Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Background Input on Energy Efficiency Cost Effectiveness

Presentation for South Dakota Public Utilities Commission

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Topics

- Cost-effectiveness basics and perspectives
  - Definitions
  - Tests used across the U.S.
  - Primary, secondary tests
- Key drivers of cost-effectiveness results
  - Avoided cost 'deep-dive'
  - Important inputs and methodology issues (screening level, discount rate, etc...)
- Key concerns for South Dakota :
  - What is the right test?
  - Cross-subsidies, impacts on non-participants, Opt-outs
  - Equity

Cost effectiveness basics and perspectives

Why analyze cost effectiveness?

Origins are in integrated-resource planning: efficiency is compared against supply-side options

- Traditional analysis yields a preferred supply plan
- Integrated supply and demand planning ("IRP") can also yield a preferred supply plan
- No 'benefits' calculation is needed in this framework, just complete characterization of all costs required to meet the planning objectives

Once you have a plan – how do you pull together a portfolio with a mix of programs to maximize cost effectiveness ?

Answer: Conduct CE analyses

Plus:

- These tests tend to be required by EE policy rules
- Compared to the macro level IRP:
  - Less complex
  - Relatively transparent
  - Unbundle the efficiency resource for comparison of EE options

Cost-effectiveness Framework

Testing whether an alternative plan is lower cost is the basic building block of CE analysis

Step 1 Evaluate the costs of the EE program

Step 2 Evaluate the change in costs of your preferred supply plan. These are the ("avoided costs") of implementing EE.

Step 3 Compute the difference (or ratio)

More formally, net present value difference of benefits and costs…

Net Benefits (difference)	Net Benefits$_a$ (dollars)	= NPV $\sum$ benefits$_a$ (dollars) -NPV $\sum$ costs $_a$ (dollars)
Benefit-Cost Ratio	Benefit-Cost Ratio$_a$	$= \frac{\text{NPV} \sum \text{benefits}_a \text{ (dollars)}}{\text{NPV} \sum \text{costs}_a \text{ (dollars)}}$

Cost-effectiveness Process

- Step 1: Overall cost-effectiveness. Is EE lower cost overall for everybody?
  - Measured by the Total Resource Cost test (TRC)
- Step 2: If the program is cost-effective, are there winners and losers?
  - Measured by the distribution tests (RIM, PCT, PAC)
  - PCT – Will the customer save money?
  - PAC – Will the utility revenue requirement decrease?
  - RIM – Will utility rates have to increase as a result?

Definition of cost tests

Cost Test		Key Question	Summary Approach
Participant Cost Test	PCT	Will the participants benefit over the measure life?	Compare costs and benefits of consumer installing the measure; important for incentive design
Utility/ Program Administrator Cost Test	UCT/ PAC	Will utility bills decrease?	Comparison of program administrator costs to supply side resource costs; values EE on a similar basis as IRP
Ratepayer Impact Measure	RIM	Will utility rates decrease?	Comparison of administrator costs and utility bill reductions to supply side resource costs; Only looks at impacts to non-participants
Total Resource Cost	TRC	Will the total costs of energy in the utility service territory decrease?	Comparison of program administrator and customer costs to utility resource savings
Societal Cost Test	SCT	Is the utility, state, or nation better off as a whole?	Comparison of society's costs of energy efficiency to resource savings and non-cash costs and benefits

Summary of costs and benefits components

- Each state adjusts these definitions depending on circumstances
- Details can significantly affect the type of energy efficiency implemented

Component	PCT	PAC	RIM	TRC	SCT
Energy and capacity related avoided costs	-	Benefit	Benefit	Benefit	Benefit
Other energy resource savings	-	-	-	Benefit	Benefit
Societal non-energy benefits (non-ratepayer benefit)	-	-	-	-	Benefit
Incremental equipment & install costs paid for by customer	Cost	-	-	Cost	Cost
Program administration overhead costs	-	Cost	Cost	Cost	Cost
Incentive payments paid by utility/program admin.	Benefit	Cost	Cost	-	-
Bill Savings	Benefit	-	Cost	-	-

Example cost test results

- Benefit / cost ratio results from three programs
- Energy efficiency is widely cost-effective

Test	So. Cal. Edison Residential Program	AVISTA Regular Income	Puget Sound Energy Com/Ind Retrofit
TRC	**4.21**	**2.26**	**1.90**
PCT	7.14	3.47	1.72
PAC	9.91	4.18	4.19
RIM	0.63	0.85	1.15

Source: National Action Plan for Energy Efficiency, cost effectiveness guide

Cost tests used by different states

Primary Cost Test Used by Different States					
PCT	UCT/PAC	RIM	TRC	SCT	Unspecified or no primary test
	CT, TX, UT, DE, MI	FL	AR, CA, CO, VA, HI, IL, IN, KS, KY, MD, MA, MO, MT, NE, NV, NH, NY, NC, NM, OH, OK, OR, PA, SD, TN, RI, VA, WA, WI, WY	DC, IA, ME, MN, VT	GA, ID, ND, NJ, SC
--	5 (12%)	1 (2%)	29 (71%)	6 (15%)	--

Source: Modified and updated by LBNL: ACEEE (2012), "A National Survey of State Policies and Practices for the Evaluation of Ratepayer Funded Energy Efficiency Programs," Report # U122.

Primary and Secondary Tests

- TRC test is the primary test used by most commissions
- RIM, PCT, UCT/PAC typically secondary tests
  - If the TRC is positive, what can we say about the distribution of costs and benefits?
  - PCT (cost-effectiveness for participants)
  - UCT / PAC (cost-effectiveness from a utility perspective)
  - RIM (economics for non-participants)
- Some states use SCT in place of/ in addition to TRC
  - Value water savings, air quality benefits, carbon reductions etc.

Comments on Cost Tests Used

- Current debates on which tests to use: TRC versus PACT versus SCT

- TRC vs. PAC test: some support the PAC test which is less stringent
  - TRC (and SCT) and PACT results are more similar as customer incentive levels increase
  - TRC includes all costs by excludes non-energy benefits, for example, windows would only based on energy savings, not comfort
  - PAC test is easier to calculate and more accurate
  - PAC test reflects the utility cost perspective used in traditional utility planning, minimize lifecycle revenue requirement
- SCT vs. TRC: some advocate for valuing the externalities, especially environmental and water savings benefits
  - SCT versus TRC – what non-energy benefits to use, how to define 'society', and what discount rate is appropriate

TRC is more conservative for EE than PACT & SCT

Key Drivers and Inputs

Key Drivers of Cost-effectiveness Results

- Benefits
  - Avoided costs (ratepayer & utility benefits)
    - Energy and capacity value, time-specific estimates
  - Bill savings (participant benefits)
- Costs
  - Equipment incremental equipment and installation costs (impacts TRC, participant)
  - Incentives (cost to ratepayers & utility)
  - Program administrative costs (cost in all tests but for participant test)
- Methodology issues
  - Test application level: portfolio, program, or measure level
  - Time frame of analysis
  - Effective useful life of measures/programs
  - Discount rates
  - Use of gross versus net savings
  - Net to gross ratio

Incremental Measure Costs

- Main driver of costs for TRC test
- Incremental cost = difference in cost between "baseline" (standard) and energy efficient measure
  - Difference in capital, O&M and, when appropriate, labor costs
- Two kinds of measures:
  - Replace on burnout: standard practice, replace equipment when existing equipment fails
    - Here, the baseline is a new inefficient equipment
  - Early replacement: replace equipment before the end of the useful life of existing equipment
    - Here, use the *full* cost of the energy efficient measure
    - "double baseline": remaining useful lifetime of early replacement equip. matters for calculating EE savings

Avoided costs

Avoided costs are the benefits for the TRC, RIM and PACT tests and are the most complex of the drivers

Electric Avoided Cost Components

- Benefits of EE are based on estimates of "avoided costs"
- Each state selects their own elements of what goes into calculating avoided costs and methods for quantification

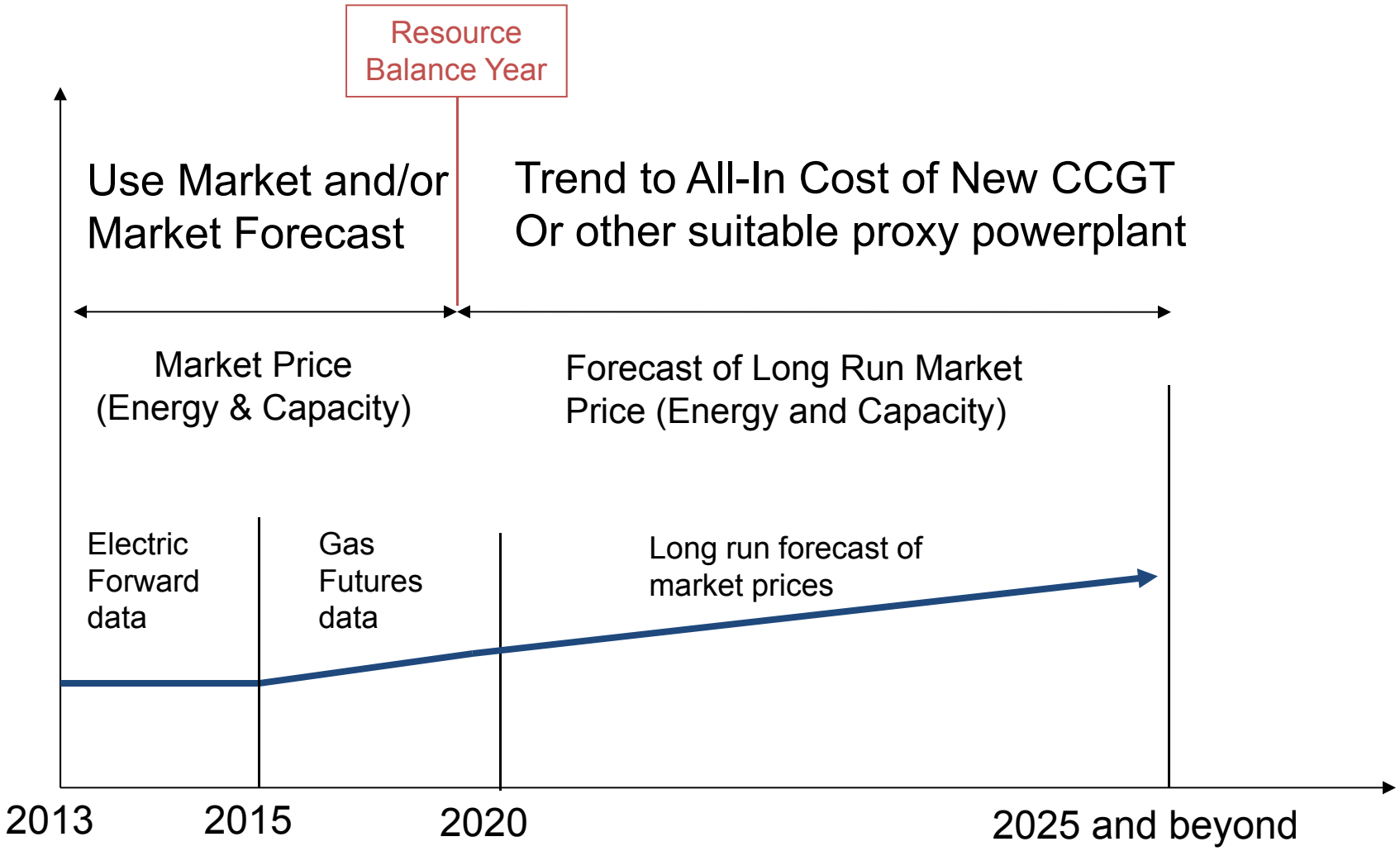
Electricity Energy Efficiency	
Energy Savings	**Capacity Savings**
Market purchases *or* fuel and O&M costs	**Capacity purchases *or* generator construction**
System Losses	**System losses (Peak load)**
Ancillary services related to energy	**Transmission facilities**
Energy market price reductions	**Distribution facilities**
Natural gas, fuel oil savings (if applicable)	**Ancillary services related to capacity**
Compliance costs with emission regs.	**Capacity market price reductions**

Methodology of Avoided Costs

- Methodology depends on market structure
- Lots of variation across states

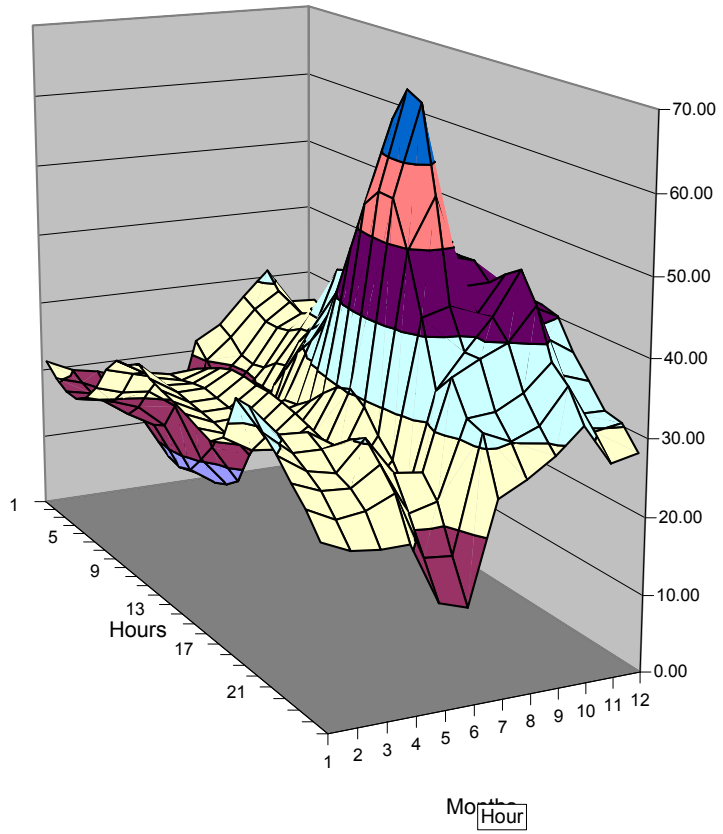
Approaches to Value Energy and Capacity		
	Near Term (Market data is available)	Long Term (No market data available)
Distribution electric or natural gas utility	**Current forward market prices of energy and capacity**	**Long-term forecast of market prices of energy and capacity**
Electric vertically-integrated utility	**Current forward market prices of energy and capacity** ***or*** **Expected production cost of electricity and value of deferring generation projects**	**Long-term forecast of market prices of energy and capacity** ***or*** **Expected production cost of electricity and value of deferring generation projects**

Generation Marginal Cost Forecast

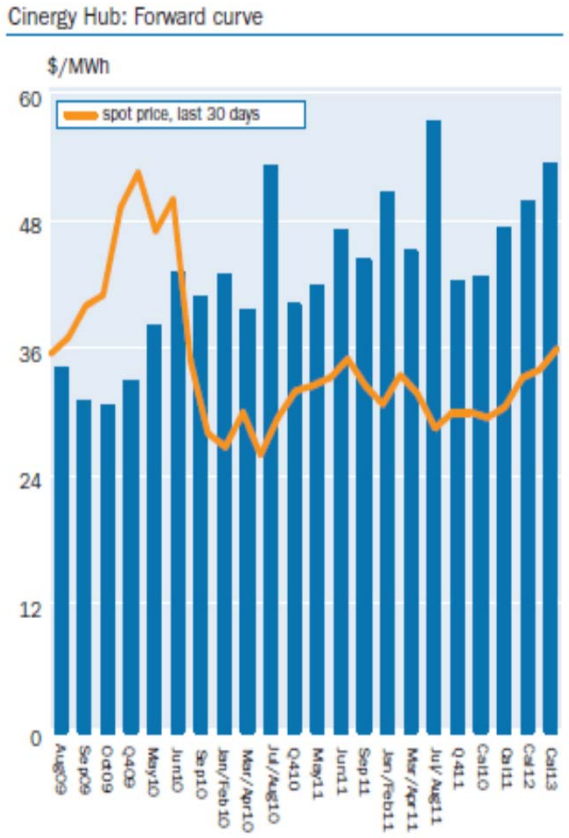


Market Data Available

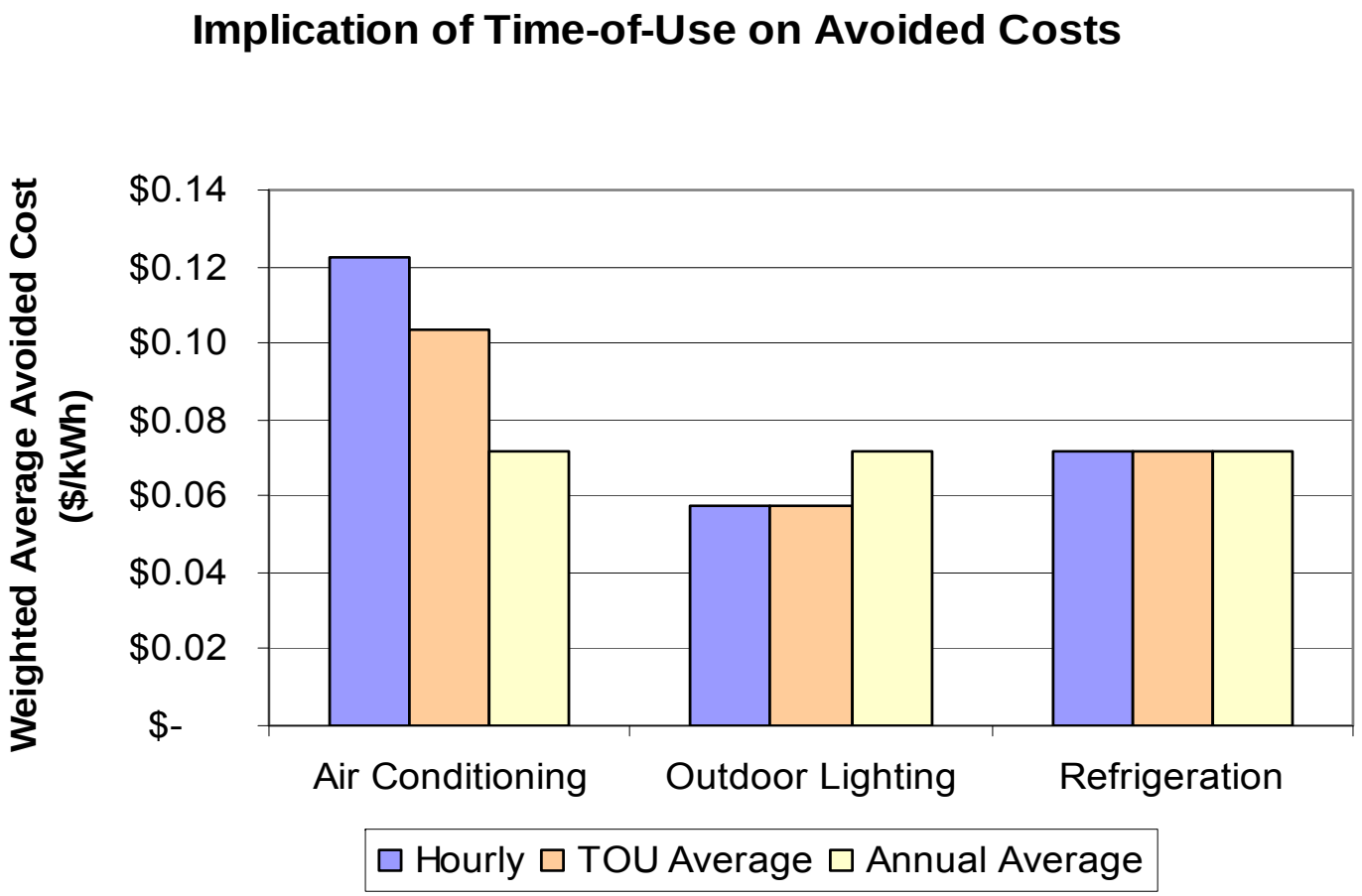
Hourly Day-ahead Market Prices (Palo Verde)



Long-term Forward Curve



Time-specific Avoided Costs



Example from California Avoided Cost Analysis

Common Practice on Avoided Costs

In summary, a typical approach to avoided cost calculations is:

- Forecasting value of energy linked to fuel prices
- Calculation of capacity value
  - Recommend real economic carrying charge method
- Discounting after the first year
- Value avoided energy & capacity by time of use (or hourly) with load shapes of efficiency savings
- Include losses for energy and capacity
- Include transmission and distribution capacity
- Include value of avoided RPS costs

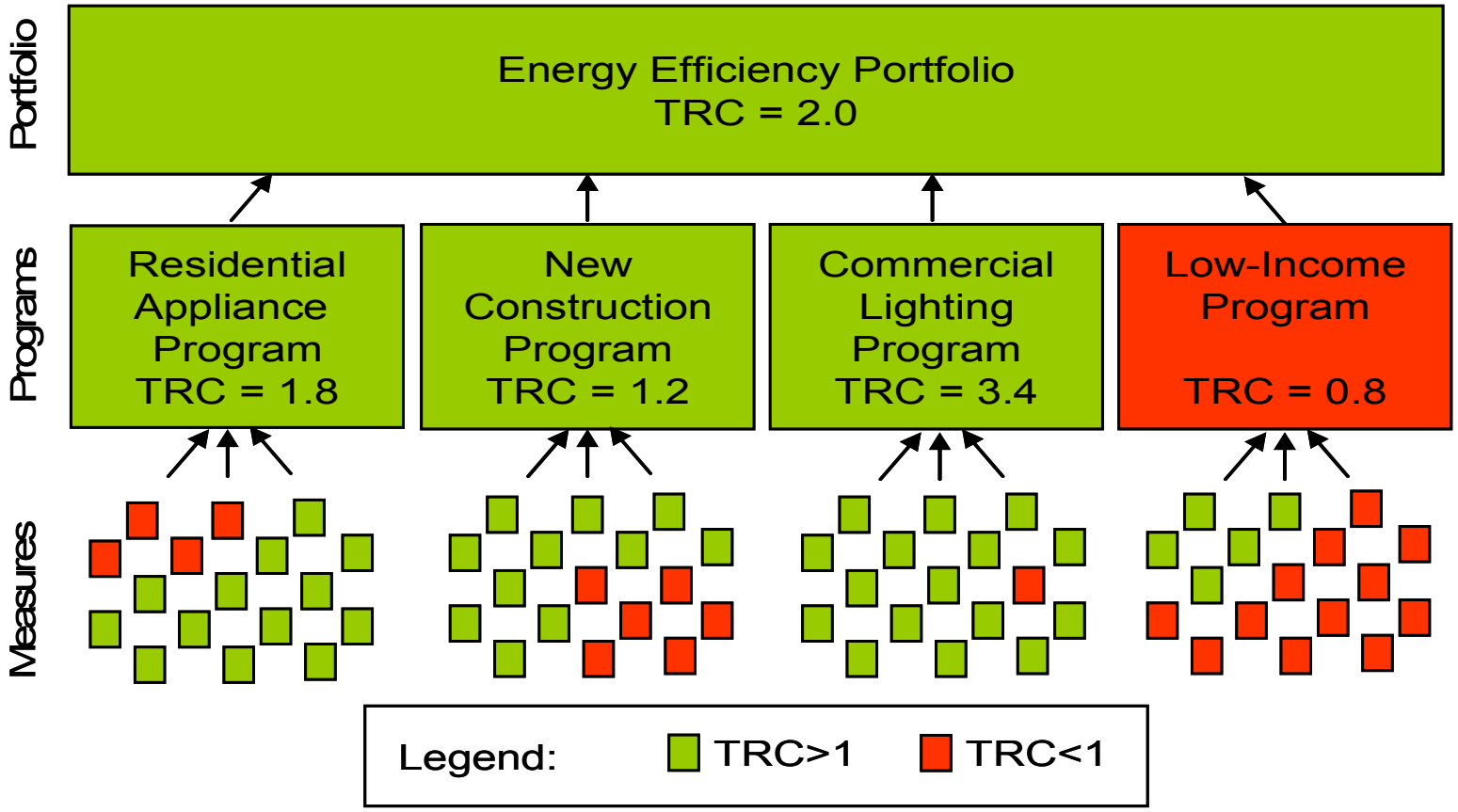
EE Avoided costs v. PURPA avoided costs

EE Avoided costs and PURPA avoided costs are similar in concept, but used for different purposes, derived using different methodologies, and regulated by different entities (FERC vs. State Commission)

	EE avoided costs	**PURPA avoided costs**
Short run vs. long run avoided costs	Can be based on a mix of short-run & long-run marginal cost (concept of 'resource balance year' is utilized in some jurisdictions to transition from SRMC to LRMC)	PURPA avoided costs are set at long run marginal cost
Jurisdiction	EE avoided costs are under PUC jurisdiction	Avoided costs for PURPA are set under a regulatory process that includes FERC
Purpose	EE avoided costs are used for screening in program design and are not used for payments to customers	PURPA avoided costs are used in settlement with QFs and determine payment; hence, they are litigated much more

Methodology issues

Where to Screen for Cost Effectiveness



- Screening EE C/E at **portfolio level** allows for inclusion of individual programs or measures that do not pass cost-effectiveness test, such as low income, emerging technologies, market transformation

Where to Screen, cont.

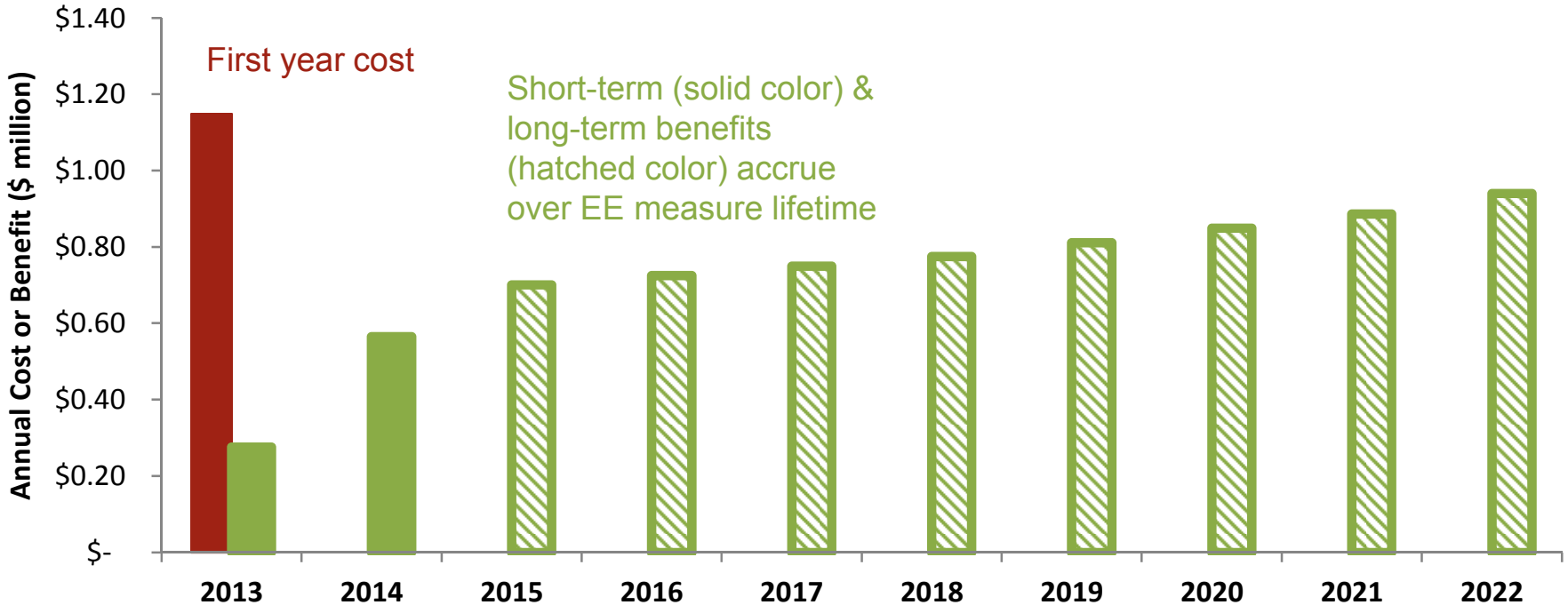
- Program/Portfolio vs. Measure-Level Screening
  - Practical implementation issues
    - Clear guidance to administrators, contractors
    - Consistent offerings to similar customers with similar projects
    - Example: “cost-effective” attic insulation varies in three homes (Baseline is R-5, R-10, R-15). Installation contractor can carry R-30 on truck and address all three homes in a day.
  - Economies of scale
  - Minimizing lost opportunities
    - Getting consumers’ attention costs $$$ - why pay again to return for complementary measures, e.g., air sealing

Assignment of Program Admin. Costs

- Program administration costs are typically assigned at portfolio level, because:
  - Difficult to parse costs at measure or program level because costs are often shared
  - Eliminating a measure or program does not necessarily reduce admin costs if these are fixed costs or shared across multiple programs. Assigning these costs at the measure or program level can lead to misleading results.

Time Frame of Analysis

- Analysis time frame accounts for full lifetime of energy efficiency measures



Timeframe of Analysis – Measure Life

- Effective useful life (EUL): an estimate of the duration of savings from a measure. *Savings can live as long as the behavior that enables the efficiency is continued.*
- EUL is an important input to CE analyses
- It is estimated through various means:
  - Historical and documented persistence
  - Laboratory and field testing
  - Field inspections, over multiple visits
  - Non-site methods such as telephone surveys and interviewS
- It is also sometimes defined as the date at which 50% of installed units are still in place and operational
- The EUL (i.e. How long to "count savings") can be affected by baseline assumptions, particularly for early replacement programs

Discount rates are a key input

The discount rate used should be appropriate to the perspective in each cost test

Tests and Perspective	Discount Rate Used	Illustrative Value	Present Value of $1/yr for 20 years	Today's value of the $1 received in Year 20
Participant Cost Test (PCT))	Participant's discount rate	9%	$9.13	$0.18
Ratepayer Impact Measure (RIM)	Utility WACC	7.5%	$10.19	$0.24
Utility Cost Test (UCT/PAC)	Utility WACC	7.5%	$10.19	$0.24
Total Resources Cost Test (TRC)	Utility WACC	7.5%	$10.19	$0.24
Societal Cost Test	Social discount rate	3%	$14.88	$0.55

Net and Gross Savings

- Estimates of gross (energy and/or demand) savings
  - Changes in energy consumption and/or demand that result directly from program-related actions taken by participants in an efficiency program, *regardless of reasons why the customers participated*
- Estimates of net (energy and/or demand) savings
  - Only those changes in energy consumption or demand that are attributable to an energy efficiency program (exclude 'free-riders', participant & non-participant spillover effects & market effects)
- Net savings are hard to accurately determine
- Net to gross ratio de-rates EE program impacts and can significantly affect the results of all cost tests (except for the PCT, where gross savings are used)
- Best practices seems to be leading towards using assessments of net savings for program design and gross savings for ex-post assessments of performance (i.e., savings)

Illustrative example

Deploy illustrative EE program

- Purpose of example
  - Illustrate relationships among cost tests
  - Illustrate the impact on rates and distributional impacts
- Key assumptions
  - Approximately based on South Dakota EE programs, rates and avoided costs
  - Statewide, not utility specific

Example South Dakota EE

Rates and Revenue Without Energy Efficiency					
		Utility Sales		11,680	GWh
Rates Before EE		$/kWh		RR ($M)	
Fixed costs	$	0.0250		$ 292	
Marginal costs	$	0.0400		$ 467	
Total	$	0.0650		$ 759	
Efficiency Program					
		Utility Budget ($M)		$4.00	
		EE Quantity		55	GWh
	Levelized Cost ($/kWh)			Amortized Cost ($M)	
Utility Cost	$	0.016		$ 0.87	
Participant Cost	$	0.019		$ 1.04	
Total EE Cost (TRC)	$	0.035		$ 1.91	

Adjustment of rates to hit earnings

Sales decreased

Same rates as before

Rates increase slightly

Total bills are less than without EE

Utility hits target ROE

Case with Energy Efficiency - Before Rate Adjustments				
	Utility Sales		11,625	GWh
Rates After EE			Revenue ($M)	
Fixed costs	$ 0.0250		$ 291	
Marginal costs	$ 0.0400		$ 465	
Total	$ 0.0650		$ 756	
Case with Energy Efficiency - After Rate Adjustments				
	Utility Sales		11,625	GWh
Rates After EE			RR ($M)	
Fixed costs	$ 0.0251		$ 292	
Marginal costs	$ 0.0400		$ 465	
Utility EE Costs	$ 0.0001		$ 0.87	
Total	$ 0.0652		$ 758	
Impact of Revenue Undercollection Before Rate Adjustment				
	Target Earnings		$ 17	$M
	Revenue Undercollection		$ 2	$M
	Earnings		$ 15	$M
	ROE Before Rate Adjustment		9.55%	
	ROE After Rate Adjustment		11.00%	

Calculation and Cost Test Results

Rates and Revenue Without Energy Efficiency			
	Utility Sales	11,680	GWh
Rates Before EE	$/kWh	RR ($M)	
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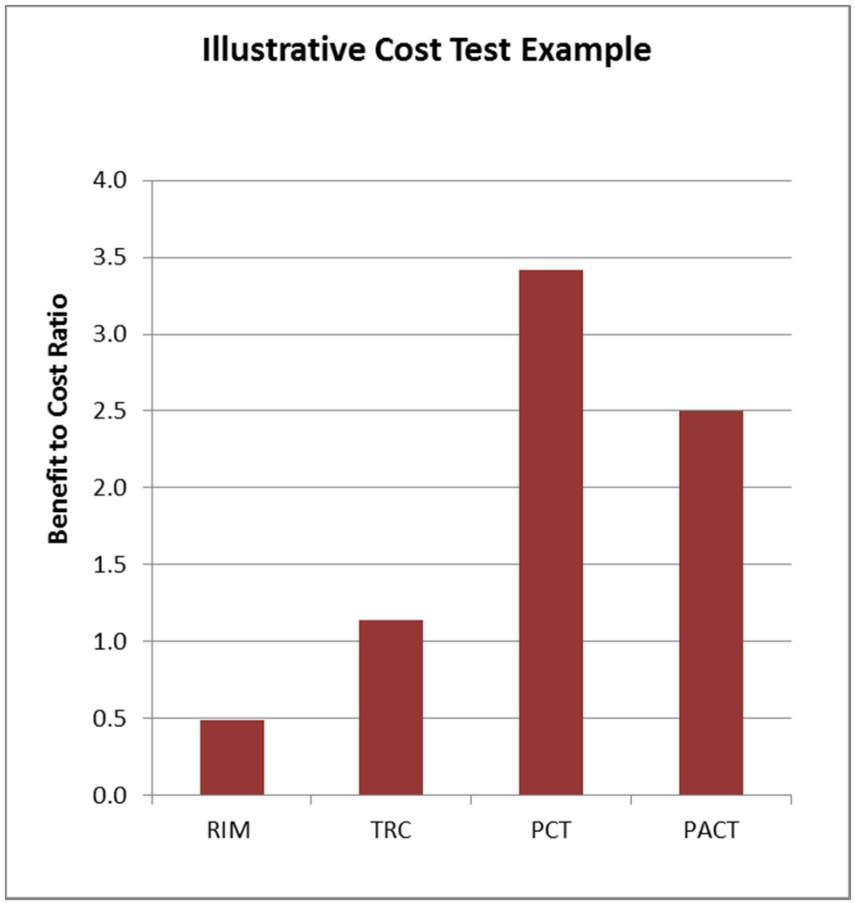
Cost-effectiveness Results using SPM				*Description of Costs and Benefits*
		$M	B/C Ratio	
RIM	Costs	$ 4.43		*Utility EE Program + Bill Savings*
	Benefits	$ 2.19		*Avoided Energy Costs*
	Net Benefits	$ (2.24)	0.5	
		$M	B/C Ratio	
TRC	Costs	$ 1.91		*Total EE Costs*
	Benefits	$ 2.19		*Avoided Energy Costs*
	Net Benefits	$ 0.27	1.1	
		$M	B/C Ratio	
PCT	Costs	$ 1.04		*Participant out of pocket costs*
	Benefits	$ 3.55		*Bill Savings*
	Net Benefits	$ 2.52	3.4	
		$M	B/C Ratio	
PAC	Costs	$ 0.87		*Utility program costs*
	Benefits	$ 2.19		*Avoided Energy Costs*
	Net Benefits	$ 1.31	2.5	

Results of Illustrative Example



- EE Program size
  - $4 million
  - Total bill savings of $1.3 million per year for 6 years after collecting back program costs
- Rate adjusment
  - EE scenario: +$0.0002/kWh, 0.3% rate increase over total rate
  - Translates to **~ +Δ $1.60/yr** for a home consuming ~8000 kWh/year

Discussion issues

Which Cost Test to Use?

- Conventional process uses TRC as the primary test for overall portfolio cost-effectiveness; secondary tests support program design (e.g., incentive levels).
- This three-step process can help bring additional structure to how the RIM and other secondary tests can be used effectively

Proposed three-step process for screening

1. eliminate all programs that don't pass the TRC test
2. implement all programs that pass the RIM test,
3. carefully evaluate the distributional impacts of the remaining programs.

Source: http://www.fortnightly.com/fortnightly/2013/07/valuing-energy-efficiency?page=0%2C10&authkey=aa2986b87d0fbbce625f243752a462709bf972274a13deb4b7cc4cdcefdd6a5a#sthash.6GKSXJEU.dpuf

Key Concerns: Non-participant Impacts

- Impacts on non-participants are a concern, should we use the RIM test and only approve EE that passes?

- This approach essentially eliminates conventional EE programs
- This approach only focuses on costs to non-participants regardless of how large the benefits are to other customers or the state overall
- Pay attention to the magnitude of cost-shifting
- There are other ways to mitigate non-participant impacts through program design
  - Increase access to programs
  - Increase equity by providing programs for all customers
  - Don’t pay larger incentives than necessary
  - Get the most value from efficiency by coordinating with supply planning

Cross-subsidies & opt-out programs

- Inequity is minimized with program designs that maximize participation across broad customer types
  - Some level of cross-subsidy is unavoidable, but all customers should be able to be a participant
- Opt-out programs can undermine industrial efficiency
  - Most industrial customers support opt-out because they have implemented all 'cost effective' efficiency and don't want the public purpose charge to fund programs
  - However, the 'cost effective' definition is typically a 1 to 2 year payback, they cannot justify longer payback measures on their own
  - With industrial programs you can move 4 to 5 year payback projects to 2 year payback and make them happen

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Thank You

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