - Look at underlying steps and adapt / update selectively
  - But think about it
- Transferability influencers
- Measure attribution
  - Short term – regression and importance factors
  - Measure-stratified surveys **right now**; tested methods
- Important – don't undermine the progress with poor techniques or overreach
- Helps programs & measures address cost-effectiveness threat
- It isn't that expensive; prioritize

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THANK YOU!!

Questions?

Lisa A. Skumatz, Ph.D.

Skumatz Economic Research Associates (SERA),

Phone: 303/494-1178

skumatz@serainc.com

MEASURE ALLOCATION EXAMPLE – DEPENDS ON NEBS INCLUDED

Measure group	Selected NEBs list	Most NEBs available
HV	10%	12%
DHW	67%	33%
Shell	10%	8%
Light	5%	29%
Appliance	6%	7%
Maintenance	0%	0%
Miscellaneous	2%	11%

About

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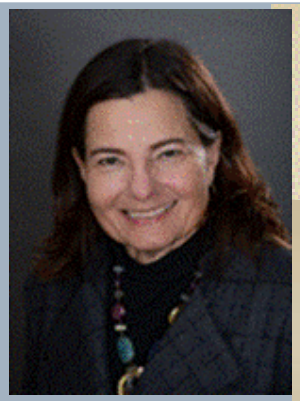
Research & Consulting in Solid Waste, Resource Economics, & Sustainability



Staff:

SERA By the Numbers…

Projects: 325+

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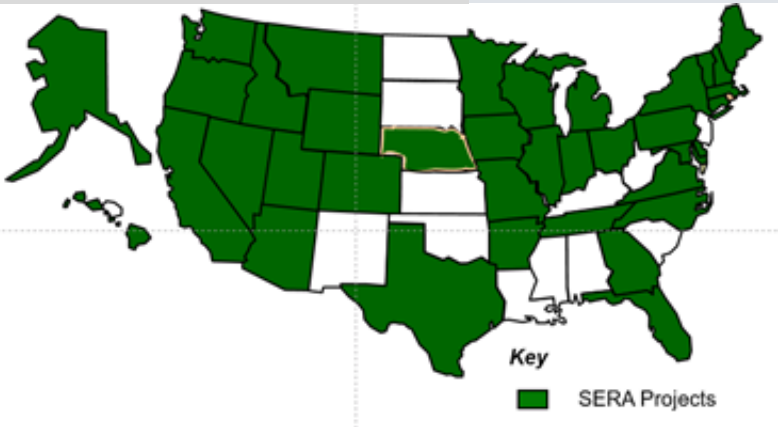

Awards / Honors: *National Lifetime Achievement Awards from*:

- SWANA
- National Recycling Coalition
- Journal of SW & Technology
- State Award: CAFR

Boards: NRC, CAFR, CO-SWANA
Former Boards: WSRA, AESP

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