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# VALUING ADVANCED LED FEATURES

Using Non-Energy Benefits  
Techniques and Other Methods

26 years in Energy Efficiency  
Evaluations, Non-Energy Benefits, and  
Hard-To-Measure Effects  
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## TOPICS

1. Overview / Background
2. Measurement – Valuing “Hard to Measure” Effects
3. Data Collection
4. Analysis / Results
5. Summary / Conclusion

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# Project Overview & Background

Objectives and Measurement Issues

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## PROJECT OBJECTIVES

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### Dollar Value of Advanced Lighting Features

Develop statistically defensible estimates of the (dollar) value of advanced lighting features to use in developing near-term (2020-25) and longer-term (2030-35) projections from a lighting sales / market share model.

### Outputs Needed

Incremental dollar value for individual (and combined) features by sector.

*Annual stream and first cost dollars*



*PNNL reviewed literature; EE approach showed potential / Hired Skumatz Economic Research Associates, Inc. (SERA) for these inputs for DOE / Guidepost Forecasting Model.*

Project conducted under contract  
To Pacific Northwest National Laboratory

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## BACKGROUND

### Beneficial features examined:

- Glare
- Flicker
- Color rendition
- Adjustability of intensity & temp
- Night sky protection



Photo Pete Strasser, IDA

### Sources of Benefits:

- Occupant satisfaction / comfort
- Productivity
- Fewer tenant calls
- Sleep, daily rhythms
- Animal protection, human safety
- Others

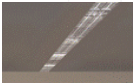
## Measurement Approaches

Technologies & Targets

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## MEASUREMENT ISSUES

### Multiple Sectors / Features



Commercial Linear



Residential Bulbs



Streetlighting

With Multiple advanced features (Glare, etc.)

### Outputs Needed

Price Increments for:

- 1) up-front and
- 2) annual to feed a market model



*Problem - How do you monetize  
"LESS GLARE"?*



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## MEASUREMENT ISSUES

### Quantifying Commercial Glare

Akin to "non-energy benefits" / non-energy impacts (NEB) research in energy efficiency (EE)

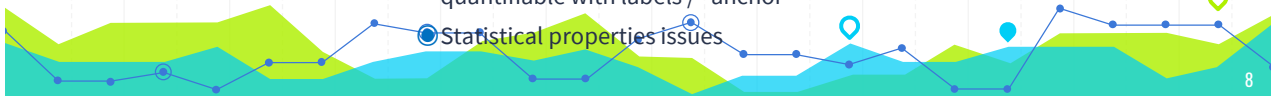
### NEB / Measurement Research Path

- From valuing "comfort" in EE weatherization program...
- WTP? Story of a Ferry...
- "Relative"/scaling is key
- Labeled magnitude scaling (**LMS**)/ non-uniform multiplier (academic); 50+ publications
- Assess relative to something quantifiable with labels / "anchor"
- Statistical properties issues

### LMS plus other Methods for Check, Risk





Used two other methods to "bound" and to approach "future" values

- Ranking with Willingness to pay (WTP)
- Ranking with percentages
- Ranking limited number of responses required



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## SECTORS AND FEATURES OF INTEREST

	Feature	Commercial 4' Linear	Residential Lamps	Street/ Roadway
	Glare	√		
	Flicker	√	√	
	Color Rendition	√	√	√*
	Adjustability (intens. & color)	√	√	

*\*Streetlighting - Color, warmer, no blue, human visibility, wildlife, night sky, 50% higher LER/80% LER/ 10% EE*  
 Near- and longer-term variations in the technologies  
 Price and EE variations compared to [baseline](#)



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## SECTORS AND FEATURES OF INTEREST

### Key Features of Lighting Technologies Studied

(EE is Energy Efficiency)

Technologies consist of multiple elements

	Feature	Near term, vs. baseline	Longer Term, vs. baseline
Commercial	Glare	15% lower EE, no price change	No EE or price changes
	Flicker	10% price increase, no EE change	No change in price or EE
	Color	10% <u>better</u> EE, no price change	20% <u>better</u> EE, no price change
	Adjustable	10% lower EE, no price change	10% <u>better</u> EE, no price change
	Flicker	10% price increase, no EE change	No change in price or EE
PW Resid.	Color	10% <u>better</u> EE, no price change	20% <u>better</u> EE, no price change
	Adjustable	10% lower EE, no price change	10% <u>better</u> EE, no price change
	Color	No change in EE or price	10% <u>better</u> EE, no price change

*Streetlighting - Color, warmer, no blue, human visibility, wildlife, night sky; 50% higher LER/80% LER/ 10% EE*



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## MOST COMMON NEBs METHOD FOR EE – LMS<sup>1</sup>

**ID “Anchor” - Something Universally Understood with Known Value - Program Savings (or price)**

**Ask value of feature (e.g. bulb with no glare) compared to “anchor” (Using special relative comparison terms; then translate to multipliers)**

**Value using Multiplier X value of relevant “anchor”**

- Ask: Positive/negative / zero; details
- For Positive or negative, ask LMS scale
- Ask: Total, Total % value

Multiplier derived from sample responses and / or from academic sources.

BUT, complexity with this project. Not all options have “tradeoffs”.

<sup>1</sup> Skumatz & Gardner, 2002, ACEEE Proceedings; adapted from Green et al., 1993, in Chemical Senses 21.

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## NEBs METHOD 2 - RANKING / ORDERED AND VALUED (WTP, %)

**Backup Method Applied**  
**Rank options provided**

**Provide Incremental Value for “best” and “worst” ranked (that wasn’t traditional bulb)**

**Also Provide Rank & Valuation for combined features**

- Maximize use of sample – Rank provides info, plus at least 2 prices from each respondent
- Dollar and percentage terms

- To ID overlap
- Not expected to be additive

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## PROS AND CONS OF BOTH METHODS

### LMS – Pro

- Quick / Easy to answer
- Consistency
- Larger sample for budget
- Better statistics result
- Academic multipliers (backup)
- Track record in EE and academic underpinnings

### LMS – Con

- Need suitable “anchor”
- Traditionally used with “tradeoffs”
- Complicated wording / long
- Data cleaning
- Long-ish module
- Confidence intervals not direct

### Ranking – Pro

- Ranking can include myriad features (+/-)
- Fairly straightforward
- Much information gathered even with limited sample
- Many applications

### Ranking – Con

- For our application, needed to add step for quantitative info (WTP/%); can be volatile, slow
- Sophisticated options can be difficult to analyze

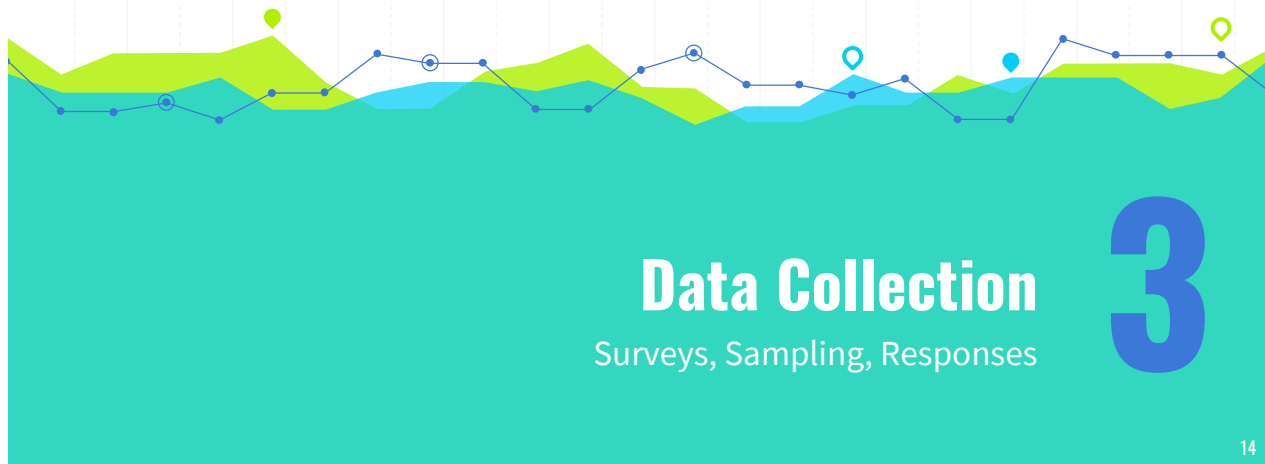


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## Data Collection

Surveys, Sampling, Responses

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## SURVEY INTERVIEWEES & PROCESS

### Commercial – Office Situation

Lighting designers  
(asked owned & leased)

Commercial  
businesses (owned &  
leased)

### Residential

Household  
decision-maker

Builders

### Streetlights

Public works  
and utility

### WEB Surveys: Incentives / Purchased

Incentives – Amazon  
gift cards (delivered  
electronically!)



Multiple rounds; some smaller samples



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## SURVEY RESPONSES

Sector / Respondent Group	Source / Administration Method to Web survey	Number of Responses
Commercial – Lighting Designers	Purchased sample/ emails; emailed link	184 (1.9%)
Commercial – Business Owners	Purchased panel survey responses, statistically representative nationwide	400
Commercial – Business Owner Follow-up sample	Purchased panel survey responses, statistically representative nationwide	104
Residential – Builders	Purchased sample / emails; emailed link	104 (1.3%)
Residential – Households	Purchased panel survey responses, statistically representative nationwide	400
Street/roadway – Public Works and Utilities	Purchased sample / emails; emailed link	79 (1.1%)



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# Analysis & Results

Cleaning, Calculation Steps

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## DATA CLEANING & ASSUMPTIONS

### Extracting from Response

- Estimate average multipliers for each LMS category
- Average dollar WTP
- Average percentage value

### Ranking – Extra Steps

- Omit if best < worst price
- Omit if “best” is baseline and worst not negative or is higher than “best”

### Assumptions Needed

- Baseline price (for relative factor)
- Baseline Savings (for relative factor)
- Lifetime and discount rate (to translate between PV and annual streams)

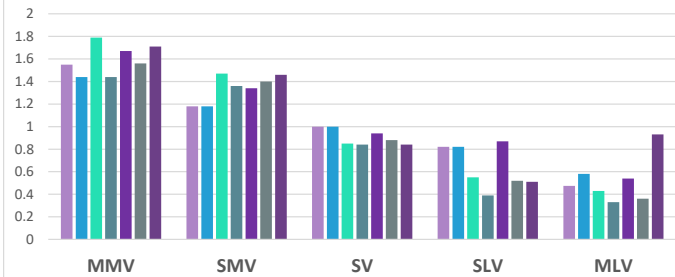
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## Academic vs. In-Sample LMS Multipliers



Project Population Multiplier Values compared to Academic Values



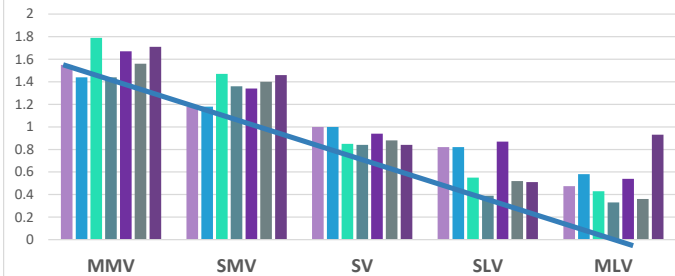
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## Academic vs. In-Sample LMS Multipliers



Project Population Multiplier Values compared to Academic Values



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## CALCULATIONS

### LMS

- Average LMS multipliers x anchor or value factor
- Some one-time (price), some energy savings (annual)

### Ranking - with WTP

- With sufficient sample, each is most / least valuable for some in sample
- Average incremental dollar WTP for each feature

### Ranking - with Percent

- With sufficient sample, each is most / least for some in sample
- Percent x Base Price for each feature

*Weighted average when multiple respondent groups  
Lifetime and discount rate used to translate between PV and annual streams*



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## COMMERCIAL

COMMERCIAL				
	Method 1 - Relative Values: First Cost	Method 1 - Relative Values: Annualized stream	Method 2 - Ranking - Purchase Price Effect	Method 2 - Ranking - Annual Stream
<b>NEAR TERM TECHNOLOGIES</b>				
Glare with 15% lower EE	\$46	\$4.04	\$29	\$2.49
Flicker with 10% price increase	\$20	\$1.72	\$29	\$2.56
Color Rendition 10% INCREASE EE	\$32	\$2.83	\$26	\$2.25
Adjustable / Color with 10% lower EE	\$26	\$2.31	\$20	\$1.74
<b>LONGER TERM TECHNOLOGIES - price premium for feature</b>				
Glare - no change in EE		Method 2 - Ranking - Purchase Price Effect	Method 2 - Ranking - Annual Stream	
Flicker - no change in EE		\$26	\$2.26	
Color Rendition - 20% INCREASE EE		\$28	\$2.47	
Adjustable / Color with 10% INCREASE EE		\$20	\$1.78	
All Features Combined		\$22	\$1.89	
		\$54	\$4.69 (56% of sum)	

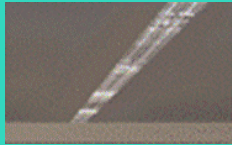
**Assumptions:**  
Savings: \$20/yr  
Price: \$160  
Lifetime: 15 yr  
Discount: 3.6%



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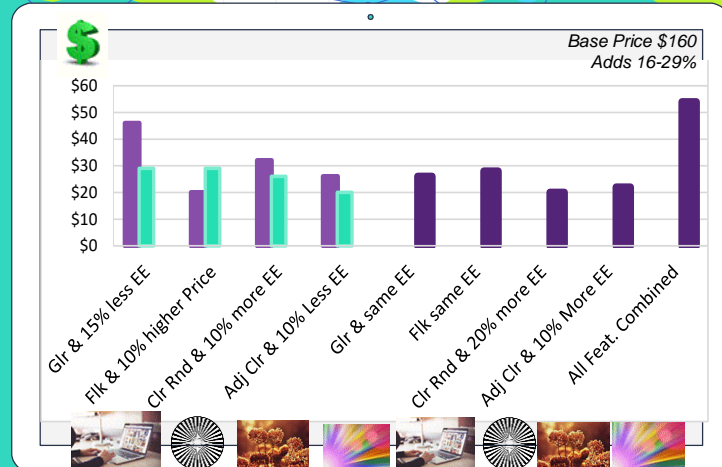
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## Commercial 4-ft Linear Advanced LED

- Label Mag Purchase Price Near Term
- Ranking / Purchase Price Near Term
- Ranking / Purchase Price Long Term



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## RESIDENTIAL

RESIDENTIAL				
	Method 1 - Relative Values: First Cost	Method 1 - Relative Values: Annualized stream	Method 2 - Ranking - Purchase Price Effect	Method 2 - Ranking - Annual Stream
<b>NEAR TERM TECHNOLOGIES</b>				
Flicker with 10% price increase (wtd)	\$1.71	\$0.10	\$3.18	\$0.19
Color Rendition 10% INCREASE EE	\$1.83	\$0.11	\$2.88	\$0.17
Adjustable / Color with 10% lower EE (wtd)	\$1.59	\$0.09	\$3.71	\$0.22
<b>LONGER TERM TECHNOLOGIES</b>				
Flicker - no change in EE	\$2.96	\$0.17		
Color Rendition - 20% INCREASE EE	\$4.37	\$0.26		
Adjustable / Color with 10% INCREASE EE	\$3.42	\$0.20		
All Features Combined	\$4.58	\$0.27 (43% of sum)		

**Assumptions:**  
Savings: \$0.07/yr  
Price: \$13.50  
Lifetime: 33 yr  
Discount: 4.5%

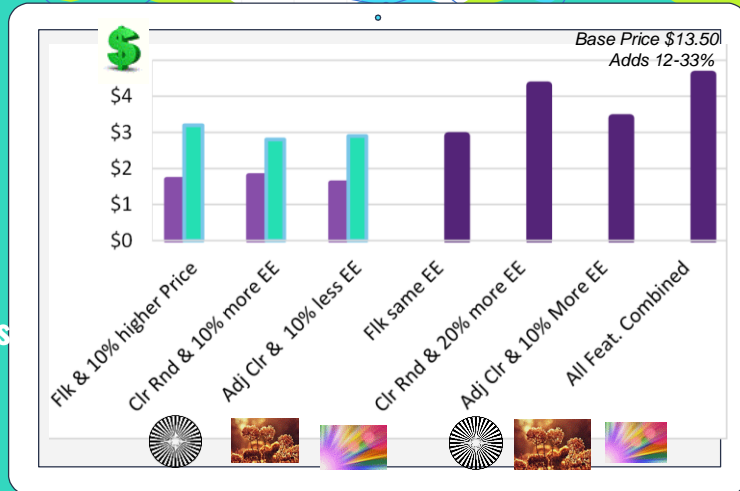
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## Residential – General Service Advanced LED Lamps


- Label Mag Purchase Price Near Term
- Ranking / Purchase Price Near Term
- Ranking / Purchase Price Long Term



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## STREET / ROADWAY LIGHTING TECHNOLOGIES

STREET / ROADWAY LIGHTING TECHNOLOGIES				
	STREET / ROADWAY LIGHTING TECHNOLOGIES	Estimated Price Increment for Advanced Feature - Average of Three Methods	Annual Discounted value for Feature	Estimated Price Difference for Feature - Most Conservative Value
	Color Near Term - Warm, Reduce Night Sky Impacts, No blue, 50% higher LER than baseline	\$62.98	\$6.15	\$39.47
	Color Longer Term - Reflects research on light / wildlife / night sky interactions, improved human visibility, 80% higher LER	\$83.36	\$8.14	\$46.00
	Color - Longer Term - Same as above but energy use for new feature is also 10% less.	\$92.02	\$8.99	\$52.27

**Assumptions:**  
Savings: \$18/yr  
Price: \$324  
Lifetime: 12.8 yr  
Discount: 3.4%

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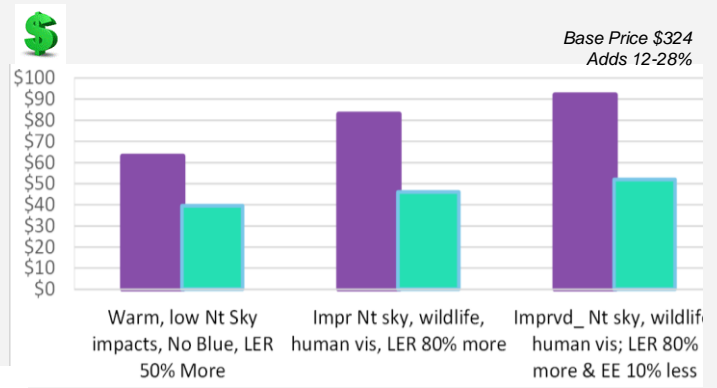
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## Street / Roadway Advanced LED Luminaires COLOR

- Avg. LMS Purchase Price Near Term
- Conservative LMS Purchase Price Long Term



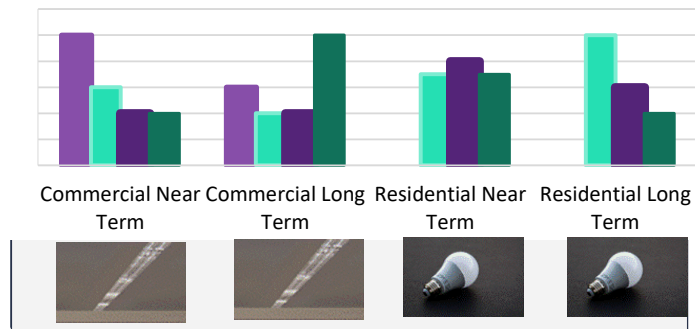
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## Feature Rankings

- Less Glare
- Better Clr Rendition
- Adjustability
- Less Flicker



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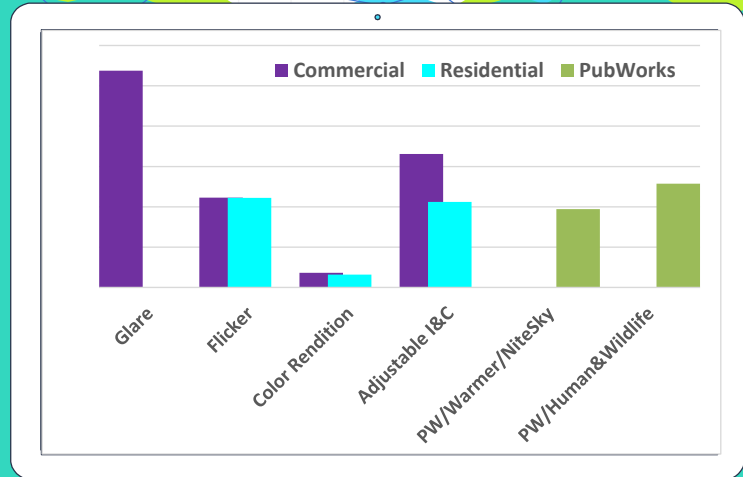
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## Feature Rankings / Relative Premiums

(extracting EE/Price components)

- Less Glare
- Better Clr Rendition
- Adjustability
- Less Flicker



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## Summary & Conclusions

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## SUMMARY

- Useful approach
- Positive value
- Monetary estimates
- Hierarchy of values/features
- Triangulation aided confidence

**Value from multiple features are not additive**

Results forwarded to forecasting model (Navigant/Guidepost/DOE) →  
(Report to be released soon by DOE)

### Lessons learned

- Refine scale and terminology
- Apply to features without tradeoffs
- Split surveys / reduce length / response rate
- Broader applications
  - ROI / BCA, valued features, marketing, R&D directions, pricing...

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# THANKS!

## Questions?

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Valuing Hard-to-Measure (HTM) Effects  
For Decision-Making for 26 years...

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