The Basics of Cost-Effectiveness Analysis

Joy Morgenstern
Senior Regulatory Analyst

Joy.Morgenstern@cpuc.ca.gov

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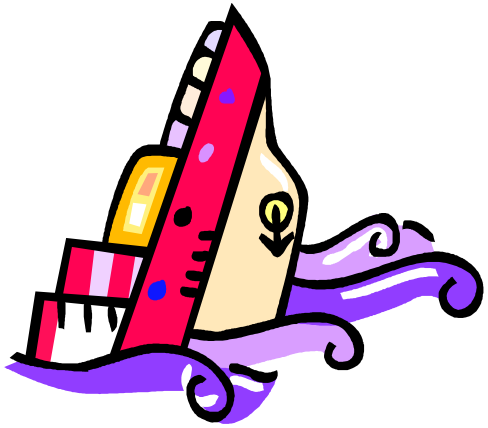
Cost-effectiveness analysis of Demand Side Programs



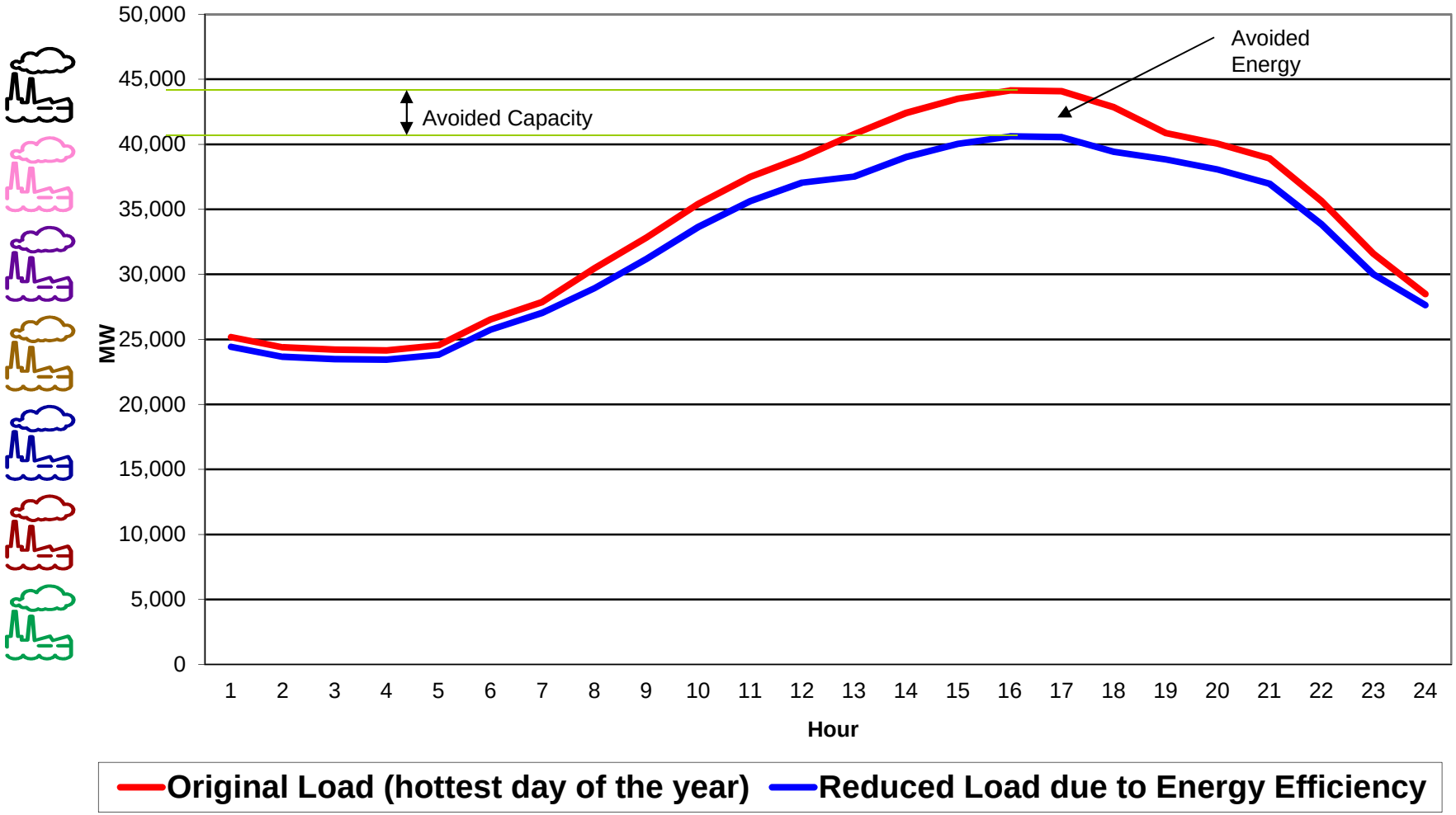
What are demand-side programs?

Anything on the customer side of the meter

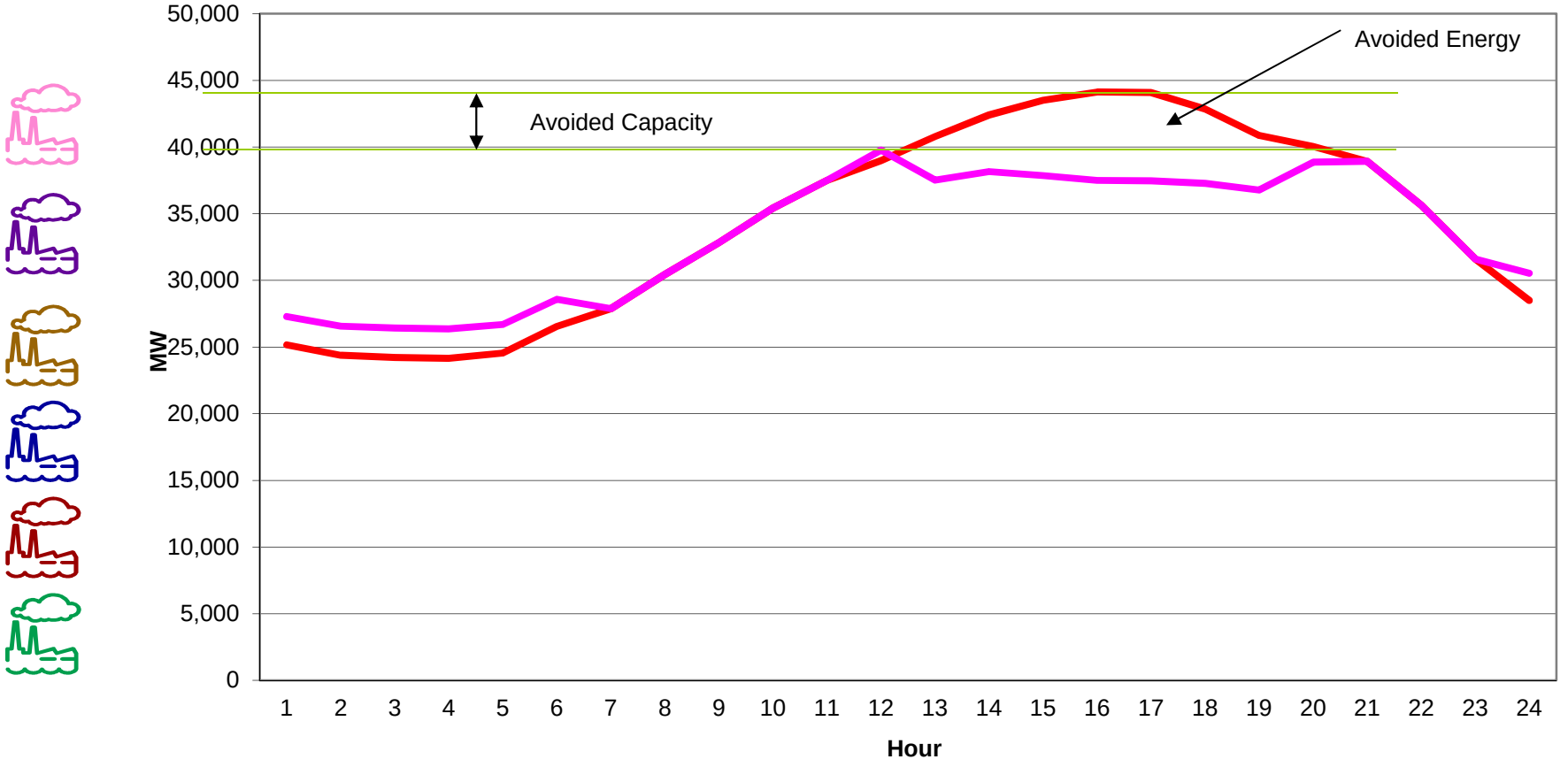
Which demand-side programs?

- Energy Efficiency
- Low Income Energy Efficiency
  (Energy Savings Assistance Program, or ESAP)
- Demand Response
- Distributed Generation

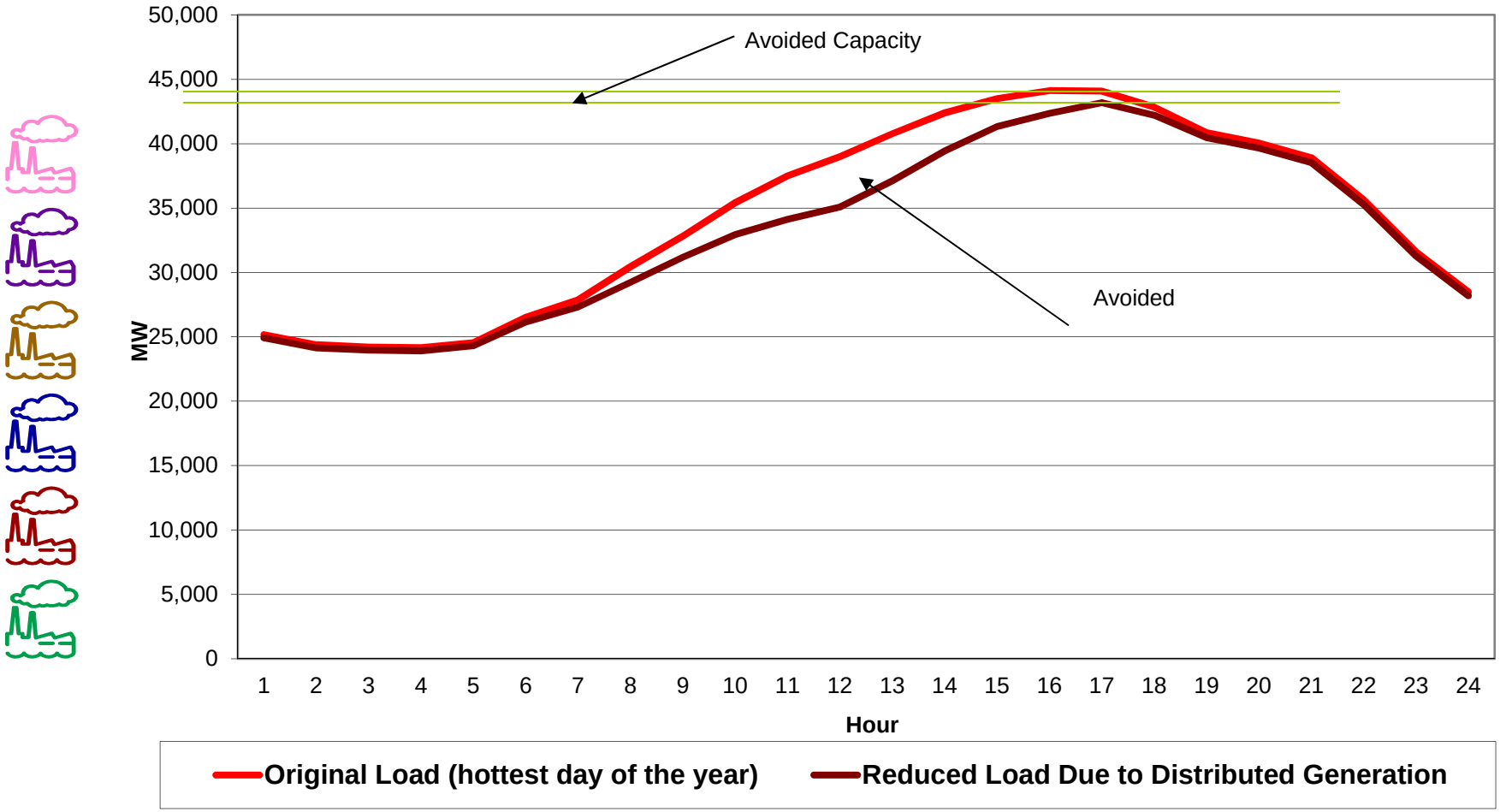
Energy Efficiency Impact on Load



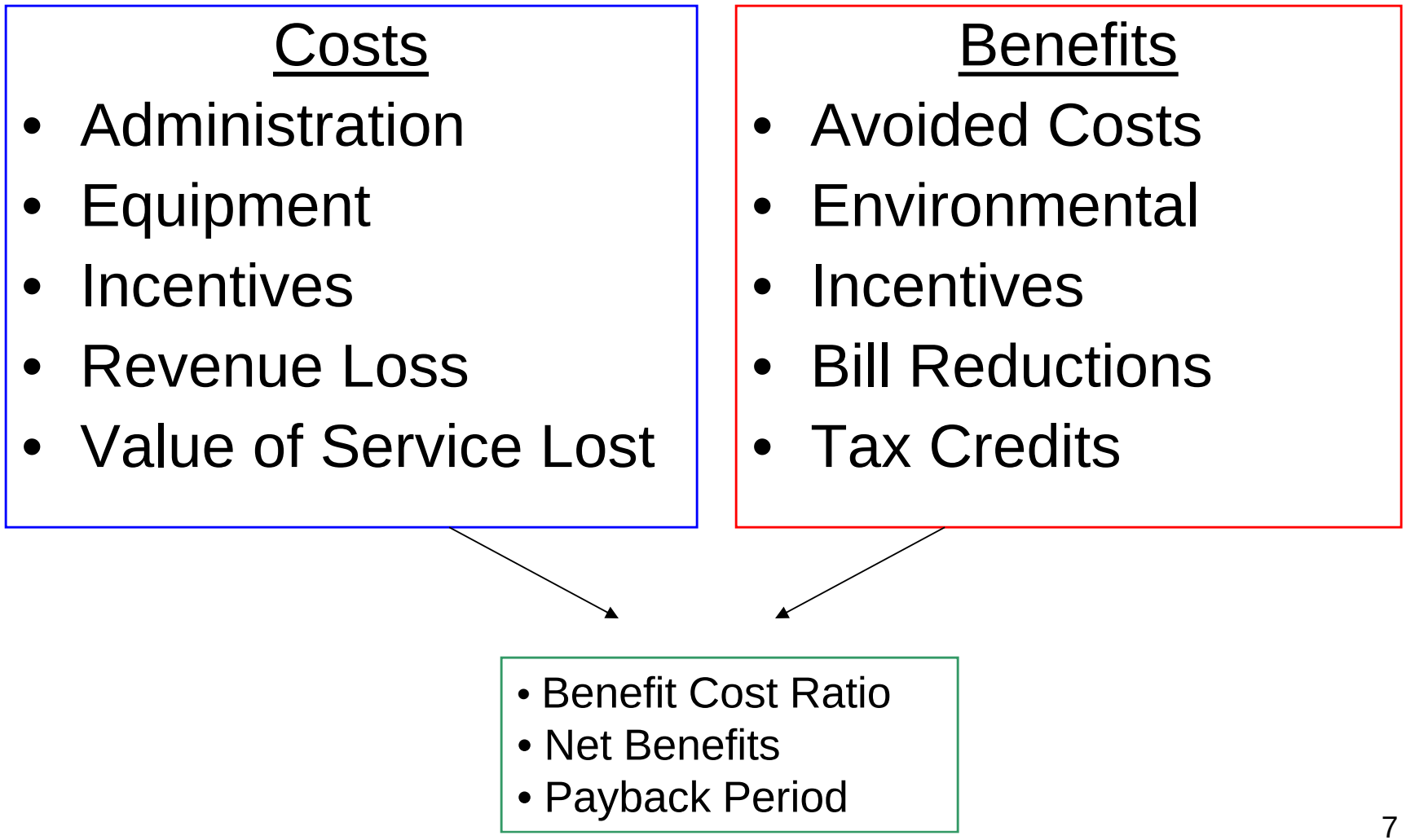
Demand Response Impact on Load



Distributed Generation Impact on Load



Cost Benefit Analysis



Cost-Effectiveness Analysis

	Benefit Cost Ratio	Net Benefits	Payback Period
Program A	3.28	$.123 M	11 years
Program B	1.05	$35.5 M	1 year
Program C	0.82	($9.036 M)	--
Program D	0.33	($15,678)	2 months

Example of Discounted Cash Flow

	Year										TOTAL
	1	2	3	4	5	6	7	8	9	10	
Benefits											
bill savings	$100	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,000
rebate	$75	$0	$0	$0	$0	$0	$0	$0	$0	$0	$75
TOTAL	$175	$100	$100	$100	$100	$100	$100	$100	$100	$100	$1,075
Costs											
purchase price	$500	$0	$0	$0	$0	$0	$0	$0	$0	$0	$500
installation	$150	$0	$0	$0	$0	$0	$0	$0	$0	$0	$150
maintenance	$0	$0	$50	$0	$50	$0	$50	$0	$50	$0	$200
TOTAL	$650	$0	$50	$0	$50	$0	$50	$0	$50	$0	$850
annual benefits	($475)	$100	$50	$100	$50	$100	$50	$100	$50	$100	$225
cumulative benefits	($475)	($375)	($325)	($225)	($175)	($75)	($25)	$75	$125	$225	
Benefit Cost ratio	1.13 at a discount rate of 4%				1.16 at a discount rate of 3%				1.1 at a discount rate of 5%		
Net Present Value	$99.53 at a discount rate of 4%				$126.90 at a discount rate of 3%				$74.42 at a discount rate of 5%		
Payback approximately 7 years											

How do discount rates and lifetimes affect cost-effectiveness?

Benefits:	$100 per year energy savings + $75 rebate				
Costs:	$650 initial investment + $50 maintenance every 2 years				
10 year EUL	3%	5%	7%	9%	
NPV benefits	$925.84	$843.60	$772.45	$710.57	
NPV costs	$798.93	$769.18	$742.28	$717.81	
Net Present Value	$126.90	$74.42	$30.18	($7.24)	
Benefit/Cost	1.16	1.10	1.04	0.99	
15 year EUL	3%	5%	7%	9%	
NPV benefits	$1,266.61	$1,109.39	$980.88	$874.88	
NPV costs	$865.07	$819.75	$781.15	$747.84	
Net Present Value	$401.54	$289.65	$199.74	$127.03	
Benefit/Cost	1.46	1.35	1.26	1.17	
20 year EUL	3%	5%	7%	9%	
NPV benefits	$1,560.56	$1,317.65	$1,129.49	$981.66	
NPV costs	$923.84	$861.35	$810.80	$769.12	
Net Present Value	$636.73	$456.30	$318.70	$212.54	
Benefit/Cost	1.69	1.53	1.39	1.28	

Discount Rates

Before-tax WACC, after-tax WACC, consumer, or social discount rate?

Weighted Average Cost of Capital (WACC): each utility's cost of borrowing money

	Pre-Tax WACC	After Tax WACC
SCE	8.74%	7.65%
PG&E	8.80%	7.66%
SDG&E	8.40%	7.36%
SoCalGas	8.68%	7.38%

Consumer Discount Rate: cost to consumers of borrowing money

Social Discount Rate: the cost to society, taking into account future generations

Program Lifetime

- For EE and DG, the expected useful lifetime (EUL) of the equipment is used.
- For DR, the three year program cycle is used, with capital costs amortized over their lifetime.
- EE and DR cost-effectiveness is *ex ante*.
- For DG, *ex post* evaluations usually focus on a few years of program history

The *Standard Practice Manual* (SPM)

- Developed to measure the cost-effectiveness of Energy Efficiency programs
- Use four tests to measure cost-effectiveness from four perspectives:
  - *"Society"*: The Total Resource Cost (TRC) test

    TRC actually measures Utility + Participant
  - *Program Admin.*: The Program Administrator (PAC) test
  - *Ratepayers*: The Ratepayer Impact Measure (RIM) test
  - *Participant*: The Participant Cost Test (PCT)
- The SPM also describes the "Societal Cost Test," a variant of the TRC that includes externalities and uses a social discount rate. This has been proposed by ED staff but not adopted by the CPUC.

Problems with the SPM tests

- Many cost and benefit inputs have contentious or difficult aspects.
- Participant costs and benefits can be hard to define and quantify/monetize.
- Avoided costs complicated, difficult to define and measure precisely, inputs always contentious.
- Externalities such as environmental impacts usually excluded, hard to quantify when included, not clear where to include them.
- Not always clear how to use each test for decision-making
- Most inputs involve measuring things that didn't happen.

Cost and Benefits Used

	TRC	PAC	RIM	Participant	DG SCT	SCT	ESACET	ESA TRC
Administrative costs	COST	COST	COST		COST	COST	COST	
Avoided costs of electricity	BENEFIT	BENEFIT	BENEFIT		BENEFIT	BENEFIT	BENEFIT	BENEFIT
Bill Increases				COST			COST	
Bill Reductions				BENEFIT			BENEFIT	
CAISO Market Participation Revenue	BENEFIT	BENEFIT	BENEFIT			BENEFIT		
Capital costs to utility	COST	COST	COST		COST	COST	COST	COST
Incentives paid		COST	COST	BENEFIT				
Increased supply costs	COST	COST	COST			COST		
Market benefits	BENEFIT	BENEFIT	BENEFIT			BENEFIT		
Non-energy social benefits	BENEFIT				BENEFIT	BENEFIT		
Non-energy utility benefits	BENEFIT	BENEFIT	BENEFIT				BENEFIT	
Non-energy participant benefits	BENEFIT	BENEFIT	BENEFIT				BENEFIT	
Participant Equipment and Installation (Measure) Costs	COST			COST	COST	COST		
Participant Transaction Costs	COST					COST		
Participant Value of Service Loss	COST					COST		
Revenue gain from increased sales			BENEFIT					
Revenue loss from reduced sales			COST					
Tax Credits	BENEFIT			BENEFIT		BENEFIT		
Capital costs to landlords/3rd parties (copayments)							COST	
Reliability Benefits	BENEFIT	BENEFIT	BENEFIT		BENEFIT			
Reliability Costs	COST	COST	COST		COST			
Non-bypassable charges (departing load charges)			COST	COST				

Blue text indicates cost or benefit which is used only for DR and/or DG, not EE

Significant Costs and Benefits

COSTS

- Administration

(e.g., program design, development, operations, maintenance, overhead, customer service, marketing & outreach, sales, IT infrastructure, customer education, program evaluation, measurement & verification)

- Measure (Capital) Costs

(equipment costs incurred by the utility and participants)

- Incentives
- Revenue Loss
- Participant Costs
- Increased Supply Costs

BENEFITS

- Avoided Costs

(complex)

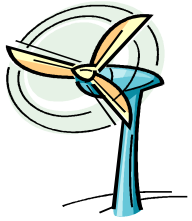
- Tax Credits

(currently available for DG only)

- Market/Reliability Benefits
- Non-energy benefits
- Incentives
- Bill reductions

Avoided Cost Calculator

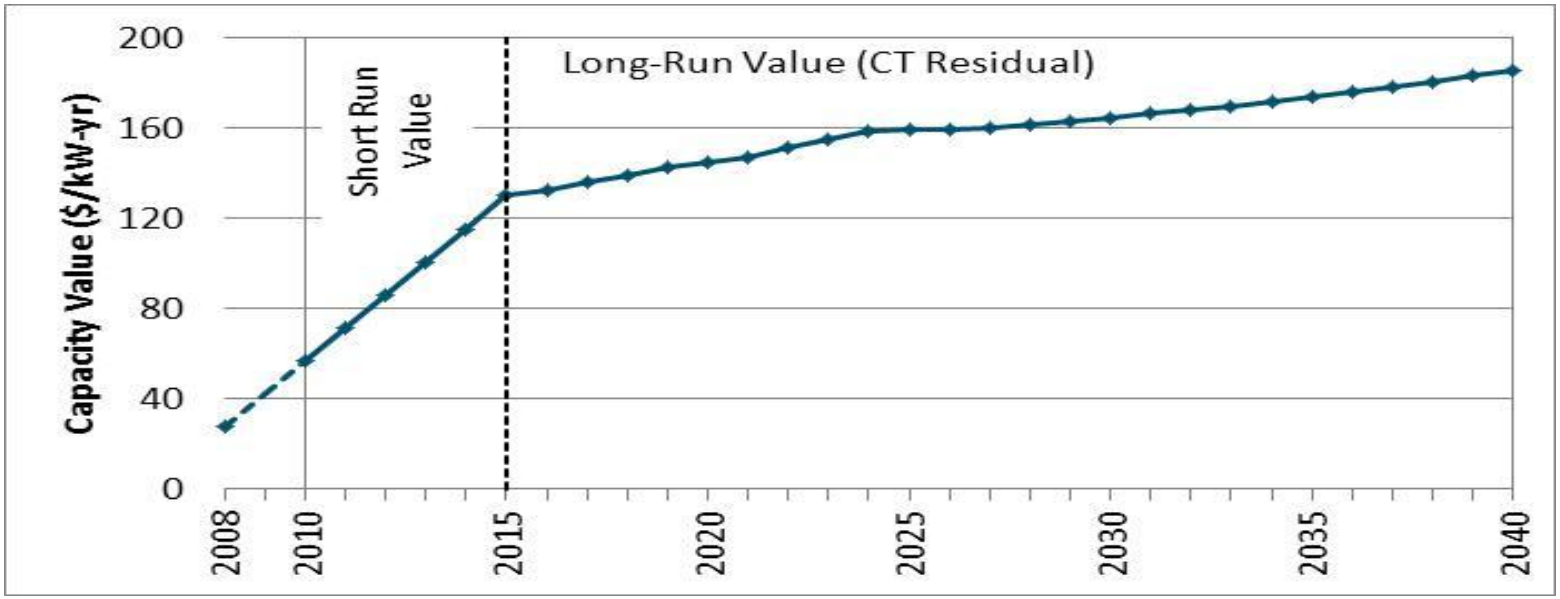
Calculates 6 types of avoided costs:

- (Generation) Capacity 
- Energy 
- Transmission & Distribution Capacity (T&D) 
- Ancillary Services 
- Renewable Portfolio Standard
- Greenhouse Gas (GHG) 

Avoided Cost of Capacity

- Short term avoided capacity costs:
  - short term value of capacity, based on current resource adequacy values. This value is linearly extrapolated from 2008 (because public data was available) until year new capacity will be needed.
- Long term avoided capacity costs:
  - Determine cost of building a new Combustion Turbine (CT), including environmental compliance
  - Subtract gross margins (revenues from energy and ancillary service sales) to determine Residual Capacity Value (annual value in $/kW-year)

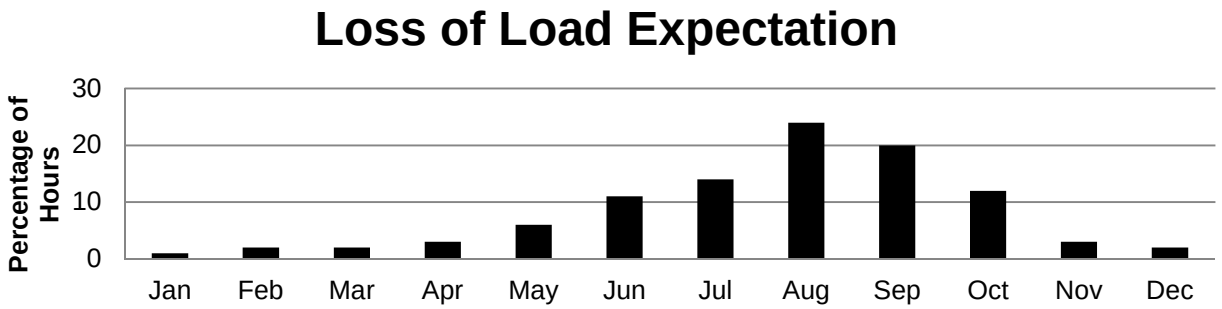
Resource Balance Year (RBY)



- The RBY is the point in the future when existing capacity (in the absence of demand side resources or new generation) will be unable to meet demand. In this example, the RBY is 2015.
- Before RBY: short term value of capacity, based on current resource adequacy values
- After RBY: long term value of capacity, based on construction of a new CT (residual capacity value)

Allocating the Residual Capacity Value

Annual Avoided Costs are spread over each month or hour of the year, based on when supply is likely to be insufficient to meet demand.



Which Loss of Load Expectation (Loss of Load Probability) Model should we use?

- IOU models (more precise and accurate according to utilities, but are proprietary, opaque, use confidential data, and are run infrequently).
- E3 default (simple) model spreads the value over the top 250 hours.
- Some prefer same model which spreads the value over the 100 hours.
- Utilities suggested a mathematical function which mimics their LOLE output.
- E3 has developed an Electric Load Carrying Capacity (ELCC) model, currently used for NEM and RPS
- Future models?

Determining Total Avoided Costs

+ *Capacity*: Residual Capacity Value x Loss of Load Expectation for each hour
+ *Energy*: Hourly energy prices, based on historical data and forecast prices.
+ *T&D*: IOU-specific costs x hourly allocators based on historical weather data. Different for each climate zone.
+ *Ancillary Services:* % of energy
+ *GHG*: GHG price (based on various studies)
+ *RPS*: Renewable Premium (difference between the average cost of a CCGT and the cost of a particular group of RPS projects)

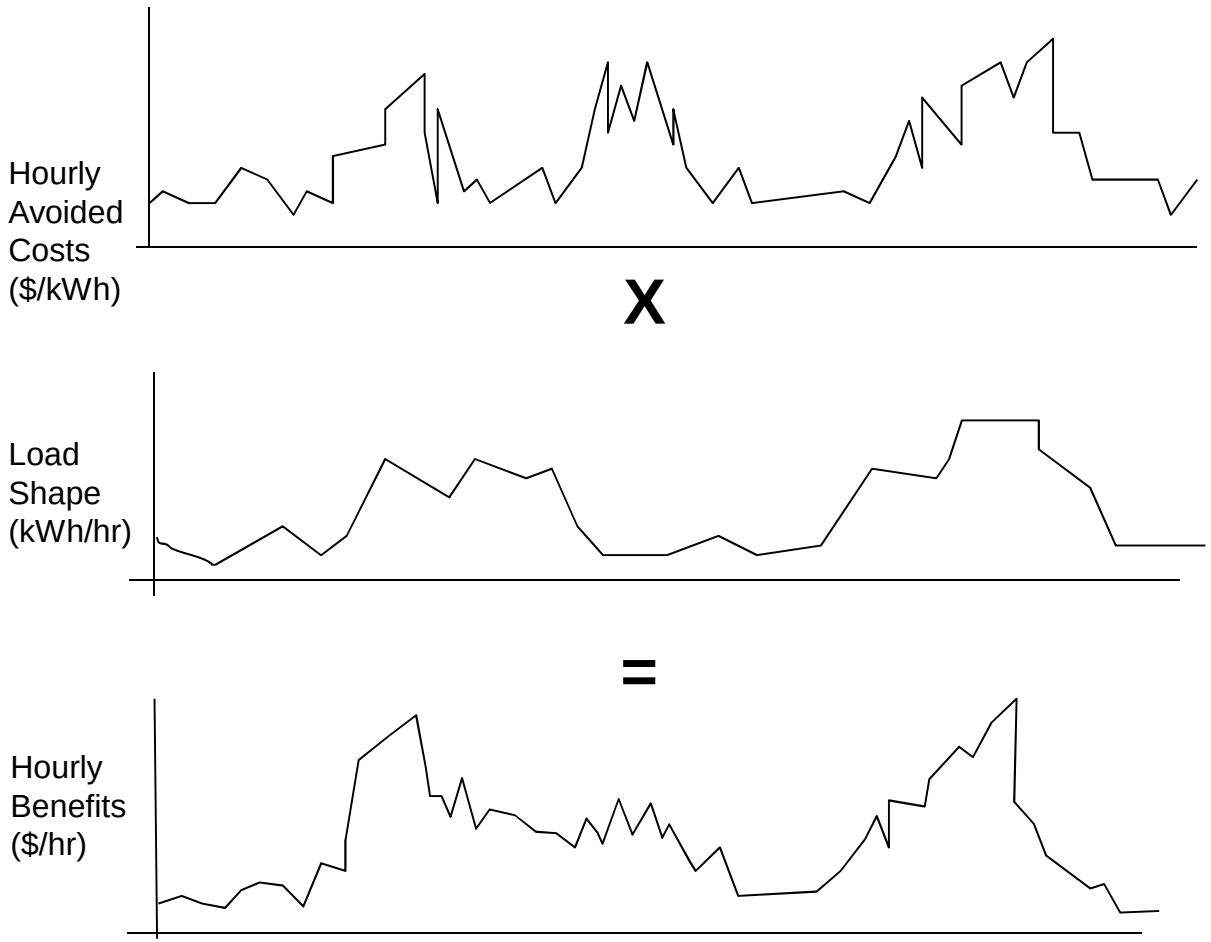
= $/kWh

Determining Avoided Costs for EE and DG

Annual avoided costs are calculated for each hour of the year, based on the sum of the six avoided costs.

Hourly Avoided Costs are multiplied by the hourly load savings for each measure…

… to determine the Avoided Cost benefit for that measure.



Calculating Avoided Costs for DR

- *Capacity*: Residual Capacity Value x Loss of Load Expectation for each month x monthly load impact x A Factor x B Factor x C Factor
- *Energy*: Average energy price x E factor x total avoided energy (monthly call hours x monthly load impact)
- *T&D*: IOU-specific annual data x D Factor
- *Ancillary Services:* currently zero
- *GHG*: GHG price x total avoided energy
- *RPS*: Renewable Premium x total avoided energy

DR Avoided Cost Adjustment Factors

Factor	Name	Description
A	Availability	Adjusts the capacity value that can be captured by the DR program based on the time of operation and the frequency and duration of calls permitted.
B	Notification Time	Accounts for differences in value of various notification times (e.g., day-ahead, day-of, 30 minute, 15 minute)
C	Trigger	Accounts for value of flexibility of the triggers or conditions that permit the utilities to call each DR program
D	Distribution	Adjusts estimated benefits based on avoided transmission and distribution (T&D) costs related to “right time,” “right place,” “right certainty,” and “right availability” of DR programs
E	Energy Price	Adjusts estimated benefits based on avoided energy costs attributable to DR programs

EE Measure Costs

- Incremental Measure Cost = Difference between baseline and efficient model
- Free-ridership = Costs that would have been incurred even if program did not exist. Net-to-Gross ratio = non-free-ridership/total participants
- Both benefits (energy savings) and costs (participant share of measure costs) are reduced using the NTG ratio, so that only costs and benefits *caused* by the EE measure are included in the calculation. Cost of rebates paid to free-riders is included.
- Replace on Burnout: Incremental energy savings and measure costs based on new equipment, not existing.
- Early Retirement: Remaining life is estimated and adjustments made.

Incentives

- TRC costs include both utility and participant costs.
- Utility costs = Admin costs + incentive costs
- Participant costs = Equipment costs – incentive costs (+ other costs for DR)
- Incentive costs cancel out when you add them together.
- Accounting is complicated because incentives can be upstream, midstream or downstream.

Participant Costs

- Energy Efficiency:
  - Net (after rebate) Incremental Measure Costs x Net-to-Gross Ratio
- Demand Response (DR):
  - Event-based DR: Value of Service Loss + Transaction Costs *(75% of incentives used as proxy)* + Capital Costs (often zero)
  - Permanent Load Shifting: Total Cost of Installed System – Rebate
- Distributed Generation (DG):
  - Total Cost of Installed System – Federal Tax Credits – Rebate

Non-Energy Benefits

- Participant NEBs accrue to the program participants (such as reduced building operating costs, increased value, comfort, health, and safety). **Currently used for Low Income programs**
- Utility NEBs are realized as indirect costs or savings to the utility (such as bill payment improvements, infrastructure savings, etc.).

  Currently used for Low Income programs
- Societal NEBs represent indirect program effects beyond those realized by ratepayers/utility. They accrue to society at large (e.g., job creation, tax receipts growth, labor productivity, housing value, neighborhood stability; reduced emissions, reduced health care costs and other environmental benefits). **Often used in Social Tests.**
- There also may be non-energy costs, although many of these are included in value of service lost and transaction costs.

Social Cost Test (SCT)

Staff Proposal: Not adopted by the CPUC; not clear if it ever will be. Provided as an example, however, a similar Social Cost Test has been used in some DG studies.

SCT is basically the TRC with 3 changes:

- Social discount rate
- Environmental health benefits
- Avoided GHG costs (above and beyond the forecast carbon allowance price of CA's cap and trade program)

NEBs Currently Included in the ESA Program* Cost-Effectiveness Tests

Participant:

- **Water/sewer savings**
- Fewer shutoffs
- Fewer calls to utility
- Fewer reconnects
- **Property value benefits**
- **Fewer fires**
- Moving costs / mobility
- **Fewer illnesses and lost days from work/school**
- **Net benefits for comfort & noise**
- Net benefits for additional hardship

Utility:

- **Reduced arrearage cost**
- **Reduced bad debt written off**
- Fewer shutoffs
- Fewer reconnects
- Fewer notices
- Fewer customer calls
- Fewer emergency gas service calls
- **CARE subsidy avoided**

*Some of these NEBs also used for MASH/SASH cost-effectiveness evaluation

ESAP Cost-effectiveness Tests

	Old Tests			New Tests	
	TRC	**MPT**	**UCT**	**ESACET**	**Resource TRC**
Administrative costs	COST	COST	COST	COST	
Avoided costs of supplying electricity	BENEFIT		BENEFIT	BENEFIT	BENEFIT
Net Bill Reductions		BENEFIT		BENEFIT	
Capital (measure) costs to landlords/ 3rd parties	COST*			COST	
Capital (measure) costs to utility	COST	COST	COST	COST	COST
Participant non-energy benefits		BENEFIT		BENEFIT	
Utility non-energy benefits			BENEFIT	BENEFIT	

**Costs of third parties had been included, although not consistently, by some utilities.*

- TRC, Modified Participant Test (MPT) and Utility Cost Test (UCT) were estimated for each measure.
- ESACET is estimated for the entire ESA Program.
- Resource TRC is estimated for each resource measure

ESA Program Cost Effectiveness

- Includes participant and utility non-energy benefits, calculated using LIPPT model
- Admin costs of individual measures difficult to estimate
- Some measure provide little or no energy savings, so no associated avoided costs or bill savings
- Recommendations of ESA Cost-effectiveness Working Group recently adopted, including:
  - Categorize each individual ESA measure as “resource” or “non-resource,” treat differently
  - Base ESA program approval on the cost-effectiveness of the entire ESA program; develop new tests and approval threshold.
  - Develop an Equity Evaluation to provide a qualitative assessment of whether measures provide identifiable, specific quality of life benefits to participants.
  - Modification of the NEBs calculation may be needed.

Equity Evaluation

Health, Comfort and Safety Criteria

- Eliminates combustion-related safety threat
- Eliminates fire safety threat / improves home security (crime prevention) or building integrity
- Reduces/eliminates extreme temperatures inside the home / increases customer ability to manage temperatures
- Improves air quality, ventilation and/or air flow (reduces drafts and leakage)

Water/Energy

Currently developing a framework to measure the energy benefits of water savings:

- Water-related energy use in CA is significant.
- Electric and gas utilities and ratepayers may benefit from embedded energy savings.
- Water utilities benefit from both energy and water savings.
- Research includes exploration of environmental benefits of reduced water use.

Cheat Sheet of Cost-effectiveness Concepts

Standard Practice Manual TRC, PAC, RIM, PCT, MPT, SCT

Discount Rate WACC, social discount rate, consumer discount rate

Effective Useful Lifetime (EUL) (refers to equipment)

Administrative Costs (may include utility capital costs)

Measure Costs incremental measure costs, net-to-gross, free-ridership

Incentives rebates, upstream, midstream, downstream

Revenue Loss/Gain bill reductions/increases

Participant Costs value of service lost & transaction costs

Avoided Costs capacity, energy, T&D, ancillary services, RPS, GHG

Resource Balance Year, Residual Capacity Value, LOLE/P; ELCC, Adjustment Factors, Load Impacts, Energy Savings

Non-energy benefits participant, utility, social (includes environmental)