EPRI Social Cost of Carbon Webcast Series

Today – Applying the Social Cost of Carbon: Technical Considerations

September 5, 2017
EPRI SCC Webcast Series

- July 25, 2017
  - Understanding the Social Cost of Carbon: A Model Diagnostic and Inter-Comparison Study

- August 16, 2017
  - Social Cost of Carbon Pricing of Power Sector CO₂: Accounting for Leakage and Other Social Implications from Subnational Policies

- September 5, 2017
  - Applying the Social Cost of Carbon: Technical Considerations

Applying the Social Cost of Carbon: Technical Considerations

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Energy and Environmental Analysis Research Group

Webcast
September 5, 2017
Important to Evaluate Social Cost of Carbon Application

- Most commentary (public & scientific) related to the social cost of carbon (SCC) is on estimation of the SCC, not its use.

- Surprising, given that we are most interested in the potential consequences of climate change and their management, not the SCC (a metric).

- Conceptual and methodological issues to consider in climate benefits and cost-benefit calculations.

- **Study Objective:** Develop intimate understanding of how the SCC is being used, and should be used, that informs public dialogue and future application.
The Social Cost of Carbon: An Important Metric & Issue

- **Social Cost of Carbon (SCC)** is an important metric
  - An estimate of damages to society from a unit of CO$_2$
  - An estimate of the benefits of avoiding a unit of CO$_2$

- SCCs increasingly being considered & used to value greenhouse gas emissions
  - Federal, state, local, and other decisions-makers

- **US Government (USG) legally obligated to value CO$_2$**
  - Obama: USG developed SCC values used.

- Lack of technical information & understanding needed for proper evaluation and discourse
  - Led to detailed EPRI assessment of SCC modeling (1st EPRI SCC webcast)
  - And now, EPRI analysis of SCC application
This Study

- Investigates SCC use to understand and evaluate the state of the art for application
- Identifies specific issues and opportunities for improving existing and future CO₂ reduction benefit and cost-benefit analyses
  - Issues and insights continue to be relevant.

Methodology

1. Catalogue types of SCC applications
2. Develop an inventory of federal regulatory applications
3. Characterize appropriate use—conceptually and mechanically
4. Evaluate applications, identifying issues and opportunities for improvement

Applying the Social Cost of Carbon: Technical Considerations

# Types of SCC Applications

<table>
<thead>
<tr>
<th>Application type</th>
<th>Examples</th>
<th>Global emissions implications</th>
<th>SCCs used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal regulatory</td>
<td>DOT (NHTSA) vehicle efficiency standards, EPA Clean Power Plan, DOE small motor efficiency standard, DOE microwave efficiency standard (1, 2, 3, 4)</td>
<td>Incremental</td>
<td>USG</td>
</tr>
<tr>
<td>Federal non-regulatory</td>
<td>CEQ NEPA reviews, BLM coal mine permitting (5, 6)</td>
<td>Incremental</td>
<td>USG</td>
</tr>
<tr>
<td>State</td>
<td>Minnesota, Maine (7, 8)</td>
<td>Incremental</td>
<td>USG considered</td>
</tr>
<tr>
<td>Local (e.g., city)</td>
<td>Austin, TX (9)</td>
<td>Incremental</td>
<td>Custom</td>
</tr>
<tr>
<td>Value of technology</td>
<td>Technology SCC pricing (10)</td>
<td>Incremental</td>
<td>USG and other</td>
</tr>
<tr>
<td>Non-U.S. regulatory</td>
<td>Canada, United Kingdom (U.K.) (11, 12)</td>
<td>Incremental</td>
<td>Canada – USG UK – Custom</td>
</tr>
<tr>
<td>Federal climate goal evaluation</td>
<td>U.S. proposed legislative GHG cap and trade policy (12)</td>
<td>Non-incremental</td>
<td>USG</td>
</tr>
<tr>
<td>Global climate goal evaluation</td>
<td>Tol (2009) (13)</td>
<td>Non-incremental</td>
<td>Custom</td>
</tr>
</tbody>
</table>

"Incremental" = policy with relatively small expected effect on global emissions

"USG SCCs" = federal Interagency Working Group values
Inventory of U.S. Federal Regulatory SCC Applications


(only primary summary results from rules shown)

- Clean Power Plan (2015)
- Proposed Medium- and Heavy-Duty Vehicle Standards (2015)

- 72% final rules, 28% proposed
- 68% DOE, 24% EPA, 6% EPA/DOT, 2% DOT
- Updating in process
The Role of CO$_2$ Reduction Benefits in Federal Rules Uncertain

- RIA “primary summary” results suggest **climate benefits not the main driver** for most rules
- However, caution about drawing conclusions!!
- More than primary summary results in RIAs – CO$_2$ benefits can be minority to majority of benefits
- Most importantly, we identify issues that need to be addressed to properly assess CO$_2$ reduction and net benefits

Primary benefits in U.S. Federal Rules (based on RIA “primary summary” values)

ECS = Energy Conservation Standards (DOE)
CO₂ Benefits Could be Minority to Majority of Benefits
E.g., Clean Power Plan RIA

Estimated 2020 and 2030 range of estimated benefits, costs, and net benefits for EPA's Clean Power Plan (Rate Based Approach)

- **Low 2030 SCC x CO₂ reduction**
- **High 2030 SCC x CO₂ reduction**

<table>
<thead>
<tr>
<th>Year</th>
<th>Low 3% DR Health Ben.</th>
<th>High 3% DR Health Ben.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>$0</td>
<td>$10</td>
</tr>
<tr>
<td>2030</td>
<td>$20</td>
<td>$100</td>
</tr>
</tbody>
</table>

- **Air pollution health co-benefits**
- **Climate (CO₂) benefits**
- **Total compliance costs**
- **Net benefits**

Developed from EPA RIA
Appropriate SCC Application

Conceptually

- SCC<sub>t</sub> = The net present value of global climate change impacts from one additional net global metric ton of carbon dioxide emitted to the atmosphere at a particular point in time
  - SCC is a **marginal value** (cost or benefit) of CO<sub>2</sub>
  - SCC depends on the **projected reference condition**
  - SCC values one unit change in **net global** CO<sub>2</sub>

- Proper use:
  - SCC is an appropriate metric for valuing incremental changes in global CO<sub>2</sub> emissions
  - Estimated CO<sub>2</sub> changes should be estimates of global net changes in CO<sub>2</sub>

Mechanically

- Two contexts—calculating CO<sub>2</sub> reduction benefits and policy net benefits

  \[
  \text{Net Present Value CO}_2 \text{ Reduction Benefits} = \sum_{t=0}^{\infty} \frac{1}{(1+i)^t} (\text{Net global CO}_2 \text{ Reduction}_t \times \text{SCC}_t)
  \]

  \[
  \text{Net Present Value Net Benefits} = \text{NPV Benefits} - \text{NPV Compliance Costs}
  = \text{NPV CO}_2 \text{ Reduction Benefits}
  + \text{NPV Other Benefits}
  - \text{NPV Compliance Costs}
  \]

- Challenges: combining calculations from different analyses, value streams over time, discounting
Key Issues Identified in SCC Applications

- Consistency between estimated benefits and costs
  - Inconsistency in reference socioeconomic and emissions assumptions
  - Inconsistency in the treatment of uncertainty across calculations
  - Inconsistency in the type of values compared (levelized vs. annual)
Inconsistency in Reference Assumptions & Uncertainty

U.S. socioeconomic and CO$_2$ emissions assumptions

Two types of inconsistency:
(1) Future represented
(2) Treatment of uncertainty

Comparing Clean Power Plan CO$_2$ reductions & compliance cost reference assumptions (AEO 2015) with SCC assumptions (USG)
Inconsistency in Reference Assumptions & Uncertainty

Socioeconomic/ emissions assumptions matter for the SCC. May matter for other cost-benefit calculations also.

Average 2020 USG SCCs by discount rate, model and socio/ emissions scenario

SCC variation across socioeconomic scenarios (60-100% in the model averages)
Inconsistency in the Type of Values Compared – Levelized vs. Annual

Why is this problematic?

Levelized cost reflects discounted stream of values. Annual benefit value does not. **Cannot compare!!**

And, potentially misleading with different conclusions depending on comparison year. **Both invalid!**

Need to compare net present values!!
Key Issues Identified in SCC Applications

- **Consistency between estimated benefits and costs**
  - Inconsistency in reference socioeconomic and emissions assumptions
  - Inconsistency in the treatment of uncertainty across calculations
  - Inconsistency in the type of values compared (levelized vs. annual)

- **Estimating net global CO₂ changes**
  - SCC is the value of a net incremental change in **GLOBAL CO₂**
  - Regulations do not typically estimate CO₂ changes beyond the regulated segment (i.e., leakage)
  - x% positive leakage = x% lower CO₂ benefits
Need to Estimate **Net Global** CO₂ Changes

- Do we need to revise CO₂ benefits estimates?
- Yes, if there is expected to be significant CO₂ leakage beyond the regulated segment
- X% leakage = X% lower CO₂ benefits!

E.g., Estimated CO₂ leakage and electricity prices changes with subnational SCC pricing of power sector CO₂

![Graph showing cumulative leakage to 2040 and in-region electricity price change in 2040](Bistline and Rose (2017))
Key Issues Identified in SCC Applications

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  - x% positive leakage = x% lower CO₂ benefits

- **Use of multiple SCC values**
  - Which SCC should be used (and corresponding benefits estimate)?
  - In one rule, across rules, across agencies?
Which SCC Should be Used?

Example range of CO₂ reduction benefits using the four USG SCC trajectories (CPP)

<table>
<thead>
<tr>
<th>Climate Benefits b</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% discount rate</td>
<td>$0.80</td>
<td>$3.1</td>
<td>$6.4</td>
</tr>
<tr>
<td>3% discount rate</td>
<td>$2.8</td>
<td>$10</td>
<td>$20</td>
</tr>
<tr>
<td>2.5% discount rate</td>
<td>$4.1</td>
<td>$15</td>
<td>$29</td>
</tr>
<tr>
<td>95th percentile at 3% discount rate</td>
<td>$8.2</td>
<td>$31</td>
<td>$61</td>
</tr>
</tbody>
</table>


Table ES-1: Social Cost of CO₂, 2010 – 2050 (in 2007 dollars per metric ton of CO₂)

<table>
<thead>
<tr>
<th>Year</th>
<th>5% Average</th>
<th>3% Average</th>
<th>2.5% Average</th>
<th>High Impact (95th Pct at 3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>10</td>
<td>31</td>
<td>50</td>
<td>86</td>
</tr>
<tr>
<td>2015</td>
<td>11</td>
<td>36</td>
<td>56</td>
<td>105</td>
</tr>
<tr>
<td>2020</td>
<td>12</td>
<td>42</td>
<td>62</td>
<td>123</td>
</tr>
<tr>
<td>2025</td>
<td>14</td>
<td>45</td>
<td>66</td>
<td>138</td>
</tr>
<tr>
<td>2030</td>
<td>16</td>
<td>50</td>
<td>73</td>
<td>152</td>
</tr>
<tr>
<td>2035</td>
<td>18</td>
<td>55</td>
<td>78</td>
<td>168</td>
</tr>
<tr>
<td>2040</td>
<td>21</td>
<td>60</td>
<td>84</td>
<td>183</td>
</tr>
<tr>
<td>2045</td>
<td>23</td>
<td>64</td>
<td>89</td>
<td>197</td>
</tr>
<tr>
<td>2050</td>
<td>26</td>
<td>69</td>
<td>95</td>
<td>212</td>
</tr>
</tbody>
</table>

NAS notional alternative for improved SCC uncertainty communication

<table>
<thead>
<tr>
<th>Year</th>
<th>5.0% Low</th>
<th>5.0% Avg.</th>
<th>5.0% High</th>
<th>3.0% Low</th>
<th>3.0% Avg.</th>
<th>3.0% High</th>
<th>2.5% Low</th>
<th>2.5% Avg.</th>
<th>2.5% High</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Key Issues Identified in SCC Applications (continued)

- **Pricing the CO$_2$ externality more than once**
  - Across policies, risk of pricing CO$_2$ twice (or more) – upstream & downstream.
  - *More than once = excess cost to society*
    - E.g., coal mine permitting / Public Utility Commission externalities pricing / Clean Power Plan
    - E.g., low-carbon subsidy / regional emissions cap / Clean Power Plan
  - Coordination (agency, jurisdiction) needed to insure CO$_2$ valued once to avoid excess costs on society

- **Valuing non-CO$_2$ GHGs**
  - Until last year, changes in non-CO$_2$ GHGs typically not valued. Now USG developed SC-CH$_4$ and SC-N$_2$O estimates.
  - Social costs of non-CO$_2$ GHGs differ from the SCC, and global damage trade-offs between GHGs differ from Global Warming Potential trade-offs
  - IMPORTANT: Many issues with current USG SCC modeling and application also relevant for non-CO$_2$ estimates

- **SCCs and overall climate objectives (global, national)**
  - Tempting to apply SCCs to evaluate or help set global and domestic climate policy goals
  - However, SCCs conceptually inappropriate for these applications
  - A different concept & framework needed
Can SCCs Inform Global Climate Policy Goals?

- No! Need a different concept and framework!

- Interested in evaluating transitions from higher to lower climate futures—changing climate and society

- Marginal benefits changing – value of $X^{th}$ ton of CO$_2$ reduced will not equal value of $1^{st}$ ton reduced
  - Shape of climate damage function important

- SCCs
  - Based on a particular assumed socioeconomic and climate future
  - Also, USG SCCs based on an amalgamation of futures

- Marginal costs also changing – rise with the level of emissions reduction ambition

- Bottom line:
  - Evaluating climate strategies requires a framework for consistent modeling of endogenous marginal benefits & costs
  - Also, need better understanding of damages
Marginal Damages are Not Constant
E.g., Implied damage functions behind USG SCC modeling

Global damage functions based on default damage parameterization results from a technical assessment of USG SCC damage component modeling

Developed from Rose et al (2017, 2014)
**Application Issues Identified Not Isolated Instances**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Passenger and light duty truck vehicle efficiency standards</td>
<td>No</td>
<td>No*</td>
<td>Partially, standards based on 3% discount rate average SCC</td>
<td>No, monetized CO₂eq emissions for illustrative purposes but not in net benefits</td>
</tr>
<tr>
<td>Clean Power Plan</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>New Source CO₂ Performance Standard (111(b))</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>NRDC analysis of potential existing source CO₂ performance standard</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cooling water intake regulations</td>
<td>No**</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cost-benefit analysis of U.S. climate legislative proposal (Holladay and Schwartz, 2009)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes, but CO₂eq</td>
</tr>
</tbody>
</table>

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**SCC estimation issues also relevant**

* RIA does estimate emissions reductions for reduced fuel consumption, including imports, but not market driven changes in international consumption

** Only reference assumption inconsistency
Concluding Remarks

- Reviewing and improving SCC use is as important as improving SCC estimation.
- This study identifies fundamental issues to address to improve the reliability of CO₂ reduction benefit and net benefit calculations, insights, and conclusions.
- Application guidance is needed to avoid these issues and facilitate consistent application and improved decision-making.
- SCC estimation issues, of course, still also need to be addressed.
Thank you for joining us today!

We hope you have enjoyed the webcast series. Stay tuned for future related research and insights.

Questions/information: Steven Rose, srose@epri.com.


SCC Webcast Series

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Resources


Inconsistency in the Type of Values Compared – Levelized vs. Annual

Levelized costs cannot be compared to annual benefit values. Comparing can be potentially misleading with different conclusions depending on comparison year. **Both invalid!**

Need to compare net present values!!