

## CO-BENEFITS OF LOW INCOME WEATHERISATION PROGRAMMES:

### Methodological Issues in NEBs

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## MEASUREMENT / METHODOLOGIES FOR NEBS

- Methods for Hard to Measure (HTM)
- Effective measurement methods
- Use of surveys in HTM
- Evaluation experiments needed

## METHODOLOGICAL ISSUES IN MEASUREMENT OF NEBS

- Literature review and primary / secondary data research
  - 100+ studies, updating 350+ study a few years ago; construction of model
- Attribution to programs – “NET” NEBs
  - Positive and negative
  - Net beyond standard efficiency – except for some Low Income
  - Net above what would have happened (NTG)
  - Redundancy, overlap
- Consistent units (per hh/yr)
- Attribution to measures barely reviewed
- Retention missing / discussion

## 4 MAIN NEBS MEASUREMENT APPROACHES USED

- Direct or simple computation
  - E.g. water bill savings (e.g. change in water use per showerhead times AWWA data on shower length times local water rates, etc.)
- Detailed Models
  - E.g. GHG / emissions, economic development & jobs
- Incremental impacts, valued
  - Examples
- Survey methods
  - Challenging, Multiple approaches – discussed later in presentation
- Considerations
  - Primary / secondary data sources
  - Options / bounding

## INCREMENTAL IMPACTS APPROACH EXAMPLES

- Incremental impacts, valued (see Skumatz 1997, 2001, 2010)
  - E.g. H&S (societal): Average baseline crises per household (insurance sources) times reduction in crises for participating households (from share receiving health & safety measures), times cost per avoided crisis (insurance sources) provides proxy for health & safety improvements
  - E.g. Direct Sick Days (participant): Average sick days from work reduced from program (survey or other records) due to presence of "shell" measures times minimum wage times 8 hours per workday provides proxy for direct illness.
  - E.g. Health costs (participant): Reported reductions in chronic health incidents / hospital / doctor visits, (control vs. test group surveys) times average cost per hospital / doctor visit, as relevant.
  - Certainly other data on improved lifetime health would be valuable, but few data in literature
  - Many other examples of this approach in the NEBs modeling / literature

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## MEASURING UTILITY & SOCIETAL NEBS

## MEASUREMENT METHODS – UTILITY PERSPECTIVE

- Arrearage studies as underpinnings for most financial and collections NEBs
  - Many studies, not much change in last 10 years
  - 25% reductions common for reasonably targeted programs, wide range
- Gaps / limited progress in:
  - Line loss reductions
  - TOD / capacity / avoided infrastructure
  - Safety & health
  - Future risk / liability

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## MEASUREMENT METHODS – SOCIETAL PERSPECTIVE

- Climate change / emissions –models & literature – significant activity
  - 3 levels of sophistication: System average vs. peak/off-peak generation (sufficient for most NEB analyses) vs. hourly dispatch (needed for cap & trade)
  - Results dependent on region, fuel, TOD, etc.
  - → Modeling, or periodically updated "deemed" ranges for fuel, vintage, peak by territory (margin)
  - Uses: cap & trade (refined); B/C; marketing, performance tracking.

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## MEASUREMENT METHODS – SOCIETAL PERSPECTIVE

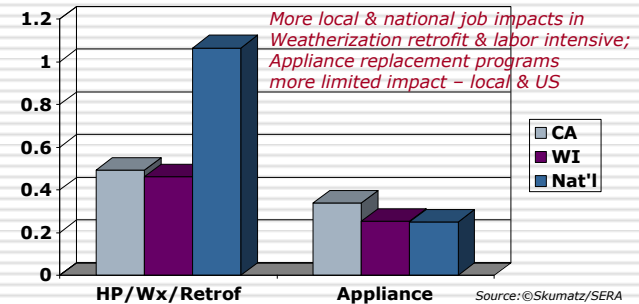
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- Economic Development / jobs – models & literature – significant activity
  - Alternative case issue
  - Care in timeline – initial effects may differ from on-going
  - Range of results – dependent on program / measures, region / industries
  - → Third party models available / reviewable.
  - Uses: auxiliary benefits; B/C; optimizing program selecting measures / programs / portfolios

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## ECONOMIC MULTIPLIER – PATTERNS

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Multiplier for indirect portion of economic output from NET transfer of funds FROM generation TO SIC/NAICS codes relevant to program's design.

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## MEASUREMENT METHODS – SOCIETAL PERSPECTIVE

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- Other societal NEBs - some work
  - Health & safety
    - Incremental impacts work from 1997 on for a few topics; weak data on impacts and link to health in a number of areas / topics; more research & monitoring needed
    - Some recent work at National level on IAQ; very complicated very fast; significant data issues
  - Low income / hardship - progress
    - Important, because goal of programs
    - Impacts on resident illness, job retention, shutoffs/payment
    - Effects from avoided moves
    - Energy burden, Home energy insecurity scale (Colton)
    - Not well monetized into common units, making it harder to consider on level playing field / incorporate into tests
- Other societal NEBs – little work
  - Water infrastructure – little work
  - National security, infrastructure, other – little progress

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## MEASURING PARTICIPANT NEBS

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## PARTICIPANT NEBS

- Computational approaches
  - Little progress / change. Direct for water savings, shutoffs\*, other bills\*, a few others
  - Incremental impacts approach
- Data collection to support some of these methods from phone, mail, web, on-site, email, records
  - Preference is pre-post test vs. control, where possible; usually in real projects the data collection is pre-post or post with recall of changes
- Survey-based methods – much attention
  - Initial breakthrough...
  - Many articles published
  - Controversies from method / confidence, and appropriate uses
  - To date, mostly per-participant basis for multiple measure programs, not measure-based (1 exception)

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## PARTICIPANT NEBS – ANALYSIS APPROACHES

- Computational
  - Primary computation, valuation (A)
  - From secondary sources (B)
  - Regression (C)
- Relative scaling (E)
  - Percentage
  - LMS
- Ranking-based (F)
  - Analytic Hierarchy
  - Ranking, ordered
- Contingent valuation (D)
  - Open-ended CV, WTP/WTA
  - Discrete CV questions
  - Double-bounded etc.
- Other
  - Hedonic decomposition (G)
  - Reported motivations (H)

*Advantages / Disadvantages with each...*

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## PARTICIPANT NEB ESTIMATION – PROS & CONS

Direct/assisted valuation	Missing obs/bias, expensive (\$\$), good
WTP/WTA	Volatile, uncertain responses
Bounded WTP/WTA/CV	Fairly strong, quick
Comparative/numeric	Fast, strong, robust
LMS/verbal relative	Fast, strong, clear
Ordered logit, ranking, conjoint	Strong, slower, complex, robust
Regression	Limited, \$\$, 1 category* (disaggregation)
Market valuation	Rarely available, observation issues
Other	Always testing...!

*Goals and practical tradeoffs... Need reasonable number of observations & NEBs AND quality responses*

Source: Skumatz / SERA primary research

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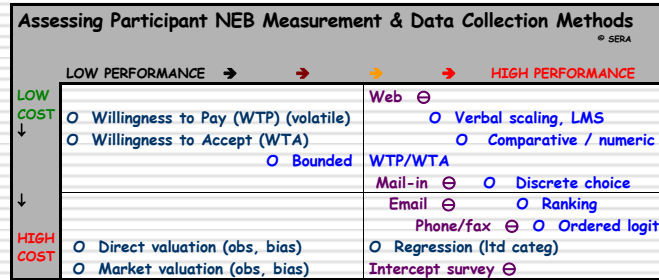
## PARTICIPANT NEB DATA COLLECTION APPROACHES (TRADEOFFS)

In-person interview	Slow/expensive (\$\$), robust, low observations
Mail survey	Limited skip / long, understanding, can be low cost
Phone survey (large)	Low cost, skip patterns OK, quick, limited flexibility, can get large sample
Phone interview	Fast, strong, flexible / skip, good quality, \$, limited sample size
Phone/fax/email	Fast, strong, clear, medium to low cost \$
Web survey	Strong, fast, flexible, skip, robust, low \$, growing all segments/paired phone
Real time forms	Limited / no skip, low cost, helps in getting high number of respondents, bias discussion
Secondary/mkt val.	Rarely available, observations a big difficulty
Other	Always testing...!

Source: Skumatz / SERA primary research

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## ASSESSMENT OF NEB MEASUREMENT & DATA COLLECTION METHODS



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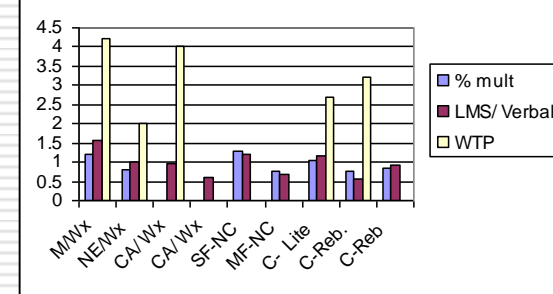
Based on SERA tests, comparisons, studies



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## PARTICIPANT MEASUREMENT METHODS COMPARISON

We always include 2 or more methods in one study to continually test / develop options.



Other papers compare WTP, Bounded WTP, LMS (SERA/WEA 2006)

(Source: Skumatz/SERA ACEEE paper 2002)



## NEBS MEASURED IN SURVEYS: CHANGES IN...

- Comfort
- Aesthetics / appearance
- Lighting quality / quantity
- Noise
- Safety
- Property value
- Moves
- Control over bill / knowledge / concern / notices, etc.
- Doing good for environment
- Equipment lifetime\*
- Equipment maintenance\*
- Illness / lost days / visits / cost
- Other bills\*
- Other
- Valuation metrics vary for valuing these impact changes
  - Some directly valued from survey responses (depending on method)
  - Others "valued" (e.g. calls times length times value of time)

Some can be derived other ways, checked  
Some should be explored as financial calculations instead (\*)



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## MEASUREMENT EXPERIMENTS

- Need well-designed samples / control group
  - Pre-post with control preferred
  - Especially needed in health and safety - related arena
- Need more testing of multiple survey measurement of impacts / changes and valuation approaches in one sample



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## SURVEY-BASED (PARTICIPANT) NEBS

- Perception vs. out-of-pocket issue...
- Accuracy / consistency
- Marry with computations for other NEBs (participant, utility, society) for comprehensive assessment
  - Subsets used for different applications
  - Total program value vs. marketing applications, regulatory tests, etc.

## SURVEY-BASED (PARTICIPANT) NEBS

- Issues
  - Negative NEBs -examples, implications / meaning (barriers) / uses (rebate-setting)
  - Consider NEB analyses with multiple actors in program chain for “disconnects”
  - Retention not studied (assumed decay with energy savings for MOST, but not all...)
  - Attribution to measures (only 1 study)

*Walkthrough of Negative NEBs / Barriers Example...*

## NEW ZEALAND – ZERO AND LOW ENERGY HOMES (ZALEH): NEB RESULTS BY CATEGORY & MEASURE (SHARES OF TOTAL NEBS)

	Double Glazing	Super Insulation	Solar Water Heat	Solar Design
<b>NEB Category</b>	<b>Share</b>	<b>Share</b>	<b>Share</b>	<b>Share</b>
Comfort	22%	19%	14%	21%
Noise	23%	14%	1%	2%
Appearance	0%	1%	-49%	-2%
Maintenance	1%	3%	-30%	-3%
Features	5%	3%	21%	6%
Environment	0%	12%	60%	22%
Health	12%	17%	10%	14%
Energy bill control	19%	16%	55%	24%
Moving avoidance	7%	5%	13%	12%
Bill-related calls	5%	5%	5%	6%
Other	7%	6%	0%	-2%

Logical matches – comfort/noise from shell, etc. but note negatives

Source: Skumatz & Stoecklein,

## NEGATIVES - BARRIERS / REMEDY

- Solar water heat had significant negative NEBs in some categories (solar design same categories)
  - Appearance
  - Maintenance
- NEBs as value & importance of barriers (and potential remedies)
- Other implications depend on "real/perceived" split

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*Walkthrough of Disaggregation to Measures...*

## BARRIERS ANALYSIS / REMEDY OPTIONS & IMPLICATIONS

	<i>Perceived</i>	<i>Real</i>
<i>Appearance</i> (→ to ~\$9, distribution implies)	Redesign, advertising (chic), modify incentive (perception=real?)	Redesign, advertising, modify incentive
<i>Maintenance</i> (→ to ~\$15, distribution implies)	Education, tests & data, change rebate (perception not= real)	Change rebate, buy-up warranty, etc.

Source: Skumatz

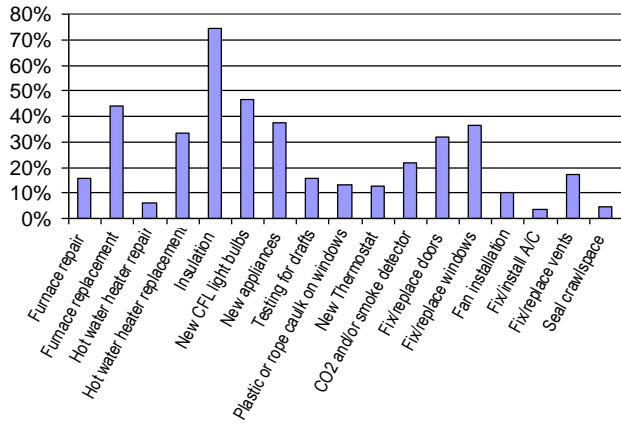
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## ATTRIBUTING PACKAGE NEBS TO MEASURES - APPROACH

- Data from low income weatherization program
  - 1-10 measures; average 5.3 measures per household (insulation most common at 74%; then furnace, CFL)
  - Savings and NEB results

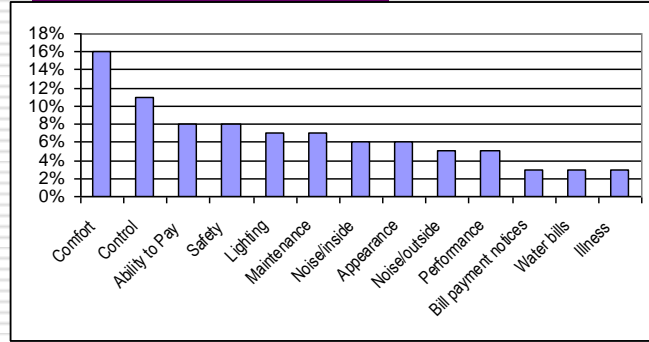
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**Percent of HHs with Measure Installed**



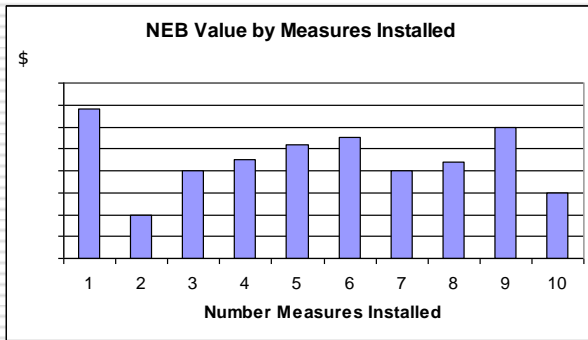
**TOP NEBS FOR PROGRAM**

(Percent of total survey-based participant NEBs)



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**NEBS VALUE BY NUMBER OF MEASURES INSTALLED**



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**ATTRIBUTING PACKAGE NEBS TO MEASURES - APPROACH**

- Statistical models included:
  - Measures and equipment (yes/no)
  - Demographics
  - Used linear and logit models

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## **MOST SIGNIFICANT FACTORS / MEASURES**

- Linear model
  - Insulation
  - Furnace repair
  - Household income
  - Number children
  - Number elderly\*
  - Next level:
    - Fix/install A/C
    - New thermostat
    - CFL
- Logit model
  - Insulation
  - Testing for drafts
  - Fan installation
  - Household income\*
  - Number residents
  - Number of elderly
  - Next level:
    - W/H replace
    - Fix/replace windows

Source: Skumatz 2006

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## **ATTRIBUTING PACKAGE NEBS TO MEASURES - RESULTS**

- NEBS results related to measures
  - Key measures significant contributor in size and sign
  - Other measures contribute
  - Not much contribution from demographics
- Statistical decomposition into causal measures promising
  - ID largest contributors from mix of measures – which measures are most valued
  - Helpful if no time for detailed interviews

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## **EXPLORATION OF EFFECTS OF DEMOGRAPHICS**

- Role of demographics on NEBs / targeting
  - realize greatest NEBs from the programs,
  - realize the greatest payback from the program expenditures, and
  - potentially be early adopters, economic case
- Important demographics:
  - Larger HHs, higher incomes, owners → lower NEBs (inverse)
  - Infirm / chronically ill → higher NEBs
  - Heating fuel differences, attitudinal differences: LPG and firewood (lower NEBs)
  - Attitudinal patterns as well

Source: Skumatz articles

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## **NEB USAGE & THE REGULATORY TEST ISSUE**

## USING PARTICIPANT NEBS IN PROCESS/PROGRAM RESEARCH

- Process / program research & equipment selection applications
- Program logic / researchable questions
- "Disconnects" within chain of measure delivery
- Negative NEBs – "barriers"
- Paybacks & Participation analysis – internal is NOT based solely on energy savings (Tide™ example)

Source: Skumatz Economics (SERA)

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## UPDATE

- US utilities do not incorporate broad, formal use of NEBs in regulatory process
  - Informal use in marketing, targeting, potential for others (many examples); exploring others.
  - Use in regulatory processes
    - Scenarios; "Readily measurable"; Screens; All measured NEBs; hybrid
- Chicken and egg – Important uses ↔ trusted metrics
  - Also, some NEBs can ONLY be measured from user perceptions; surveys; modeling work progressed as well...

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## USES OF NEBS

	Utility NEBs	Societal	Participant
Marketing & targeting		Suitable	Yes
Program refinement	Yes	Yes	Yes
B/C internal customer		Suitable	Yes
Portfolio dev'p	Yes	Yes	Yes
B/C tests	Yes	Potential (high)	Potential

Source: Skumatz 2010

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## NEBS AND REGULATORY TESTS

- Low income program goals
- Direct and improved economic and GHG NEBs in screening & B/C
  - TRC – case to include resource-related (GHG, labor, Water/wastewater)
  - Societal – case to include utility, societal, participant
- Readily measured NEBs into screening and B/C
- Developing acceptable multipliers for "other" HTM for proxies / conversation
- Use metrics for NEB values for screening, B/C, protocols

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## RECOMMENDATIONS AND NEXT STEPS

## WHAT HAS BEEN LEARNED? STATE OF MEASUREMENT

- Arrearage based
- Readily measured
- Model based societal
- Incremental impacts, valued
- Survey based participant
  - Some values ONLY from perceptions
  - Some most readily from surveys
  - Surveys fastest for multiple NEBs
- Explore financial computations
- Weak / unexplored NEBs
- Weak on across-program comparisons (methods & values)
- Missing:
  - Measure-based (easily kWh for most EXCEPT: safety/emergency, health, some participant)
  - Better incremental values in H&S, and link to health, health costs
  - kW based computations

## NEBS ADDRESSED WELL

Utility Perspective	Social perspective	Participant perspective
Collection activities	Economic dev'p	Water / sewer savings
Transmission & distribution	Emissions	Shutoffs / reconnections
Utility rate subsidy	Possibly social / hardship indicator	Calls and notices
		Property value
		Sick days*
		Moves
		"Soft" NEBs in total, not associated with measures

Source: Skumatz 2010

## NEBS NOT ADDRESSED WELL

UTILITY	SOCIETY	PARTICIPANT
Health	Tax impacts	Performance / operations of measures
Safety	Water / wastewater infrastructure	Maintenance / lifetime
Insurance / self-insurance	Fish/wildlife	Fires / safety
Substation / infrastructure	National security	Chronic health / indoor air quality
Power quality	Health	
	Full treatment of social hardship indicators	

Source: Skumatz 2010

## NEB VALUES RESEARCH PRIORITIES

Very High	High	Medium	Low
Relevant to Low Income; little work			Not relevant to Low Income, or well-known
<ul style="list-style-type: none"> <li>•Health, IAQ (S, P)</li> <li>•Social / hardship (S, P)</li> </ul>	<ul style="list-style-type: none"> <li>•Health / days lost (P)</li> <li>•Stability / moves (P)</li> <li>•Prop value / neigh. (S, P)</li> <li>•H&amp;S, fires, insurance (P, S)</li> <li>•Emergency calls (U)</li> <li>•Insurance (U)</li> <li>•Infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>•Knowledge/control (P)</li> <li>•Subsidies (U)</li> <li>•Jobs (S)</li> <li>•Water (P)</li> <li>•Other bills (P)</li> <li>•GHG (elsewhere)</li> <li>•Participant effects (comfort, etc.) (PI)</li> <li>•Negative effects</li> </ul>	<ul style="list-style-type: none"> <li>•Arrears-related</li> <li>•Fish / wildlife (S)</li> <li>•National security</li> </ul>

Source: Skumatz 2010

U=Utility perspective; S=Societal; P=Participant

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## GAPS / NEXT STEPS

- Surveys with embedded tests, modules, comparisons
- Additional analysis in health & safety (multiple perspectives) Which measures, impact, value of effect;
  - Potentially will take engineering, inspections, health research, etc.
- Peak / off-peak enhancements for some NEBs (T&D, infrastructure)
- Utilities define "hardship" and develop metrics and survey – Important – initial progress made
  - Independently estimated vs. survey
  - Goals-related
- Revisit appropriate B/C tests, computational integration

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## WRAP-UP - NEBS

- Effects are large
- Progress made – focus of literature
- Measurement progress
- Developments in hardship – goals of low income
- Movement on uses by different utilities / regulators
- Some gaps / remaining research

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## QUESTIONS? CONTACT INFORMATION

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