Appendix E
Methods for Quantification

This appendix describes in brief the methods used in quantifying the greenhouse gas (GHG) emission reductions and costs/cost savings associated with the policy recommendations, and provides examples of the distinction between "direct" and "indirect" costs. In addition, the combined impacts of all of the policy recommendations within and between each sector were estimated as if all of the recommendations were implemented together. This involved eliminating any overlaps in coverage of affected entities that would occur to avoid double counting of impacts. These quantification methods are based on those widely accepted among climate change mitigation policy analysts. The following general methods were used as the starting point, but were customized as needed to address the policy design features and specifications for analysis of each policy, as approved by the South Carolina Climate, Energy and Commerce Advisory Committee (CECAC):

Methods for Quantifying the Impacts of Policy Recommendations

- **Focus of Analysis:** Quantify the net GHG reduction potential in physical units of million metric tons (MMt) of carbon dioxide equivalent (CO_2e) and net cost per metric ton reduced in units of dollars per metric ton of carbon dioxide equivalent ($/t$CO_2e$). Where possible, full life-cycle analysis is used to evaluate the net energy (and emissions) performance of actions (taking into account all energy inputs and outputs to production). Net analysis of the effects of carbon sequestration is conducted where applicable.
- **Cost-Effectiveness:** Because monetized dollar values of GHG reduction benefits are not available, use physical benefits instead, measured as dollars per $MMtCO_2e$ (cost or savings per ton) or "cost-effectiveness" evaluation. Estimate both positive costs and cost savings (negative costs) as a part of compliance cost.
- **Geographic Inclusion:** Measure the GHG impacts of activities that occur within the state, regardless of the actual location of emission reductions. For instance, a major benefit of recycling is the reduction in material extraction and processing (e.g., aluminum production). While a policy recommendation may increase recycling in South Carolina, the reduction in emissions may occur where this material is produced. Where significant emission impacts are likely to occur outside the state, this has been clearly indicated. These emission reductions are counted toward the achievement of the state's emission goal, since they result from actions taken by the state.
- **Direct vs. Indirect Effects:** Define "direct effects" as those borne by the entities implementing the policy recommendation. For example, direct costs are net of any benefits or savings to the entity. Define "indirect effects" as those borne by the entities other than those implementing the policy recommendation. Indirect effects were quantified on a case-by-case basis, depending on magnitude, importance, time available, need and availability of data. (See additional discussion and list of examples below.)
- **Non-GHG (External) Impacts and Costs:** Include these impacts and costs in qualitative terms where deemed important. Quantify then on a case-by-case basis as needed, depending on need and where data are readily available.

- **Discounting and Annualizing:** Discount a multi-year stream of net costs (or savings) to arrive at the "net present value cost" of the cost of implementing a policy recommendation. Discount costs in constant 2005 dollars using a 5% annual real discount rate for the project period of 2008 through 2020 (unless otherwise specified for the particular policy recommendation). Represent capital investments in terms of annualized or amortized costs through 2020. Create an annualized cost or cost savings per ton by dividing the present value cost or cost savings by the cumulative reduction in tons of GHG emissions.
- **Time Period of Analysis:** Count the impacts of actions that occur during the project time period and, using levelized emission reduction and cost analysis, report emission reductions and costs for specific target years, such as 2012 and 2020. Where additional GHG reductions or costs occur beyond the project period as a direct result of actions taken during the project period, show these for comparison and potential inclusion.
- **Aggregation of Cumulative Impacts of Policy Recommendations:** In addition to "stand-alone" results for each of the policy recommendations, estimate the cumulative impacts of all policy recommendations combined. In this process, we avoid simple double counting of GHG reduction potential and cost when adding the emission reductions and costs associated with all of the policy recommendations. To do so we note and or estimate interactive effects between policy recommendations using analytical methods where significant overlap or equilibrium effects are likely.
- **Policy Design Specifications and Other Key Assumptions:** Include explicit notation of the timing, goal levels, implementing parties, the type of implementation mechanism, and other key assumptions as determined by the CECAC.
- **Transparency:** Include policy design choices (above) as well as data sources, methods, key assumptions, and key uncertainties. Use data and comments provided by the CECAC to ensure best available data sources, methods, and key assumptions using their expertise and knowledge to address specific issues in South Carolina. Make modifications through facilitated decisions.

For additional reference, see the economic analysis guidelines developed by the Science Advisory Board of the U.S. Environmental Protection Agency, available at: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html.

Examples of Direct/Indirect Net Costs and/or Savings

Note: The following examples are meant to be illustrative.

Residential, Commercial, and Industrial (RCI) Sectors

Direct Costs and/or Savings

- Net capital costs (or incremental costs relative to standard practice) of improved buildings, appliances, equipment (cost of higher-efficiency refrigerator versus refrigerator of similar features that meets standards)
- Net operation and maintenance (O&M) costs (relative to standard practice) of improved buildings, appliances, equipment, including avoided/extra labor costs for maintenance (less changing of compact fluorescent light (CFL) or light-emitting diode (LED) bulbs in lamps relative to incandescent)
- Net fuel (gas, electricity, biomass, etc.) costs (typically as avoided costs from a societal perspective)
- Cost/value of net water use/savings
- Cost/value of net materials use/savings (for example, raw materials savings via recycling, or lower/higher cost of low-global-warming-potential refrigerants)
- Direct improved productivity as a result of industrial measures (measured as change in cost per unit output, for example, for an energy-/GHG-saving improvement that also speeds up a production line or results in higher product yield)

Indirect Costs and/or Savings

- Respending effect on economy
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)
- Net embodied energy of materials used in buildings, appliances, equipment, relative to standard practice
- Improved productivity as a result of an improved working environment, such as improved office productivity through improved lighting (though the inclusion of this as indirect might be argued in some cases)

Energy Supply (ES) Sector

Direct Costs and/or Savings

- Net capital costs (or incremental costs relative to reference case technologies) of renewables or other advanced technologies resulting from policies
- Net O&M costs (relative to reference case technologies) renewables or other advanced technologies resulting from policies

- Avoided or net fuel savings (gas, coal, biomass, etc.) of renewables or other advanced technologies relative to reference case technologies resulting from policies
- Total system costs (net capital + net O&M + avoided/net fuel savings + net imports/exports + net transmission and distribution costs) relative to reference case total system costs

Indirect Costs and/or Savings

- Responding effect on economy
- Higher cost of electricity reverberating through economy
- Energy security
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)

Agriculture, Forestry, and Waste Management (AFW) Sectors

Direct Costs and/or Savings

- Net capital costs (or incremental costs relative to standard practice) of facilities or equipment (e.g., manure digesters and associated infrastructure, generators, ethanol production facilities)
- Net O&M costs (relative to standard practice) of equipment or facilities
- Net fuel (gas, electricity, biomass, etc.) costs or avoided costs
- Cost/value of net water use/savings

Indirect Costs and/or Savings

- Net value of employment impacts
- Net value of human health benefits/impacts
- Net value of ecosystem health benefits/impacts (wildlife habitat, reduction in wildfire potential, etc.)
- Value of net environmental benefits/impacts (value of damage by air or water pollutants on structures, crops, etc.)
- Net embodied energy of water use in equipment or facilities relative to standard practice
- Reduced vehicle miles traveled (VMT) and fuel consumption associated with land-use conversions (e.g., as a result of forest/rangeland/cropland protection policies)

Transportation and Land Use (TLU) Sector

Direct Costs and/or Savings

- Incremental cost of more efficient vehicles net of fuel savings

- Incremental cost of implementing smart growth programs, net of saved infrastructure costs
- Incremental cost of mass transit investment and operating expenses, net of any saved infrastructure costs (e.g., roads)
- Incremental cost of alternative fuel, net of any change in maintenance costs

Indirect Costs and/or Savings

- Health benefits of reduced air and water pollution
- Ecosystem benefits of reduced air and water pollution
- Value of quality-of-life improvements
- Value of improved road safety
- Energy security
- Net value of employment impacts

Methods for Quantifying Cumulative Impacts of Overlapping Policy Recommendations

In addition to estimating the impacts of each individual policy recommendations, the *combined* impacts of the policy recommendations in each sector were estimated assuming that all were implemented together. This involved eliminating any overlaps in coverage that would occur to avoid double counting of impacts. Also, some of the policy recommendations in one sector overlapped with policy recommendations in another sector; therefore, these overlaps were identified and the impact analysis was adjusted to eliminate double counting of impacts associated with these intersector overlaps. The following section identifies where these overlaps occurred and explains the methods used to adjust the impacts analysis to avoid double counting of impacts.

RCI Cumulative Impacts Analysis Methodology

To assess the cumulative emission reductions for the policies in the RCI sector, it is necessary to consider any overlaps among the policies that affect similar types of energy use. Specifically, some policies (such as RCI-1 and RCI-2) are defined by their goals for reducing energy use, while others (such as RCI-3) are defined by addressing a specific type of energy use. In these cases, it is important to consider whether addressing the specific energy use would add to the overall reductions, or would just be subsumed into the more general reduction goal.

To address this issue, policies were compared in terms of the type of energy use they target and the energy reduction strategies they implement. Overlaps were identified and quantified by sector (RCI or government/institutional), type of energy use targeted (water heating, space heating, etc.), and measure (e.g., solar hot water). If a policy's impact by sector and type of energy use was less than the impact from an overlapping policy for that same sector and type of energy use, it was excluded from the cumulative analysis.

Table E-1 summarizes the overlaps for each RCI policy.

Table E-1. Cumulative Impacts Summary

No.	Policy Recommendation	Interaction	Notes
RCI-1	Energy Efficiency Programs, Funds, or Goals for Electricity (Including Expansion of Same)	Effects of new manufactured housing and residential, commercial, and government new construction overlap with RCI-6 and RCI-7.	Partially included in the cumulative totals for RCI. Results for residential and commercial existing stock, existing manufactured homes, and all industrial facilities are incremental to other policies.
RCI-2	Demand-Side Management/Energy Efficiency Programs, Funds, or Goals for Natural Gas, Propane, and Fuel Oil	Effects of new manufactured housing and residential, commercial, and government new construction overlap with RCI-6 and RCI-7.	Partially included in the cumulative totals for RCI. Results for residential and commercial existing stock and industrial stock are incremental to other policies
RCI-3	Incentives and Regulatory Reform To Promote Implementation of Renewable Energy Systems, Including Solar Hot Water (Residential, Commercial, and Industrial)	No overlaps	Fully included in the cumulative totals for RCI. Measures targeting cooling load of businesses with existing chilled water systems are unlikely to be included in broad energy efficiency programs (RCI-1 and RCI-2). Measures targeting hot water use are likely to constitute a very small portion of generic energy efficiency portfolios.
RCI-4	Energy Management Training/Training of Building Operators	Not quantified—no overlaps.	
RCI-5	Incentives, Resources, and Regulatory Reform To Promote Energy Recycling, Including Combined Heat and Power	Negligible overlaps with space heating efficiency improvements in RCI-1 and RCI-2.	Fully included in the cumulative totals for RCI. Combined heat and power is not typically included in electricity energy efficiency portfolios.
RCI-6	Incentives and Policies for Improving Building Efficiency, Including Building Energy Codes	Building code and ENERGY STAR efforts for manufactured homes overlap with residential and commercial new construction within RCI-1 and RCI-2.	Fully included in the cumulative totals for RCI. The impacts from the residential and commercial components of this policy are greater than the impacts of residential and commercial new construction components for RCI-1 and RCI-2 combined.
RCI-7	Improved Design and Construction in New and Existing State and Local Government Buildings, “Government Lead by Example”	Energy efficiency efforts overlap with government and school efforts within RCI-1 and RCI-2.	Fully included in the cumulative totals for RCI. The impacts from this policy are greater than the impacts of the government components of RCI-1 and RCI-2 combined.
RCI-8	Participation in Voluntary Industry–Government Partnerships (Including Incentives)	No overlaps.	Fully included in the cumulative totals for RCI. This policy is assumed to primarily target process emissions, which are not covered by any other policy.
RCI-9	Incentives and Policies for Improving Appliance Efficiency, Including Appliance Standards	Overlaps with appliance programs and upgrades in RCI-1, RCI-2, and RCI-7.	Not included in the cumulative totals for RCI. Fully subsumed by these policies.

Interaction of RCI Policy Recommendations With Other Sectors

RCI and ES

There are two primary interactions between the RCI and ES sector policies, both concerning the clean energy portfolio components in policy ES-1 (Efficiency and Renewable Portfolio Standard and Statement of Support for Nuclear Energy). First, ES-1 includes a requirement that some of the electricity demand in the state be met with energy efficiency measures. This component is assumed to fully overlap with the efficiency target for electricity under RCI-1. In addition, a number of the RCI policies (RCI-1, RCI-3, RCI-5, RCI-6, and RCI-7) decrease overall electricity demand. As the clean energy portfolio requirements are based on meeting a percentage of load with specific clean energy or nuclear resources, the impact of ES-1 would be reduced by reducing energy demand through these RCI policies.

A smaller interaction involves green power purchasing under RCI-7 and renewable energy generation under ES-1. RCI-7 indicates that any portion of electricity consumption that is procured or generated consistent with its goal (i.e., a minimum of 20% of electricity consumed by state and local facilities and schools should come from in-state renewable resources) and is in excess of ES-1's renewable energy requirement, as a percentage of total load, would not count toward the portfolio standard in ES-1. Under ES-1, 5% of government electricity consumption would be required to be supplied with renewable generation. Therefore, the first 5% of the green power provision under RCI-7 fully overlaps with ES-1 and was removed from the RCI cumulative analysis. The incremental impacts from RCI-7's green power requirement (i.e., 15%) were kept in the RCI cumulative analysis.

An additional feedback is that certain ES policies (including ES-1) will have the effect of reducing the GHG emissions associated with energy production, so that RCI policies that target electricity use will have a reduced impact on overall emissions. However, this impact is small and has not been reflected in the analysis.

RCI and Other Sectors

There are no significant overlaps between RCI and any of the other sectors.

ES Cumulative Impacts Analysis Methodology

The ES sector has a number of policies directed toward promoting low- or zero-carbon electricity generating infrastructure, and some overlaps among these policies have been taken into account in the cumulative analysis.

Specifically, the incentives for utility-scale renewable energy projects in ES-3 (Renewable Energy Financing, Tax Incentives, Loans) are assumed to fully overlap with the renewable energy mandate in ES-1. However, the distributed energy incentives in ES-3 are found to be larger than the impact of ES-8 (Distributed Renewable Energy Incentives and/or Barrier Removal [Including Interconnection Rules]), and ES-8 is found to have no incremental impact over ES-3. These distributed renewable energy incentives in ES-3, as well as voluntary green power initiatives (ES-6 [Green Power Purchases and Marketing, 1% Participation by 2012]) are assumed to be incremental and not to overlap with ES-1.

Interaction of ES Policy Recommendations With Other Sectors

ES and RCI

As indicated in the RCI sector cumulative impact discussion, the energy efficiency component of ES-1 is assumed to fully overlap with the energy efficiency policy under RCI-1. In addition, the goals for the nuclear and renewables components of ES-1 are based on total sales in South Carolina, and thus have been adjusted to reflect energy savings under the combined impact of the RCI policy recommendations.

ES and AFW

Several ES policies rely on biomass feedstock to replace fossil-based electricity generation. Similarly, a number of AFW policies also rely on the use of biomass for both electricity production and other energy-related uses. Specifically, the biomass generation benefits in ES-1, ES-3, and ES-6overlap with AFW-2 (On-Farm Waste Energy Recovery), AFW-5 (Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production), and AFW-9 (Waste-to-Energy Reclamation). The fundamental limit that creates an overlap among these policies is the availability of biomass feedstock in South Carolina.

To accommodate this limit, the cumulative impact analysis for the ES sector does not include any of the electricity generation from woody biomass, swine waste, or poultry litter resulting from ES policies, and the impact of landfill gas generation has been reduced by 18%. Either this generation is already accounted for in AFW policies, or else the feedstock is used for another purpose that has a similar or greater impact in mitigating GHG emissions in the state.

ES and TLU

There are no overlaps between the ES and TLU policy recommendations.

TLU Cumulative Impacts Analysis Methodology

CCS calculated the net cumulative impact of the TLU policy recommendations in order to account for overlap and interaction among policies. The GHG reductions resulting from individual stand-alone policies are not additive. For example, a policy that reduces VMT will reduce the GHG benefits of a policy that improves vehicle fuel economy or reduces fuel carbon intensity, and a mile not driven removes the opportunity to reduce the carbon content of the fuel that would otherwise have been used to drive that mile.

The first step in the analysis was to determine whether each policy affects emissions from light-duty vehicles (LDVs), heavy-duty vehicles (HDVs), or both. The second step was to determine whether each policy reduced VMT, improved fuel economy, or reduced the carbon intensity of

fuels. All policies affecting LDVs have overlapping impacts with one another, and all policies affecting HDVs have overlapping impacts with one another.

Table E-2 summarizes the basic relationships between policies and their treatment in the analysis. It also highlights any special considerations for overlap between policies.

Table E-2. TLU Sector Overlaps

Policy No.	Policy Recommendation	Primary GHG Reduction Mechanism	Overlap Considerations
TLU-1	Adopt a South Carolina Clean Car Standard	Increases LDV fuel economy.	Overlaps with federal Corporate Average Fuel Economy (CAFE) requirements established by the Energy Independence and Security Act of 2007.
TLU-2	Transportation System Management	Increases LDV and HDV fuel economy.	
TLU-3	Tax Credits for Efficient Vehicles	Reduces carbon intensity of LDV fuel.	Contributes to TLU-12 total; removed from cumulative totals.
TLU-4	Improve Development Patterns	Reduces LDV VMT.	
TLU-5	Transit & Bike-Pedestrian	Reduces LDV VMT.	Contributes to TLU-4 total; removed from cumulative totals.
TLU-6	Alternative-Fuel Infrastructure	Reduces carbon intensity of LDV and HDV fuel.	Contributes to TLU-12 total; removed from cumulative totals.
TLU-7a	Diesel Engine Emission Reductions and Fuel Efficiency Improvements: Efficiency Improvements	Increases HDV fuel economy.	
TLU-7b	Diesel Engine Emission Reductions and Fuel Efficiency Improvements: Biodiesel	Reduces carbon intensity of HDV fuel.	Contributes to TLU-12 total; removed from cumulative totals.
TLU-8	Stricter Enforcement of Speed Limits	Increases LDV and HDV fuel efficiency.	
TLU-10	Commuter Choice and Commuter Benefits Programs	Reduces LDV VMT.	Contributes to TLU-4 total; removed from cumulative totals.
TLU-12	Low-GHG Fuel Standard	Reduces carbon intensity of LDV and HDV fuel.	Overlaps with AFW-4.

GHG = greenhouse gas; HDV = heavy-duty vehicle; LDV = light-duty vehicle; VMT = vehicle miles traveled.

The net annual cumulative GHG reduction from the TLU policy recommendations (5.53 $MMtCO_2e$ in 2020) is 36% lower than the sum of the individual policy impacts. The overlap total is lower primarily because the impacts of several policies (TLU-3, TLU-5, TLU-6, TLU-7b, and TLU-10) explicitly support, and are therefore subsumed by, the impacts of other policies.

Interaction of TLU Policy Recommendations With Other Sectors and Policies

TLU and Federal Requirements

The impact of TLU-1 overlaps with the new Corporate Average Fuel Economy (CAFE) standard included in the Energy Independence and Security Act of 2007 (EISA). The primary impact of both policies is to increase LDV fuel economy. Since EISA has been passed into law, we have treated the new CAFE requirements as the baseline against which to compare TLU-1. The

overlap between the two policies is accounted for in the stand-alone GHG reduction estimate for TLU-1. Please see the full description of TLU-1 in Appendix I for more information.

TLU and AFW

TLU-12 (Low-GHG Fuel Standard) overlaps with AFW-4 (In-State Liquid Biofuels Production). Specifically, AFW-4 would reduce life-cycle GHG emissions from biofuels by encouraging their production within South Carolina and thereby reducing GHG emissions associated with their transportation and distribution. AFW-4 would therefore contribute to the goal set by TLU-12, to reduce the life-cycle emissions of on-road vehicle fuels by 10%. To account for this overlap, we removed the emission reductions and costs associated with AFW-4 from the adjusted cumulative totals for of TLU policies.

TLU and ES/RCI

There are no overlaps between TLU policies and policies in the ES or RCI sectors.

Overlap Adjustments to TLU Sector

Based on the assumptions above, the cumulative TLU total, adjusted for overlaps, would be as shown in Table E-3.

Table E-3. Overlap Adjustments to TLU Sector

TLU Sector	2012 GHG Reductions ($MMtCO_2e$)	2020 GHG Reductions ($MMtCO_2e$)	2008–2020 GHG Reductions ($MMtCO_2e$)	2008–2020 Costs (Savings) (Net Present Value Million $)	2008-2020 Cost-Effectiveness ($/$tCO_2e$)
Totals of Individual Policies Without Adjustments for Overlaps	1.37	8.64	47.57	*Not calculated*	
Totals Adjusted for Overlaps Among Policies	0.75	5.53	29.29	$2,582†	$88

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

† For policies that have a range of net present values, this figure includes the midpoint. For policies with net present values stated as less than zero, this figure includes zero. The cost of TLU-7b is excluded, because this cost would be covered under the cost of TLU-12.

AFW Cumulative Impacts Analysis Methodology

No interaction between policy recommendations was considered, other than to compile an assessment of available biomass in South Carolina. This assessment revealed that sufficient biomass is available to meet all the goals of the AFW policy recommendations without accounting for overlap.

Interaction of AFW Policy Recommendations With Other Sectors

There was determined to be an interaction between AFW-2 (On-Farm Waste Energy Recovery), AFW-5 (Expanded Use of Biomass Feedstocks for Electricity, Heat, or Steam Production), AFW-9 (Waste-to-Energy Reclamation) and ES-1 (Efficiency and Renewable Portfolio Standard and Statement of Support for Nuclear Energy). This interaction was a result of the AFW policy

goals, which require additional electricity and direct energy generation from biomass sources (biogas from manure, biomass residues, and biogas from landfills). The cumulative totals for the ES sector were adjusted to account for these overlaps.

AFW-4 (In-State Liquid Biofuels Production) overlaps with TLU-12 (Low-GHG Fuel Standard). As previously discussed, the cumulative totals for the TLU sector were adjusted to account for these overlaps.

Overlap Adjustments to AFW Sector

Based on the discussions above, overlaps between AFW and TLU policies and between AFW and ES policies were accounted for by adjusting the cumulative totals for the TLU and ES policies.