The Basics of Cost-Effectiveness Analysis
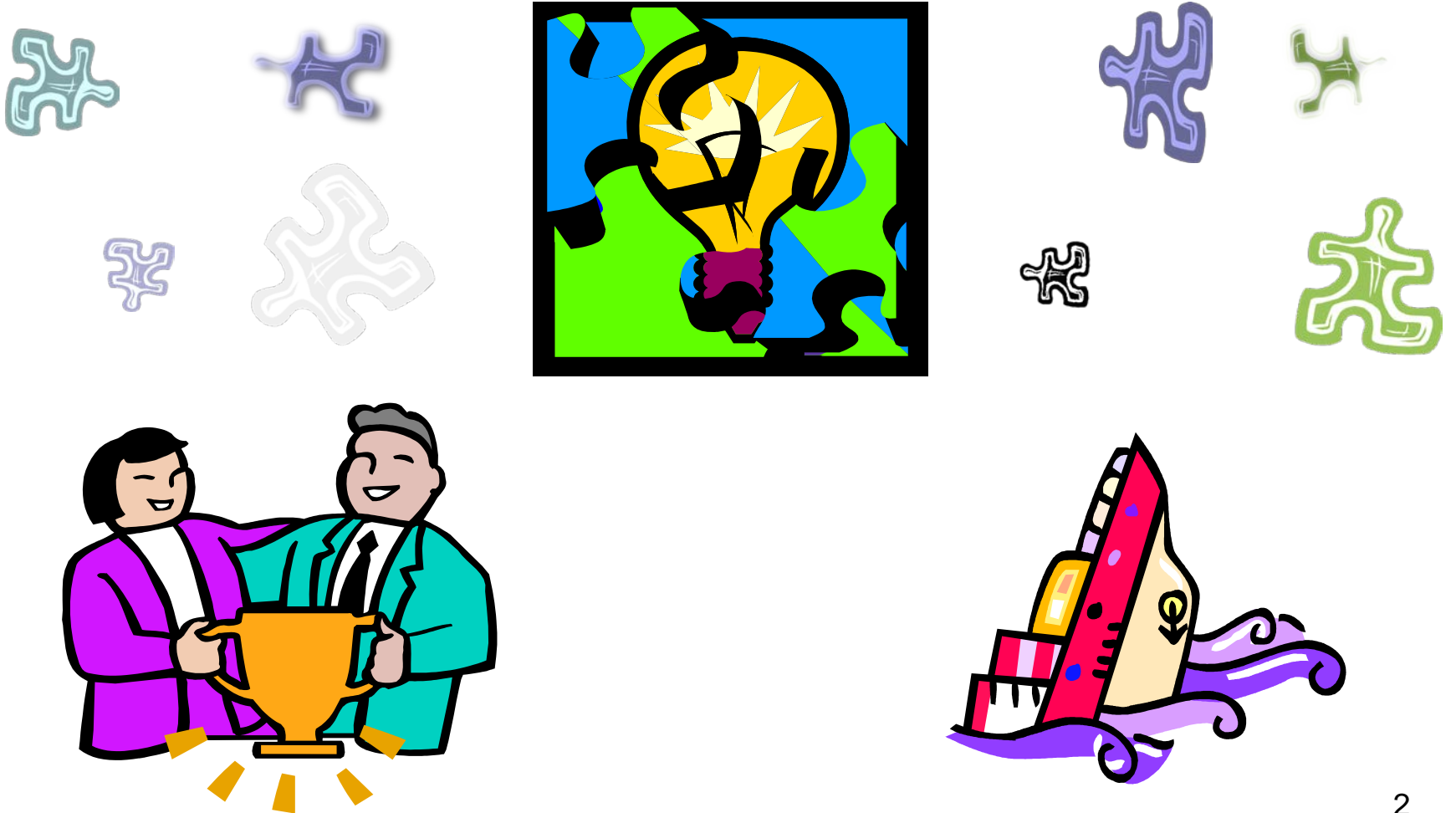
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Cost-effectiveness analysis of Demand Side Programs

What are demand-side programs?

- Energy Efficiency

- Low Income Energy Efficiency

(Energy Savings Assistance Program, or ESAP)

- Demand Response

- Distributed Generation

Cost Benefit Analysis

Costs	Benefits
• Administration	• Avoided Costs
• Equipment	• Environmental
• Incentives	• Incentives
• Revenue Loss	• Bill Reductions
• Value of Service Lost	• Tax Credits

• Benefit Cost Ratio
• Net Benefits
• Payback Period

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?

	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%

NRDC: Use a social discount rate for the TRC

- A social discount reflects the high value of investing in efficiency today to avoid energy use later and the need to meet our aggressive climate goals and the ever increasing costs of providing energy to customers. It's consistent w/ how CEC values energy savings due to EE codes and standards.

TURN: The social discount rate is NOT appropriate

- Discount rates should reflect the real cost of raising capital to build the generation that is being avoided. This is the opportunity cost for projects that are not undertaken due to efficiency and what ratepayers would have to pay for them.
- If we are making tradeoffs of one type of investment versus another it is important that the same discount rate be used in these tradeoffs to properly allocate limited resources.

DRA, Efficiency Council: A consumer discount rate may sometimes be appropriate

- A consumer discount rate would, in theory, better reflect customers' costs of borrowing money, or how customers value their investments.
- It is difficult to determine which consumer discount rates to use, for which groups of consumers, and under what circumstances
- Proposals range from mortgage rates to credit card rates.

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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.

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
    - *"Society" is actually Utility + Participant*
  - *Program Administrator*: The Program Administrator (PAC) test
  - *Ratepayers*: The Ratepayer Impact Measure (RIM) test
  - *Participant*: The Participant Test
- 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.

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New slide

Problems with the SPM tests

- Critics claim that TRC includes all participant costs but not all participant benefits (we disagree, but participant costs, especially for DR, are very hard to quantify)

- Avoided costs difficult to define and measure precisely, inputs always contentious.

- Other cost and benefit inputs have contentious or difficult aspects.

- Externalities such as environmental impacts usually excluded; hard to quantify when included.

- Unclear how to use each test for decision-making, decision-makers don't like imprecision.

- Most inputs involve measuring things that didn't happen.

Cost and Benefits Used

MEASURE	EE/DG TRC	EE/DG PAC	DR TRC	DR PAC	RIM	DR Participant	ESAP TRC	ESAP MPT (participant)	ESAP UCT
Administrative costs	COST	COST	COST	COST	COST		COST	COST	COST
Avoided costs of supplying electricity	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT		BENEFIT		BENEFIT
Bill Increases						COST			
Bill Reductions						BENEFIT		BENEFIT	
CAISO Market Revenue			BENEFIT	BENEFIT	BENEFIT				
Capital costs to participant	COST		COST			COST			
Capital costs to utility	COST	COST	COST	COST	COST		COST	COST	COST
Environmental benefits (GHG only)	BENEFIT	BENEFIT	BENEFIT	BENEFIT	BENEFIT		BENEFIT		BENEFIT
Incentives paid		COST		COST	COST	BENEFIT			
Increased supply costs	COST	COST	COST	COST	COST				
Market benefits			BENEFIT	BENEFIT	BENEFIT				
Non-monetary/Non-energy benefits			*BENEFIT*			*BENEFIT*		*BENEFIT*	*BENEFIT*
Revenue gain from increased sales						BENEFIT			
Revenue loss from reduced sales						COST			
Tax Credits	BENEFIT		BENEFIT			BENEFIT			
Value of service lost and transaction costs to participant			COST			COST			

Blue text indicates optional, hard-to-quantify benefits. (DR only)
Italic text indicates that value may be different for different tests.
Green text indicates values that are often considered to be externalities.

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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

(bill reductions)

•Participant Costs

(Other than capital costs – value of service lost & transaction costs)

BENEFITS

•Avoided Costs

(complex)

•Tax Credits

(currently available for DG only)

•Market/Reliability Benefits

•Non-energy benefits

•Incentives

•Bill reductions

Energy Efficiency Impact on Load
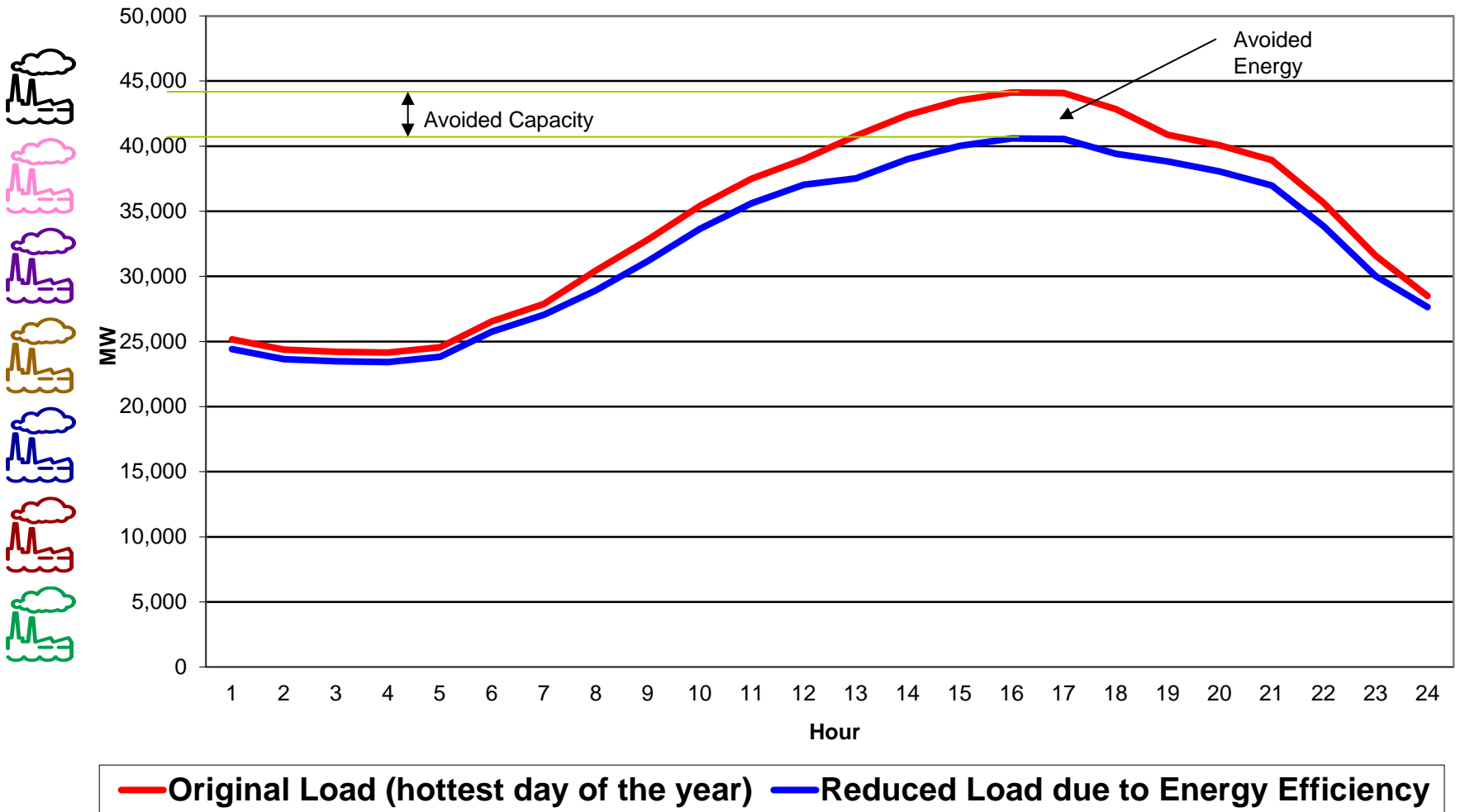
Demand Response Impact on Load
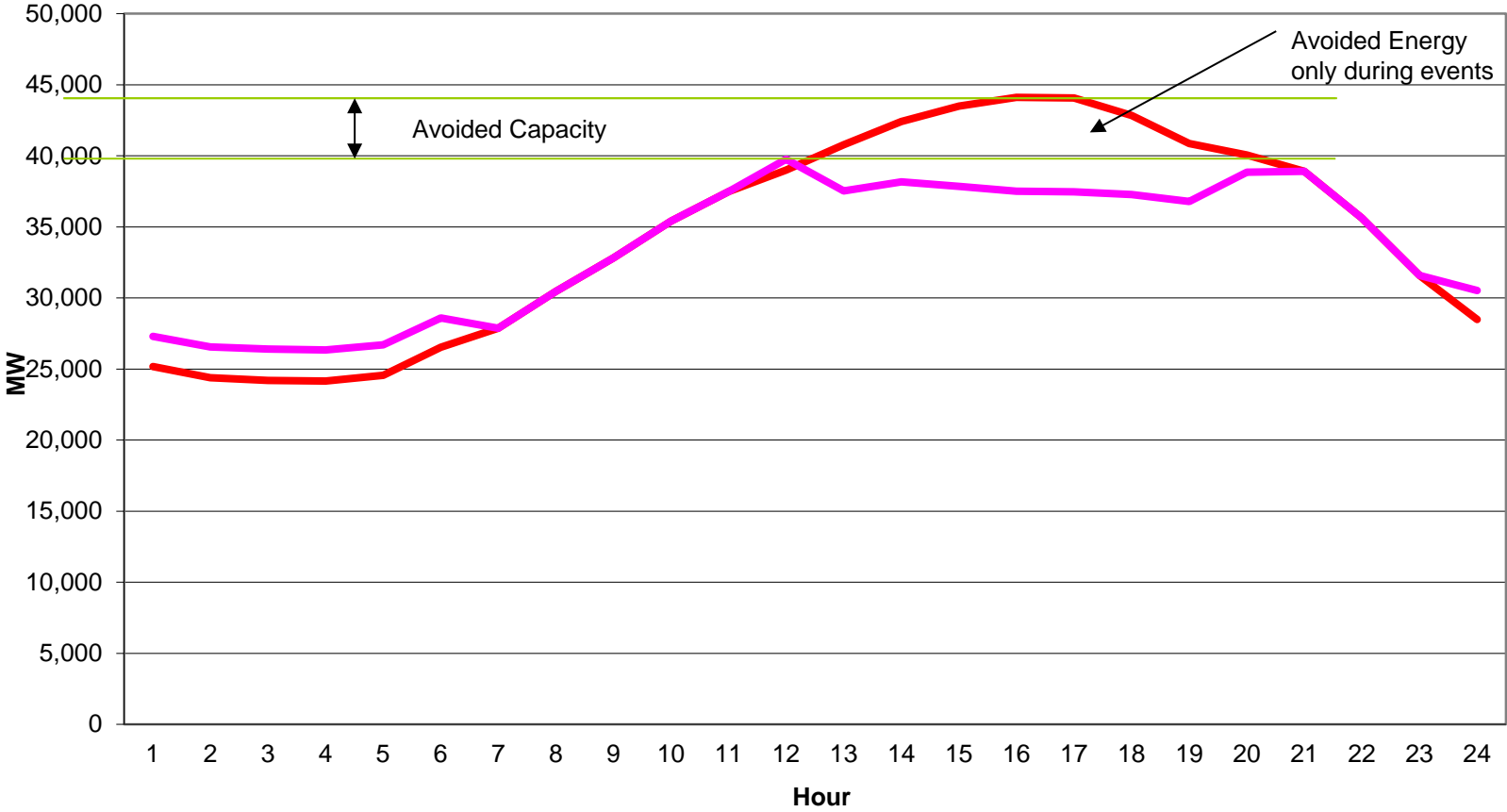
Distributed Generation Impact on Load
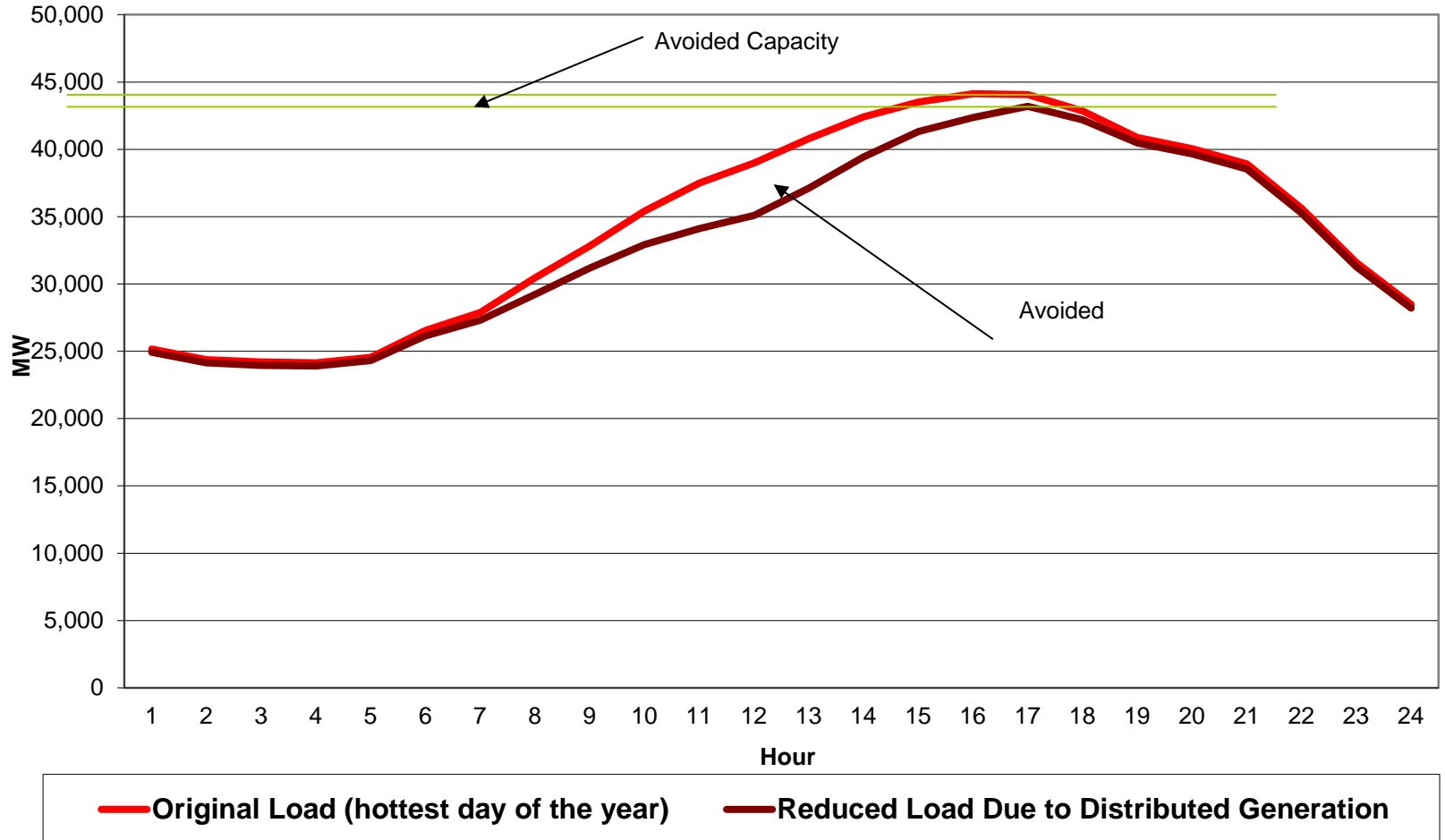
Avoided Cost Calculator

Calculates 6 types of avoided costs:

- (Generation) Capacity
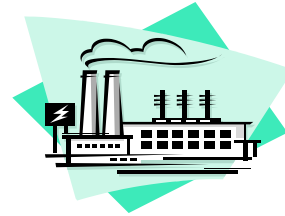
- Energy

- Transmission & Distribution Capacity (T&D)

- Ancillary Services

- Renewable Portfolio Standard
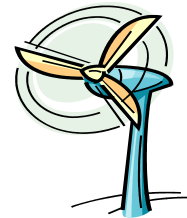
- Greenhouse Gas (GHG)

Avoided Cost of Capacity

- Short term avoided capacity costs:
  - short term value of capacity is based on current resource adequacy values, whose low magnitudes ($28/kW-yr in 2008) reflect the CAISO's large current capacity surplus. This value is linearly extrapolated from 2008 to the RBY.

- 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)
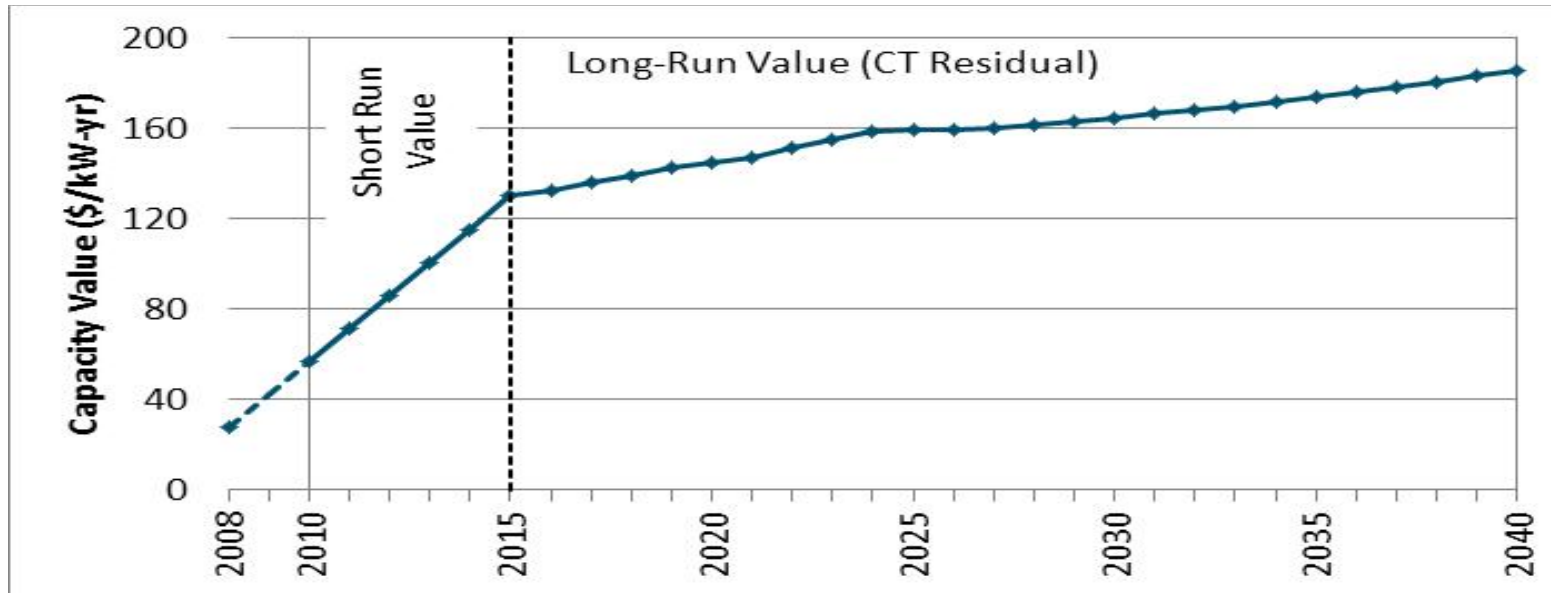
- The RBY is the point in the future when existing capacity (in the absence of demand side resources or new generation) will be unable to meet demand. In this example, the RBY is 2015.

- Before RBY: short term value of capacity is based on current resource adequacy values

- After RBY: long term value of capacity is based on construction of a new Combustion Turbine (CT)

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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.

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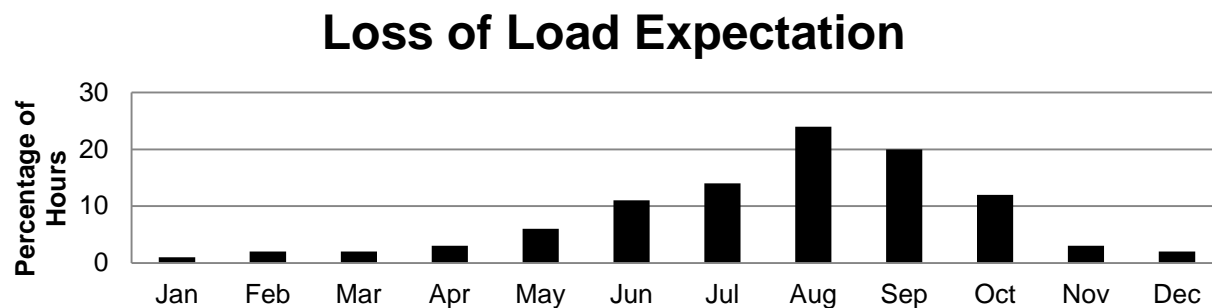
Which Loss of Load Expectation (Loss of Load Probability) Model should we use?

- 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 suggested a new, somewhat more complex version of their default model.
- Same model is used to determine A factor so the LOLE model used is a key component of DR cost-effectiveness.
- SERVm: run by ED staff, includes DR, but not ready yet.

Avoided Cost of EE

+ *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

+ *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 of an EE Measure

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

Hourly Avoided Costs ($/kWh)

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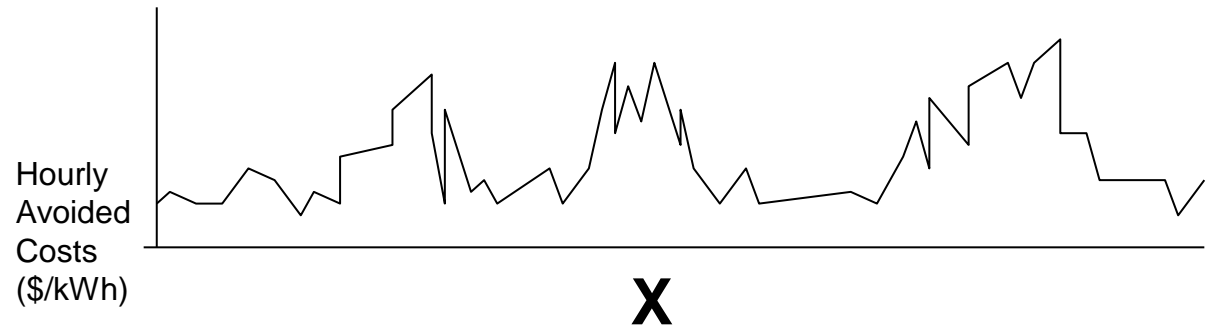
Hourly Avoided Costs are multiplied by the hourly load savings for each measure…

Load Shape (kWh/hr)

=
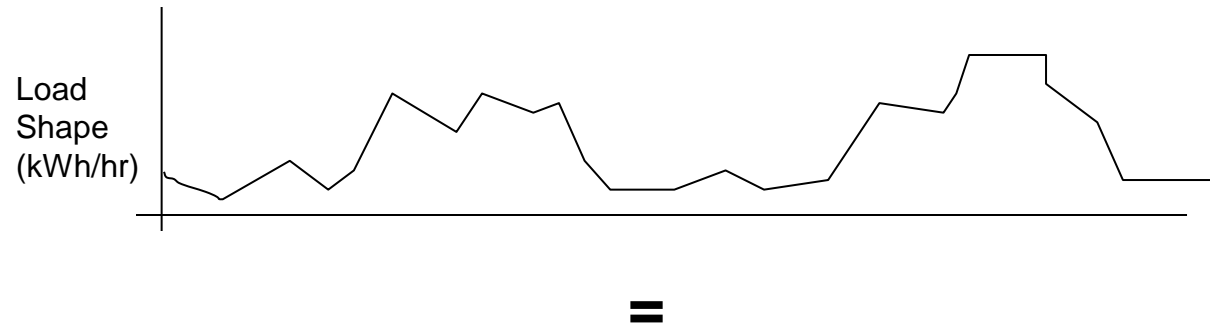
… to determine the Avoided Cost benefit for that measure.

Hourly Benefits ($/hr)
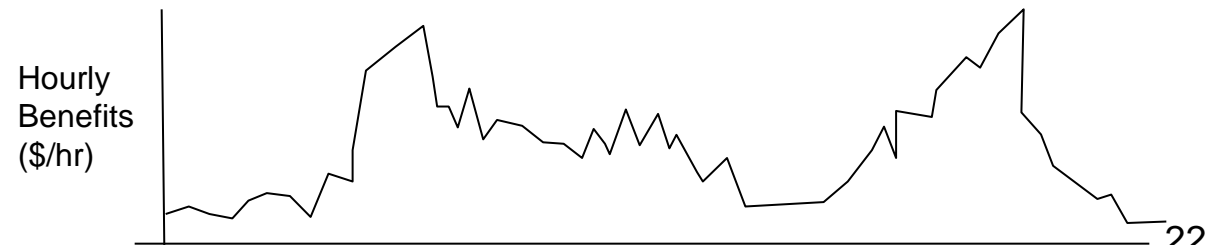
Calculating Avoided Costs for DR

- *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, for each month)

- *T&D*: IOU-specific annual data x D Factor

- *Ancillary Services:* currently zero

- *GHG*: GHG price x total avoided energy

- *RPS*: Renewable Premium (difference between the average cost of a CCGT and the cost of a particular group of RPS projects) 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 = Free-ridership/Total participants

- Both benefits (energy savings) and costs (participant share of measure costs) reduced using the NTG ratio, so that only costs and benefits *caused* by the EE measure are included in the calculation, although the cost of rebates paid to free-riders is also included.

EE Measure Costs (cont.)

See "Ex Ante Review Fact Sheet #1

- Replace on Burnout
  - Incremental energy savings based on new equipment, not existing.

- Early Retirement
  - Remaining life is estimated and adjustments made.

- Codes and Standards/Industry Standard Practice
  - Saving estimates usually calculated as the "above code" portion of the savings.
  - Exception made if data indicates standard practice is far below code.

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

- <u>Participant NEBs</u> accrue to the program participants (such as reduced building operating costs, increased value, comfort, health, and safety).

- <u>Utility NEBs</u> are realized as indirect costs or savings to the utility (such as bill payment improvements, infrastructure savings, etc.).

- <u>Societal NEBs</u> represent indirect program effects beyond those realized by ratepayers/utility, and they accrue to society at large (such as job creation, tax receipts growth, labor productivity, housing value, neighborhood stability, and reduced emissions and health care costs and other environmental benefits).

- There also may be non-energy costs, although many of these are included in value of service lost and transaction costs.

ESAP(low income EE) tests

- MPT – Modified Participant Test
  - Benefits are bill reductions and participant non-energy benefits
  - Costs are measure costs (administrative and capital costs of the measure)

- UCT – Utility Cost Test
  - Benefits are the avoided costs of the energy savings and utility non-energy benefits (NEBs)
  - Costs are measure costs (administrative and capital costs of the measure)

- TRC – Total Resource Cost
  - Benefits are the avoided costs of the energy savings
  - Costs are measure costs (administrative and capital costs of the measure)

Avoided costs and NEBs are calculated by discounting annual values over the lifetime of the equipment to determine the Net Present Value.

The % of ESAP's administrative costs and NEBs assigned to each measure are based on the measure's energy savings.

Cheat Sheet of Cost-effectiveness Concepts

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

Discount Rate WACC, social discount rate, consumer discount rate

Effective Useful Lifetime (EUL)

Administrative Costs

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

Incentives rebates, upstream, midstream, downstream

Revenue Loss bill reductions

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; Adjustment Factors, Load Impacts, Energy Savings

Non-energy benefits participant, utility, social