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Summary of CPUC Workshop on Societal Cost Test

September 22, 2016

Originally presented June 2013

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Purpose of this workshop

- Start the discussion on the Societal Cost Test
- Present representative values and their impacts
  - CO_2 cost
  - Criteria pollutant health impacts
  - Social discount rate
- Gain stakeholder feedback on the use of such societal values
- Hear thoughts on other societal values that could be quantified and included

Standard Practice Manual on SCT

- SCT is a "secondary" test that attempts to quantify total resource costs to society as a whole, rather than only to the service territory (the utility and its ratepayers)
- Enumerated differences from the TRC test
  1. SCT may use higher marginal costs than TRC if a utility faces marginal costs that are lower than other utilities or out-of-state suppliers.
  2. Tax credits are treated as a transfer payment in the SCT, and thus are left out.
  3. Interest payments are considered a transfer payment since society actually expends the resources in the first year. Therefore, capital costs enter the calculations in the year in which they occur.
  4. A societal discount rate should be used.
  5. SCT should include externality costs of power generation not captured by the market system.

Standard Practice Manual on SCT, 2

Societal benefits specifically listed in SPM:

- Avoided environmental damage
- Benefits of increased system reliability
- Non-energy benefits of reduced water use and waste streams.
- Non-energy benefits for low income programs.
- Benefits of fuel diversity

SCT Inputs – The Big Three

- Societal discount rate
- Health costs of electricity production
- Environmental costs above current market price forecasts
- Ranges are intended to provide food for thought and illustrate the impact of different approaches to the valuation of key drivers

Theoretical (philosophical) underpinnings

- Why do individuals, societies discount future costs and benefits?

(Textbook answers)

- Capital is productive, can be invested elsewhere, has an opportunity cost
- People care more about current than future utility
- Uncertainty or anticipated decrease in future utility
- People care less about the welfare of future generations

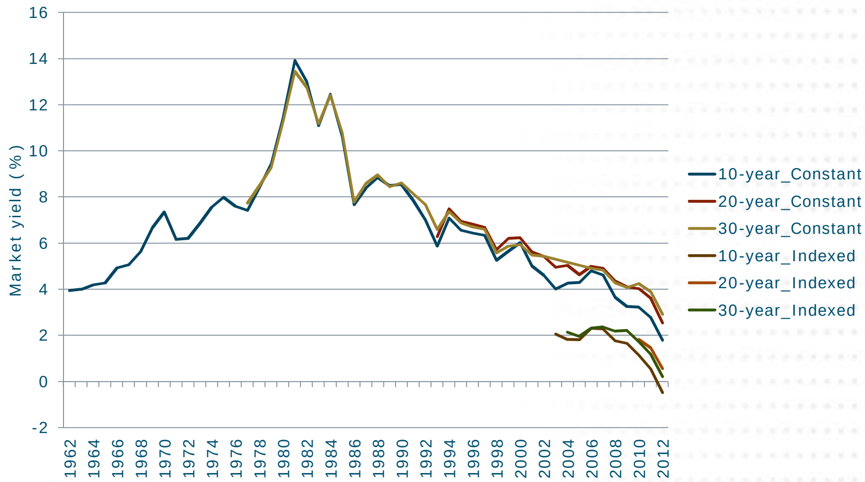
Most states use government securities for SCT discount rate

State	Basis for Discount Rate	Program Design; Source of Funds
DC	10-year T-note	Administered through DC Energy Office; system benefits charge (SBC)
Iowa	12-month average of 10-year T-note and 30-year T-bond	Administered through utilities; tariff rider
Maine	10-year T-note	Administered through Efficiency Maine Trust; SBC
Minnesota	20-year T-note	Administered through utilities; integrated resource planning (IRP)
Vermont	3%	Administered through Efficiency Vermont; SBC

Sources: Forster, HJ, S Price, I Hoffman, 2013. Cost Effectiveness is WACC! The Need for More Effective, Comparable, and Comprehensive Cost Assessment; ACEEE website

Yield on government securities can be volatile

Figure. Market yield on 10, 20, and 30-year Treasury securities, constant maturity and inflation-indexed



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Source: http://www.federalreserve.gov/releases/h15/data.htm

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What discount rate to use in the SCT?

"… those looking for guidance on the choice of discount rate could find justification for a rate at or near zero, as high as 20% and any and all values in between."

Portney and Weyant, 1999, "Introduction," Discounting and Intergenerational Equity, Resources for the Future Press

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Discount rates used in this analysis

Lower

↓

Higher

1.4% real	Source: Stern (2006) Pros: Reflects intergenerational equity Cons: Controversial
3% real	Source: Est. long-run avg yield on govt securities Pros: Precedent, consistency, stability Cons: Proxy basis

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Non-Energy Benefits (NEBs)

+ NEBs included in this analysis
  - Value of CO_2 reductions above the monetized cost of AB32 allowances already included in the TRC
  - Health benefits of reduced electricity generation and natural gas combustion beyond existing compliance costs included in TRC
+ Partial list of NEBs not currently included
  - Water savings
  - Reduced waste streams
  - Reduced land use impacts
  - Macroeconomic benefits
  - Privatized non-energy benefits such as greater comfort or productivity of participants
  - Lifecycle costs of electricity and natural gas consumption (drilling etc)

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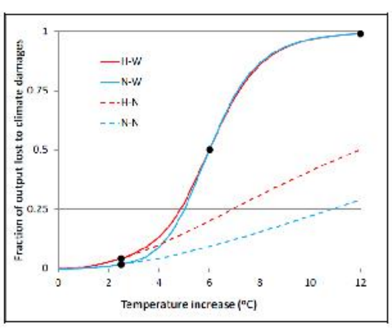
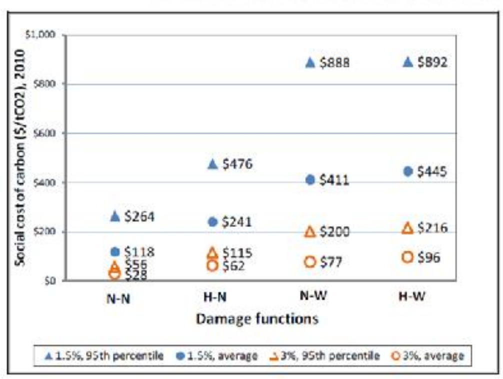
SCC Approach 1: Damage Cost

- Damage to society from GHG emissions:
  - Damage costs are the impact on society's total productive output and aggregate welfare due to climate change
  - These costs arise from GHG-induced changes in agricultural production, hydrology, sea level, human health, ecological health, extreme weather severity and frequency, etc
- Damage cost calculation includes these general steps:
  1. Calculate the total economic costs of climate change for different equilibrium CO_2 concentrations and trajectories, and the resulting changes in radiative forcing and earth's mean surface temperature
  2. Estimate the marginal damage cost of carbon by calculating the cost differences resulting from small changes in carbon emissions on equilibrium CO_2 concentrations and trajectories
  3. Discount marginal damage costs to present value measured in \$/tonne CO_2

Damage Cost Sensitivity

- A recent study (Ackerman and Stanton, 2012) shows SCC results can vary widely, even using the same model (DICE)and many of the same assumptions





Marginal Abatement Cost Approach

- Damage function approach intended to help policy makers set carbon targets. If target is already set, the implied carbon cost is the marginal cost of abatement
- "If policy makers decide upon a 2 degree target, then the appropriate social cost of carbon to use is the shadow price associated with that path." (Nordhaus)
- Most scenarios for eliminating carbon dioxide emissions as rapidly as technologically feasible require spending $150 to $500 per ton of reductions of carbon dioxide emissions by 2050. Examples:
  - UK 2°C scenario: $165-$495/tonne
  - IEA BLUE Map 450 ppm: $175-$500/tonne
  - Potsdam Institute 400 ppm: $150-$500/tonne
  - McKinsey 480 ppm: $90-$150/tonne

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SCC Approach 2: Avoided Electricity Decarbonization Cost

- **Long run electricity decarbonization costs provides an alternative approach to the SCC in California**
  - Reflective of established GHG reduction policies
  - Potentially higher level of certainty about underlying costs
  - Consistent with driving investment in known opportunities for climate mitigation
- **In determining the avoided costs of carbon reductions, we can compare mitigation costs in EE to an "avoided electricity decarbonization cost" of alternative investments**
- **Market price of CO2 in cap and trade system is not an appropriate guide for EE investment because:**
  - Capped emissions are relatively small share of total mitigation. Market price likely does not reflect actual marginal cost of mitigation.
  - If CO2 price is returned to ratepayers through revenue recycling, it would be a net zero cost in the electricity sector

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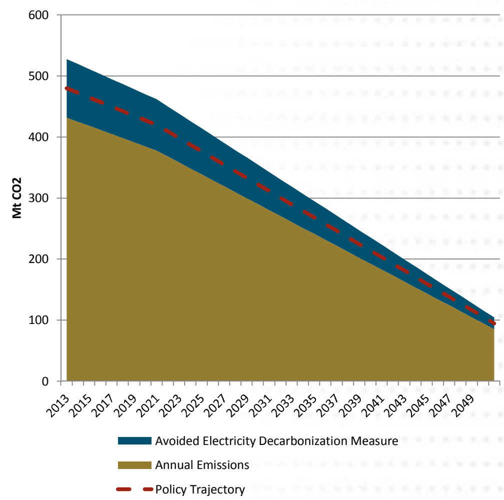
Avoided Electricity Decarbonization Cost Approach

- Annual Emissions Targets
  - Proposed Policy Trajectory in this example sets annual targets following straight line from 2013 to 2020 AB32 target, followed by straight line from 2020 to 2050 target
- Avoided decarbonization cost is the annual avoided cost ($/tonne) of the marginal supply side electricity decarbonization measure in each year
  - If we don't do X amount of least cost decarbonization measure we will have to do Y amount of the marginal supply-side decarbonization measure
- Approach based on annual emissions targets is consistent with existing California climate policy
  - Reflects actual decarbonization costs, not carbon prices in residual cap and trade market
  - Follows policy trajectory linking AB32 and S. 3-05 goals
- Also consistent with established California policy concerning preferred resources (i.e. loading order)



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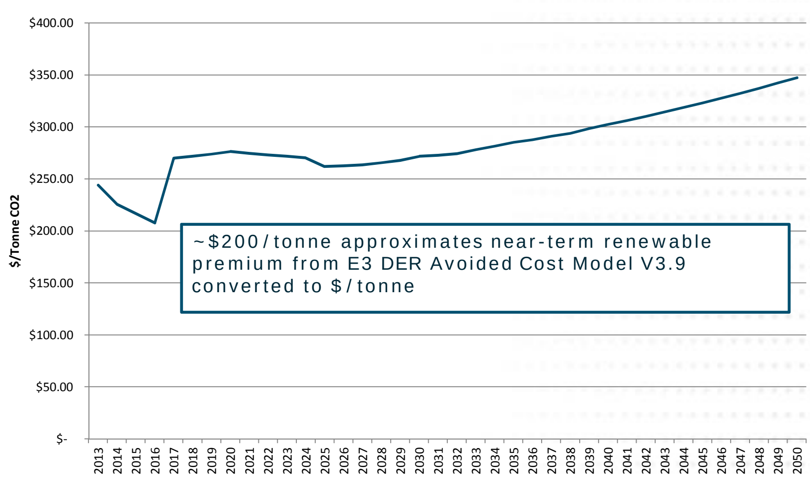
Implied Electricity Decarbonization Cost ($/tonne CO2): Current View



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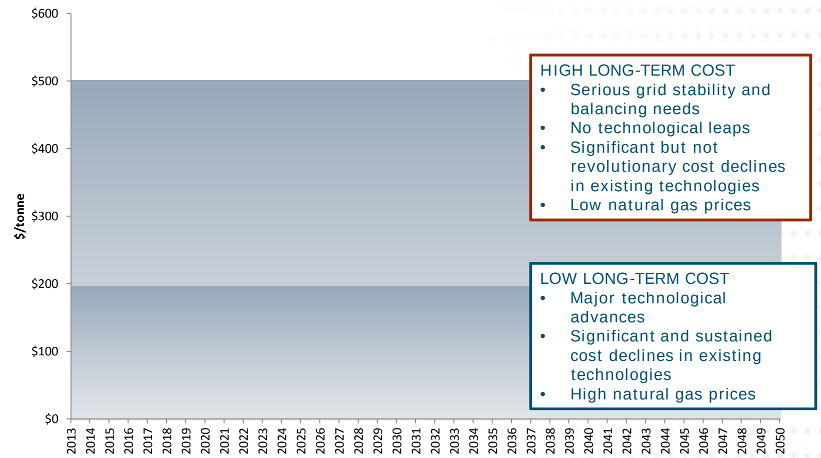
Decarbonization Cost Range Could Vary Widely in the Future



SCC Summary

- SCC Approach 1: Damage Cost

	2010	2050
Lower	$32	$73
Upper	$1,024	$1,717

- SCC Approach 2: Avoided Electricity Decarbonization Cost

	2013	2050
Lower	$200	0
Upper	$200	$500

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Non-Energy Benefits:

Avoided Health Costs

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Non-GHG Environmental Costs of Electricity and Natural Gas

- Emissions impacts ← Initial focus, most literature available
  - NO_x, SO_2, $PM_{2.5}$, PM_{10}, Hg
- Land use impacts
  - Land footprint and intensity of impacts vary by tech. type
- Water use impacts
  - Consumptive/non-consumptive, fresh water/salt water, etc.
- "Lifecycle" environmental & other impacts
  - Fuel and mineral extraction, waste processing & storage
  - Tourism impacts from reduced air quality
  - Ecosystem impacts from sulfur and nitrogen deposition

Health Benefits in other Jurisdictions

- Minnesota: Pollutant specific values for PM_{10}, CO, NO_x, Pb, CO_2
  - Based on survey of existing values in literature
- Maine: Non-Energy Benefit (NEB) factors for environmental externalities
  - Also includes O&M Reductions, other fuel, water savings, and other NEBs where quantifiable
- Other states embed Health Benefits in a simple adder that includes other NEBs
  - 10% used by Colorado, Washington, Oregon, DC
  - 15% used by Vermont.
  - 7.5% for gas and 10% for electricity in Iowa

Health Benefits Quantification: Avoided Damage Costs

- Health damages result from air emissions, which lead to exposures, which lead to health impacts, which lead to costs to individuals and society
- There is an extensive literature on environmental health impacts due to air pollution
- Two main approaches to determining societal health cost benefits of avoided air emissions:
  1. Using emission factors from the scholarly/regulatory literature
  2. Calculation of damages using air quality and exposure assessment tools

Damage Cost Sources

1. Emission factor from the literature approach: The National Academy of Sciences “Hidden costs of energy”, 2009, represents the most recent consensus based, and comprehensive scientific assessment of the issue
   - Damage costs are estimated for 498 gas fired power plants
   - http://www.nap.edu/catalog.php?record_id=12794
2. Calculation approach: Air quality and exposure assessment tools
   - EPA uses the BenMAP tool for estimate health benefits from proposed air quality regulations
   - EPA developed a simplified damage cost estimator, COBRA
   - Other tools (e.g. APEEP)

Distribution of damages: Hidden Costs of Energy report

FIGURE 2-17 Regional distribution of criteria-air-pollutant damages from gas generation per kWh (U.S. dollars, 2007). Damages related to climate change are not included.

Natural gas plants in California exhibit a range of damages from less than 0.1 ¢/kWh to over 5 ¢/kWh for a few plants in Southern CA

Exposure assessment tools used by US EPA: COBRA and BENMAP

- BenMAP ('Benefits Mapping' tool) is a tool developed by the EPA that estimates the benefits to the population from changes in air pollutant concentrations
  - Used by EPA to conduct impact analysis of proposed regulations, such as the Mercury Air Toxics Rule (MATS)
- COBRA ('Co-Benefits Risk Assessment' tool) is a simplified screening tool developed by the EPA to estimate benefits from changes in air pollutant emissions in 2017 (the year modeled for MATS)
  - Intended user is a state agency interested in understanding the air quality or health benefits from clean energy

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Example of Cobra Estimate Components

- Sample health impact and damage costs for Alameda County based on a 1 ton per year average reduction of $PM_{2.5}$ across California in 2017

	Low-Case		High Case	
	Incidence	Cost	Incidence	Cost
Adult Mortality	0.0002	$1,831.30	0.0006	$4,712.59
Non-fatal Heart Attacks	0	$3.42	0.0003	$31.81
Infant Mortality	0	$3.86		$3.86
Resp. Hosp. Adm.	0.0001	$2.32		$2.32
CDV Hosp. Adm.	0.0001	$2.43		$2.43
Acute Bronchitis	0.0004	$0.18		$0.18
Upper Res. Symptoms	0.007	$0.46		$0.46
Lower Res. Symptoms	0.0049	$0.21		$0.21
Asthma ER Visits	0.0002	$0.08		$0.08
MRAD	0.2264	$15.39		$15.39
Work Loss Days	0.0383	$5.78		$5.78
Asthma Exacerbations	0.0073	$0.84		$0.84
$ Total Health Effects		$1,866.28		$4,775.96

Damage costs dominated by mortality

High and low estimates in COBRA based on two authoritative studies, by ACS (Krewski) & Harvard (Laden)

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Example: Illustrative Damage Costs Using COBRA

- Benefits to Californians due to reductions of NO_X, $PM_{2.5}$, SO_2 in California in 2017 are considered (benefits to nearby states are excluded)
- Electricity Generation
  - Reductions occur uniformly across California in 2017
  - Emissions factors from the CARB RES calculator are used to convert $/ton into $/MWh and $/MMBtu
  - Damage costs (in 2017) ~ $8/MWh - 20/MWh ($2010) (equivalent to $1/MMBtu - $2.5/MMBtu at 8000 Btu/kWh heat rate)

NAS estimate is $36/MWh

- Natural Gas
  - Emissions from commercial and institutional boilers category reduced by EE or DER measure
  - Damage costs (in 2017)
    - ~$1/MMBtu - $3.5/MMBtu (small boilers)
    - ~$1.3/MMBtu – $4.70/MMBtu (large uncontrolled boilers)

Values for Scenario Runs

Key Driver	Low Case	High Case
Societal Discount Rate	3.0% real	1.4% real
Cost of Carbon	$50/t CO_2	$200/t CO_2
Health Benefits	$1/MMBtu	$2.5/MMBtu

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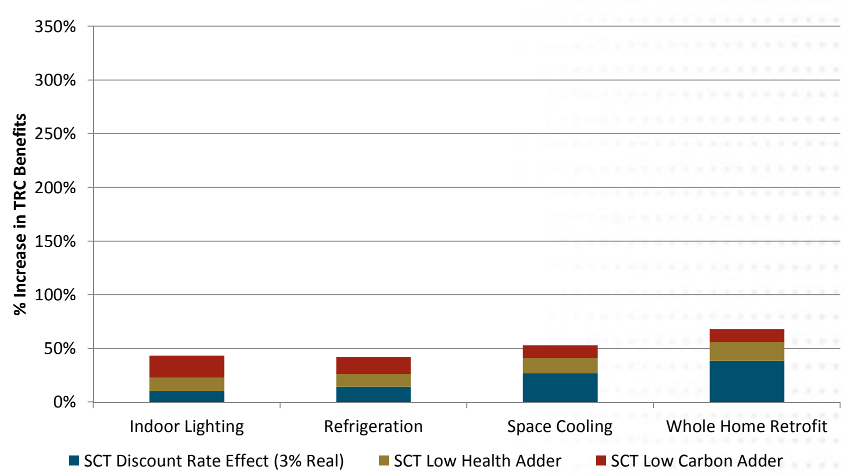
SCT Benefits Increase Over TRC – Low Case



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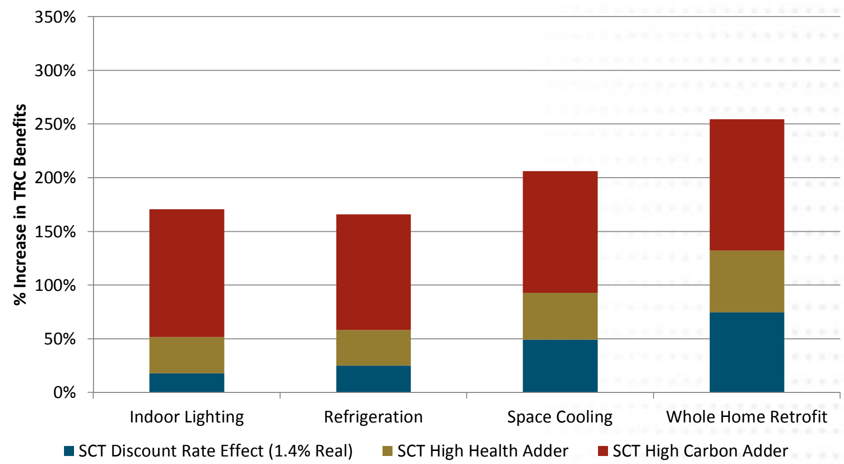
SCT Benefits Increase Over TRC – High Case



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