2019 CARE Carpet Recycling Cost Survey

CARE Models Evaluation

August 28, 2019
Table of Contents

1. Introduction ........................................................................................................................................ 1-1
   A. Report Overview ........................................................................................................................... 1-1
   B. Introduction to CARE Models ....................................................................................................... 1-1
   C. Summary of Findings .................................................................................................................... 1-9

2. Methodology ....................................................................................................................................... 2-1
   A. Model Review ............................................................................................................................... 2-1
   B. Cost Conversion Model Validation .............................................................................................. 2-1
   C. Analysis and Recommendations .................................................................................................... 2-1

3. Cost Conversion Model Validation ................................................................................................... 3-1
   A. Cost per Pound Tool Validation .................................................................................................... 3-1
   B. Productivity Tool Validation ........................................................................................................ 3-3

4. Overview and Relationships Between Models ................................................................................... 4-1
   A. Legislative Intent and Program Goals .......................................................................................... 4-1
   B. Factors Driving Increased Recycling .......................................................................................... 4-2
   C. Relationship Between CARE Models and Increased Recycling ................................................ 4-3

5. Evaluation and Recommendations ................................................................................................... 5-1
   A. Economic Model .......................................................................................................................... 5-1
   B. Cost Conversion Model ............................................................................................................... 5-2
   C. Financial Model .......................................................................................................................... 5-6
   D. Subsidy Justification Model .......................................................................................................... 5-7
   E. Overall Recommendations .......................................................................................................... 5-9

Appendix A: Glossary ............................................................................................................................ A-1
Section 1
Introduction
1. Introduction

Crowe LLP (Crowe) is conducting a first ever Carpet America Recovery Effort (CARE) Cost Analysis to determine the cost of recycling post-consumer carpet. The Cost Analysis Scope of Work also requires Crowe to “work with CARE to understand and offer recommendations for improvement of CARE’s Economic, Cost Conversion, Financial, and Subsidy Justification Models.” This report provides Crowe’s assessment of the CARE models. This section of report is organized as follows:

A. Report Overview
B. Introduction to CARE Models
C. Summary of Findings

A. Report Overview

Crowe’s evaluation of the CARE models encompasses holistic and detailed approaches. We consider the models from an overall policy perspective, as well as a technical perspective. The CARE Models Evaluation report is organized into the following five sections:

1. **Introduction** – Provides a description of the CARE Models and summary of our evaluation.
2. **Methodology** – Provides an overview of Crowe’s methodology in conducting the evaluation.
3. **Cost Conversion Model (CCM) Validation** – Provides a summary of Crowe’s validation of the CCM utilizing data obtained during the Cost Analysis.
4. **Overview and Relationship Between Models** – Offers an evaluation of the models from a broad perspective.
5. **Evaluation and Recommendations** – Summarizes our analyses and provides an evaluation of each model and recommendations for future iterations of CARE’s modeling effort.

B. Introduction to CARE Models

As described by CARE in Attachment 9 of the California Carpet Stewardship Plan 2018-2022, CARE’s models are intended to be comprehensive planning, predictive, and subsidy facilitation tools. Each of CARE’s four primary models has been developed for a particular purpose in support of the California Carpet Stewardship Program (CCSP). The CARE models represent a substantial body of work and are the first of their kind as it relates to PCC recycling. Crowe has not seen this level of analyses and modeling prepared for other recycling programs. The models reflect CARE’s in-depth knowledge and understanding of the numerous factors and dynamics that influence carpet recycling, and as such provide a foundation for CCSP planning and implementation. **Exhibit 1-1** provides a summary of the purpose, key inputs, and key outputs of the models. **Exhibit 1-2** provides a graphic version of the relationships between key model inputs and outputs. In the remainder of this subsection we provide a brief overview of each model.
Exhibit 1-1
Overview of CARE Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Purpose</th>
<th>Key Inputs</th>
<th>Key Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>• What are the expected prices of PCC fiber and pellets?</td>
<td>• US and CA GDP</td>
<td>• Price of Post-Industrial (PI) carpet</td>
</tr>
<tr>
<td></td>
<td>• What are expected carpet sales?</td>
<td>• Oil prices</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Commodity prices</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Construction/Housing</td>
<td></td>
</tr>
<tr>
<td>Cost Conversion</td>
<td>• How much does it cost to recycle (sort/ process/ manufacture) PCC?</td>
<td>• Operating costs</td>
<td>• Cost per pound to sort, process, manufacture PCC (based on assumptions and data inputs)</td>
</tr>
<tr>
<td></td>
<td>• What is the return for recycling PCC?</td>
<td>• Wages</td>
<td>• Return on Cost Conversion (ROCC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Carpet weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Throughput</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operating assumptions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Market prices</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Subsidy rates</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>• Provide financial guidance on program costs, subsidy payouts</td>
<td>• PCC quantities by company (actual and projected)</td>
<td>• Fund balance (current and projected)</td>
</tr>
<tr>
<td></td>
<td>• Provide information to determine whether the assessment is adequate to cover costs?</td>
<td>• Aggregated mill sales by quarter</td>
<td>• Revenues and expenditures</td>
</tr>
<tr>
<td></td>
<td>• Determine status of and track CARE budget</td>
<td>• Subsidy amounts</td>
<td>• Viability of fund</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• CARE expenses and cash flow</td>
<td>• Adequacy of assessment</td>
</tr>
<tr>
<td>Subsidy Justification</td>
<td>• Identify the per pound subsidy amount for each fiber and pellet type that is required to cover recycling costs</td>
<td>• PI price per pound by fiber and pellet type</td>
<td>• Cents per pound required to cover cost to recycle by fiber and pellet type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PCC cost to recycle by fiber and pellet type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ROCC</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit 1-2 illustrates the flow of information into and out of the four primary CARE models. The economic model estimates carpet sales, pounds of recycled carpet discarded, and projections of the price of post-industrial (PI) fiber and pellets. While the price of PI is generated from the economic model, it is not clear that those prices are currently utilized in the Subsidy Justification Model, as shown. Rather, the Subsidy Justification Model draws on multiple inputs to determine the price of PI. Within the plastics industry, there has been a consistent 10 cent per pound discount for post-consumer carpet (PCC) fiber and pellets as compared to PI, thus the price of PCC is determined from the price of PI.

The CCM generates estimates of the cost to recycle PCC and the associated return under various scenarios and throughput assumptions. The CCM can be applied at the CSE, processor, and/or manufacturer levels. The Subsidy Justification Model utilizes PCC fiber and pellet prices from the economic model and other sources in combination with the CCM cost to recycle data to calculate the amount of subsidy needed to incentivize use of PCC.

The theoretical subsidy requirement from the Subsidy Justification Model, along with carpet sales and recycling projections from the economic model can be utilized in the Financial Model (along with additional CARE data) to calculate total subsidy payouts and determine whether the assessment on carpet sales is adequate to support the program and maintain that approved fund reserve.

In the remainder of this subsection, we provide a brief description of each of the CARE models.
1. Economic Model

The economic model provides an inclusive approach to describe the economic variables and relationships for the costs incurred in the production of post-industrial fiber. The model compares historic economic prices and virgin fiber prices to forecast future post-industrial fiber pricing. Virgin fiber prices are directly related to PCC prices and thus are one factor influencing subsidies.

Purpose

The purpose of the economic model is to detail and describe the economic variables that impact the recycled fibers market. The economic model also describes the relationship between the economic variables and the effect on the recycled fibers pricing.

Structure

The economic model describes the flow of costs and impacts of general macro-economic variables. The model details the forecast and impact of projected US gross domestic product (GDP) and then details the forecast and impact of California GDP. The expectations for California construction and home sales index is also referenced as a benchmark indicator for expected carpet sales in California.

The model describes the cost to produce virgin fiber by detailing the production components such as crude oil and natural gas. The model also discusses the forecasted range of crude oil and natural gas prices and the effect of Force Majeure events upon crude oil and natural gas prices. The model then describes the relationship between crude oil prices, virgin fiber prices and post-industrial fiber prices.
Inputs
The inputs of the economic model include:
- US Gross Domestic Product (GDP)
- California Gross Domestic Product (GDP)
- California construction and housing starts
- Oil and Natural Gas Prices
- Component Prices

Outputs
The outputs of the economic model include Forecasted Post-Industrial prices for:
- Nylon 6
- Nylon 66
- PET
- Polypropylene
- Data to inform estimates of California carpet sales
- Data to inform estimates of California carpet discards

Key Assumptions
The two key assumptions of the economic model is that past performance of price observations is indicative of future performance and that the relationships between the identified economic variables will remain constant. The first key assumption is that the relationship between economic price drivers and the observed historical prices creates a historical pricing pattern or trend that the future price of post-industrial fiber will follow. The second key assumption is that the interrelationships between the economic price drivers will not change significantly and therefore the pattern of historical price trend will not change significantly.

Utilization
CARE utilizes the economic model as one of the first steps to describe the costs associated with fiber pricing and is ultimately among the primary factors in subsidy pricing. The economic model describes the costs incurred to produce virgin fibers, which correlates to post-industrial fiber pricing. The post-industrial fiber pricing correlates to post-consumer pricing which is a principal component in the Subsidy Justification Model. CARE also uses the economic model to inform/validate estimates of carpet sales and discards in the Financial Model.

2. Cost Conversion Model

In collaboration with CARE, Frank Endrenyi developed the Cost Conversion Model (CCM), which was first utilized as a decision-support tool in 2017. The CCM intends to capture all the details of a carpet recycling operation and to allow a variety of inputs to generate both theoretical and actual operational costs and profitability. At this time, there is no other tool that provides the same level of cost and revenue detail on PCC recycling. The CCM is intended to be highly flexible, allowing for a range of operational variations, including inputs and outputs. This unique tool has allowed CARE to better understand the level of subsidy required for different types of recycling operations. Additionally, the CCM can be used to evaluate existing and proposed business models. This subsection provides a high-level overview of the CCM.

Purpose
The purpose of the CCM is to support the Subsidy Justification Model by providing cost per pound and return on cost conversion results to validate current subsidy levels and to suggest adjustments to properly incentivize recycling of carpet.
CARE Models Evaluation

Exhibit 1-3
CCM Input and Output Process

<table>
<thead>
<tr>
<th>Input</th>
<th>Calculation Process</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Productivity Data</td>
<td></td>
<td>• Total Revenue</td>
</tr>
<tr>
<td>• Carpet Material Data</td>
<td></td>
<td>• Total Expense</td>
</tr>
<tr>
<td>• Revenue Data</td>
<td></td>
<td>• Revenue per Pound</td>
</tr>
<tr>
<td>• Expense Data</td>
<td></td>
<td>• Cost per Pound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Net Profit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• % ROCC (Target: 15%)</td>
</tr>
</tbody>
</table>

Structure
The CCM based on a 12-month lifecycle and is organized into five worksheets within a single Excel workbook, each worksheet requires specific inputs to properly generate outputs. Refer to Appendix B for a detailed explanation of each component of the model. Each worksheet is listed below, in order of appearance:

1. Input Summary
2. Process Calculation
3. Expenses
4. Wages
5. Financial

Inputs
The CCM accepts a variety of productivity, carpet material, revenue, and expense inputs. Exhibit 1-3 illustrates the general input and output process of the CCM. Below is a list of the key inputs along with brief descriptions of data requirements:

• Productivity Data
  o Maximum throughput per hour (max gross number of pounds of PCC in per hour)
  o Number of operational days per week and month
  o Percent of up time
  o Number of shifts per day

• Carpet Material Data
  o Face weight
  o Percent of fiber process loss
  o Percent of unusable PCC
  o Percent of each fiber type (Nylon 6, etc.) making up 100% of the PCC used

• Revenue Data
  o Sales revenue per pound per material type (incorporating transportation)
  o Subsidy revenue per pound per material type
• Expense Data
  o Build up costs (utilities, rent, landfill, wages, etc.)
  o Monthly costs (all other costs not relying on build up calculations)

Outputs
There are many intermediate outputs that ultimately results in the key outputs listed below:
• Total revenue
• Total expense
• Revenue per pound
• Cost per pound
• Net profit
• EBITDA
• % Return on Cost Conversion (ROCC)

Key Assumptions
The most significant assumption of the CCM is that most of the input data to generate cost per pound and ROCC results involve a combination of CARE’s extensive carpet recycling experience along with a dialogue involving a subset of existing carpet recyclers. Other key assumptions are listed below:
• All processed material is sold (after factoring in % unsold)
• Broadloom carpet only
• Processor and pellet manufacturer with specific equipment cost rates
• Cost per pound does not include depreciation in the current iteration
• Shipping costs is treated as a reduction in revenue
• Carpet constituent yields based on face weight
• Calcium carbonate (PC4) has no market and only generates subsidy revenue
• Specific processed and manufactured materials sold
• A deep understanding of carpet recycling operations.

Utilization
Ultimately, CARE uses the CCM as a decision-support tool to inform proper subsidy levels by providing cost per pound, and ROCC results. Additionally, the CCM is used as a predictive, scenario-based projection tool that assists with business process optimization.

3. Financial Model
The Financial Model (FM) displays a tiered approach for internal CARE Executives to determine future projections and performance in the Post-Consumer Carpet (PCC) Industry. The model compares budget to actual on a monthly/quarterly/yearly basis, provides past year’s performance for the current plan, and looks forward for the term of the plan to determine if the current budget will sustain the fund balance at the proper level.

Purpose
The purpose of the Financial Model is to provide financial guidance on the costs associated to run the CARE Program, and to estimate subsidy payments, general program and administrative expenses, and assess the needs of California Carpet Stewardship Program (CCSP). CARE uses the Financial Model as an internal tool to make budgetary decisions based on market projections and historical data.
Structure
The Financial Model describes the costs associated with the program, divided into two tiers and their costs by company. Tier 1 consists of Type 1 Processed Fiber, and Sifted PC4. Tier 2 consists of Non-Nylon PET/PTT, Non-Nylon PP, and Nylon 6 + Nylon 66 manufactured products.

Each tier includes:
- The company’s actual total monthly pounds
- Budgeted monthly pounds
- Numerical and percentage change from month-to-month
- Total monthly payout, and
- Actual monthly payout for the 12 months in the fiscal year.

The model totals the actual and budgeted total for each month by previous month’s difference, assessments, interest incomes, total subsidies, and total expenses to come up with an accrued fund balance for the given month.

Moreover, the model includes a scenario analysis to look at various subsidy levels, recycled output pounds required to reach targets, and different activated strategy elements. The model uses a range of ‘what-if’ scenarios to evaluate and inform budgetary decision-making based on the volatile inputs.

The Financial Model cash balance calculation incorporates the starting fund balance carried forward from the prior Plan in the previous year to represent the offset of costs to fund the current year’s Program. The FM is inclusive of the 5-year fully funded plan.

Inputs
A key input is the recycled output performance given by individual collector/sorter, processor, and manufacturer companies, and subsidy payments by month of the basis of the Plan.

Expenses in the model include grants, salaries, education and outreach, contractor services, technical assistance, accounting and legal expenses, CalRecycle administrative fees, collections costs, public drop-off sites, and more. The total monthly payout and total budgeted monthly payout are calculated for each month, which eventually is subtracted from the interest incomes and assessments. The fund reserve is calculated at the end of each quarter by dividing the total payouts (subsidies and other expenses) for that quarter by three and multiplying by two.

The inputs in the FM draw on predictions and actual data from the economic model’s projected market sales as well as the amount of carpet sold. The inputs of the Financial Model are standalone estimates based on the collaboration with the Aprio survey given to carpet mills to determine sales and projected market environments for the near future. The inputs were also determined based on inside industry input to CARE to determine sales and other factors contributing to the market. There are three categories of expenses in regards to running the program: general program expenses, subsidies, and administrative costs.

Outputs
The key outputs from the Financial Model are as follows:
- Actual revenue and expenditures (historical)
- Projected revenue and expenditures (future)
- Current and previous month’s payouts
- Fund reserve per quarter
- Pounds of recycled output and recycling rate
- Calculated stand-alone assessment cost per square yard to fund the quarter versus actual assessment.
Key Assumptions
The key assumptions regarding the Financial Model involve the market and projected revenue from carpet mills each quarter. The assumptions include:

- Estimated sales on new carpet in California
- Estimates recycled output pounds in each category being subsidized by CARE.

Utilization
The Financial Model was designed to provide guidance on costs associated with the program and to estimate the subsidy payments, general program and administrative costs, and requirements to fund Plan activities. It is an internal tool for CARE to track reserves for predicted expenditures during the length of the 5-year Plan.

4. Subsidy Justification Model
The Subsidy Justification Model draws on inputs from the Cost Conversion Model and potentially the economic model. The model supports CARE decision-making related to the need for subsidies and subsidy levels to support PCC recycling.

Purpose
The purpose of the Subsidy Justification Model (SJM) is to identify the per pound subsidy amount for each fiber and pellet type that is required to cover recycling costs. CARE can utilize this information to determine whether subsidies are providing an adequate incentive to support recycling of PCC.

Structure
The SJM has the most basic structure of the four CARE models, consisting of one simple Excel worksheet. The model framework clearly identifies data sources and equations. The SJM calculates subsidy levels for eight different PCC components and/or fiber types:

- Nylon 6 pellets
- Nylon 6 fiber
- Nylon 66 pellets
- Nylon 66 fiber
- PET pellets
- PET fiber
- PP pellets
- PC4 (calcium carbonate).

The model includes a series of calculations to determine the cost to recycle (conversion cost) with a profit (rate of return or return on conversion cost (ROCC)) of 15 percent. The calculated subsidy required to incentivize the use of PCC materials (column H) is the difference between the conversion cost with return and the PCC market price. A positive number means that the cost to recycle is greater than the market value of the material (thus requiring a larger subsidy), while a negative number means that the market value is greater than the cost to recycle the material.

Inputs
There are three primary inputs to the SJM. The first is the market price of post-industrial (PI) material for each of the eight PCC components identified above. Currently these material prices are based on multiple inputs, including actual prices paid by compounders. Current and historical PI and post-consumer plastic fiber prices are available from industry sources. The economic model also generates estimates of PI fiber prices that provide a comparison or check to the market prices. The second input is the cost to recycle for each of the eight PCC components. These costs are generated from the CCM. The third input is the
current subsidy for each of the eight components. In the SJM, the subsidies reflect the combined processor and manufacturer subsidies.

Outputs
The SJM output is the subsidy difference: the combined processor/manufacturer subsidy minus the subsidy required (column J). The difference is negative if the current subsidy is not high enough to incentivize use of PCC materials. The difference is positive if the current subsidy is above the amount needed to incentivize use of PCC materials.

Key Assumptions
The SJM incorporates a number of assumptions. These assumptions influence model outcomes. Key assumptions include:

- A PCC discount of 10 cents per pound as compared to PI pellet prices
- A market price of PET PI bottle flake that is representative for PCC PET fiber prices
- That CCM conversion costs provide reasonable estimates of the cost to recycle
- A small, but positive subsidy difference reflects an adequate subsidy level to incentivize recycling
- That a 15 percent return on conversion cost is reasonable.

Utilization
CARE utilizes the SJM to inform decisions related to the subsidy level for each material type and provide assurance that the subsidies are set at appropriate levels to incentivize PCC recycling. Decisions related to subsidy levels are influenced by a number of other factors, including real-time market responses, CalRecycle and stakeholder opinions, and AB1158’s “highest recyclability” requirement.

Based on the current iteration of the SJM, the subsidy levels are essentially on target for nylon 6 pellets and fiber, nylon 66 fiber, polypropylene (PP) pellets, and PC4. Based on the model, the subsidies are higher than required for nylon 66 pellets, which have a significantly higher market price than the other materials. Based on the model, the subsidy is not adequate for PET pellets, although at the present time there are no PET pellet markets. CARE will address this issue as appropriate.

C. Summary of Findings
Crowe evaluated the CARE models at several levels, as described in the remainder of this report. We briefly summarize our results below for three levels:

- Individual evaluation of the models
- Validation of the Cost Conversion Model
- Evaluation of overall modeling approach.

Individual evaluation of the models
The extent of Crowe’s review of the four CARE models was dependent on the model versions and information available. Thus, our comments are more detailed for the CCM model.

- Economic Model – This model describes the economic variables that influence post-industrial fiber prices and carpet sales to inform CARE decision-making, the CCM, and the Subsidy Justification Model. Crowe recognizes the model as a predictive tool and recommends evaluating opportunities to simplify the model by reducing overlapping variables.

- Cost Conversion Model – The CCM is a valuable tool to predict carpet recycling costs to inform subsidy levels. The model also has several limitations resulting from the formulas, links, and assumptions. In Section 5 we provide a number of structural and functional recommendations to improve transparency and accuracy, streamline, and add value.
- **Financial Model** – This model is an effective internal budgeting tool. The model results are dependent on assumptions of carpet sales and recycled output, thus variations in these factors could result in substantially different results.

- **Subsidy Justification Model** – The SJM consists of relatively few inputs and is a straightforward tool to evaluate subsidy levels and the values necessary to incentivize recycling. While the results are highly dependent on the assumptions and data inputs, the simplicity and transparency of the model allow for adjustments and varied assumptions.

**Validation of the Cost Conversion Model**

Crowe’s validation of the CCM is provided in Section 3 of this report. We evaluated two aspects of the model: cost per pound and productivity, comparing CCM results to those of our cost analysis results for four recyclers. Crowe’s methodology includes depreciation and shipping, while the CCM version that we compared against did not include depreciation and shipping in the cost per pound calculations. When we removed depreciation and shipping from our cost analysis results, the cost per pound calculation was the same as the CCM. However, the fact that there are no differences between the CCM cost per pound and the Crowe methodology cost per pound minus depreciation and shipping simply reflects the fact that this component of the CCM is simply comparing costs divided by total pounds.

When we included depreciation and shipping in our cost analysis results and compared cost per pound with the CCM, the CCM results were lower, as expected. In this comparison, the CCM underestimated costs as compared to Crowe’s methodology. The difference depends on a company’s depreciation and shipping costs.

Crowe validated productivity projections by comparing the CCM’s net output weight available for sale against actuals from the recyclers that provided productivity data (which was not part of Crowe’s survey). The output assumptions in the CCM appear to be higher than actual based on our sample of two recyclers. This indicates that there could be other factors to consider when projecting net output.

**Evaluation of Overall Modeling Approach**

Crowe recognizes that the CARE models are not “final” versions. CARE has developed these models over the last few years, with multiple iterations and refinements occurring in parallel on an ongoing basis. These models represent a significant body of work on the part of CARE and their modeling team. Crowe’s overall recommendations and our recommendations on individual models are intended to support the further refinement and development of the models, simplify them where possible, provide better insight into carpet recycling economics, and support of the goals of the CCSP.

Our primary overall recommendation is to eventually combine the models into one comprehensive workbook. At this point, we recommend combining the Economic, Cost Conversion, and Subsidy Justification Models, and leaving the Financial Model as a separate tool. In combining models, we recommend simplifying and streamlining each model to minimize duplication. We also recommend clarifying the linkages between models and improving transparency. We recognize this would be a major undertaking, and do not recommend combining models until they are more fully developed to avoid unnecessary work and revisions.
Section 2
Methodology
2. Methodology

Crowe conducted a three-part evaluation of the CARE models. This section provides a summary of Crowe’s approach to the CARE Model Evaluation, as follows:

A. Model Review
   - Purpose of each model
   - Validity of the model, inputs, and outputs to meet the model needs
   - Technical accuracy of the model
   - Assumptions and potential limitations
   - Inputs and outputs.

B. Cost Conversion Model Validation
   - Evaluation of CCM equations, linkages, and key assumptions
   - Validation of cost per pound results
   - Validation and sensitivity analysis of productivity assumptions.

C. Analysis and Recommendations
   - Reviewed the purpose and intent of the California Carpet Stewardship Program (CCSP) and the models
   - Individually evaluated each of the model’s inputs, assumptions, relationships, and outputs
   - Identified additional information or approaches to further support the CCSP
   - Identified recommendations to further improvements to the CARE models.
Section 3
Cost Conversion
Model Validation
3. Cost Conversion Model Validation

The Cost Conversion Model (CCM) is essential to derive cost per pound and return information to support the justification of subsidy levels. Crowe selected four recyclers from the cost analysis to validate the CCM against. This section is organized as follows:

A. Cost per Pound Tool Validation
B. Productivity Tool Validation

A. Cost per Pound Tool Validation

Cost per pound is the key output that supports the Subsidy Justification Model. Having accurate cost per pound data is critical to properly evaluate subsidy levels. This metric has been selected for validation due to its criticality, the available data collected, and the ability to objectively compare results. In this test, cost per pound is validated through using actual expenses and weights from four recyclers to compare the CCM cost per pound results against Crowe's cost per pound results. The cost per pound reflects an average across all material types. Validation was performed using two methods, described below:

1. Cost per pound without depreciation and without shipping
2. Cost per pound with depreciation and without shipping
3. Cost per pound without depreciation and with shipping costs
4. Cost per pound with depreciation and with shipping costs.

All tests were performed without making any formula modifications to the CCM. The CCM removes depreciation from the costs in cost per pound while Crowe’s cost per pound methodology incorporates depreciation and shipping as applicable expenses for a recycling operation. The CCM handles shipping as reducing revenue and therefore it is not shown as an expense in the financial worksheet. This understates total expenses, which in turn understates cost per pound. Because of its apparent effect on cost per pound, Crowe is performing two additional tests to evaluate the impact of this method of reducing revenue and not treating shipping as an expense for the selected recyclers. By doing this, it will demonstrate levels of effects it can have on cost per pound results.

The results for cost per pound without depreciation and without shipping is presented in Exhibit 3-1. The fact that there are no differences between the CCM cost per pound and the Crowe methodology cost per pound minus depreciation simply reflects the fact that this component of the CCM is simply comparing costs divided by total pounds.

### Exhibit 3-1
Cost per Pound without Depreciation and without Shipping

<table>
<thead>
<tr>
<th>Company</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.00%</td>
</tr>
<tr>
<td>B</td>
<td>0.00%</td>
</tr>
<tr>
<td>C</td>
<td>0.00%</td>
</tr>
<tr>
<td>D</td>
<td>0.00%</td>
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<tr>
<td>E</td>
<td>0.00%</td>
</tr>
<tr>
<td><strong>Non-Weighted Average</strong></td>
<td><strong>0.00%</strong></td>
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</tbody>
</table>
The results for cost per pound with depreciation and without shipping are presented in **Exhibit 3-2**. Percent difference is compared against the CCM's cost per pound result, meaning that a negative percentage represents that the CCM cost per pound is lower than Crowe's cost per pound result. Since the CCM removes depreciation from the cost per pound calculation, it is not reflecting total expenses. This results in negative differences among all tests, that is, the CCM underestimates costs as compared to Crowe's methodology. The difference depends on a company's depreciation. The CCM would not provide an accurate representation of all costs for companies that were making significant investments in new equipment, for example. As depreciation is a very real and true cost to a recycling operation where substantial to complete reliance on large equipment is commonplace, depreciation should be not be excluded.

**Exhibit 3-2**

Cost per Pound with Depreciation and without Shipping

<table>
<thead>
<tr>
<th>Company</th>
<th>% Difference</th>
<th>Depreciation % of Total Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.17%</td>
<td>0.17%</td>
</tr>
<tr>
<td>B</td>
<td>-0.13%</td>
<td>0.13%</td>
</tr>
<tr>
<td>C</td>
<td>-0.15%</td>
<td>0.15%</td>
</tr>
<tr>
<td>D</td>
<td>-1.74%</td>
<td>1.71%</td>
</tr>
<tr>
<td>E</td>
<td>-6.53%</td>
<td>6.13%</td>
</tr>
<tr>
<td><strong>Non-Weighted Average</strong></td>
<td><strong>-1.74%</strong></td>
<td><strong>1.66%</strong></td>
</tr>
</tbody>
</table>

The results for cost per pound without depreciation and with shipping costs are presented in **Exhibit 3-3**. Percent difference is compared against the CCM's cost per pound result, meaning that a negative percentage represents that the CCM cost per pound is lower than Crowe's cost per pound, which includes shipping.

**Exhibit 3-3**

Cost per Pound without Depreciation and with Shipping Costs

<table>
<thead>
<tr>
<th>Company</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.07%</td>
</tr>
<tr>
<td>B</td>
<td>-24.55%</td>
</tr>
<tr>
<td>C</td>
<td>-0.06%</td>
</tr>
<tr>
<td>D</td>
<td>-17.40%</td>
</tr>
<tr>
<td>E</td>
<td>-0.41%</td>
</tr>
<tr>
<td><strong>Non-Weighted Average</strong></td>
<td><strong>-8.50%</strong></td>
</tr>
</tbody>
</table>

The results in **Exhibit 3-4** show the combined effect of including both depreciation and shipping costs. Percent difference is compared against the CCM's cost per pound result, meaning that a negative percentage represents that the CCM cost per pound is lower than Crowe's cost per pound, which includes shipping. Because all recyclers incurred some level of shipping, all percent differences are negative. Results presented in both Exhibit 3-3 and 3-4 indicate that there is an impact to all recyclers who incur shipping costs, with the most significant impact to recyclers with a high cost of shipping. In order to provide transparency and to calculate the proper cost per pound, shipping should be handled as an expense rather than a reduction in revenue. To conclude, cost per pound will be understated within the CCM for any recycler with depreciation or shipping costs.
Exhibit 3-4
Cost per Pound with Depreciation and with Shipping Costs

<table>
<thead>
<tr>
<th>Company</th>
<th>% Difference</th>
<th>Depreciation % of Total Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.24%</td>
<td>0.17%</td>
</tr>
<tr>
<td>B</td>
<td>-24.72%</td>
<td>0.13%</td>
</tr>
<tr>
<td>C</td>
<td>-0.21%</td>
<td>0.15%</td>
</tr>
<tr>
<td>D</td>
<td>-19.44%</td>
<td>1.71%</td>
</tr>
<tr>
<td>E</td>
<td>-6.96%</td>
<td>6.13%</td>
</tr>
<tr>
<td>Non-Weighted Average</td>
<td>-10.31%</td>
<td>1.66%</td>
</tr>
</tbody>
</table>

B. Productivity Tool Validation

The CCM also serves as a productivity tool that involves throughput, up time percentages, number of operating days in a month, and the resulting net output. As a productivity tool, it allows scenario-based projections by allowing adjustments to the aforementioned productivity inputs. This tool directly drives the amount of revenue that a recycler may expect to receive based on total net output weight, which is multiplied by revenue and subsidy per pound rates. The high positive correlation with projected revenue within the CCM makes this tool essential to understand how the CCM works as a productivity tool. In this test, Crowe validated productivity projections by comparing the CCM’s net output weight available for sale against actuals from the recyclers that provided productivity data (which was not part of Crowe’s survey). Crowe conducted the tests using two methods, described below:

1. Net output using default assumptions on percentages of processed fiber that is sold
2. Net output using actual percentages of processed fiber that was sold.

Net output using default assumptions on the percentages of sold processed fiber (95% for face fiber and 97% for PP backing) is presented in Exhibit 3-5. Net output using actual percentages of sold processed fiber (100%) is presented in Exhibit 3-6. We compare percent difference between the two recyclers’ net output against the CCM’s net output weight. A positive amount means that the CCM generated a higher net output than actuals from recyclers. In both cases the output assumptions in the CCM appear to be higher than actual based on our sample of two recyclers. This indicates that there could be other factors to consider when projecting net output and that productivity cannot be based solely on max throughput and up time, and number of operating days in a month—which are the components used in the CCM to drive net output numbers. While up time and number of operating days in a month are straightforward; there must be an efficiency factor that impacts actual throughput. Improving the CCM as a theoretical productivity tool might require a more intricate method to consider efficiency differences between various machinery and processes. It would also be beneficial to conduct this comparison for more than two companies.
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Section 4
Overview and Relationships Between Models
4. Overview and Relationships Between Models

This section examines the CARE models within the broader context of the overall California Carpet Stewardship Program (CCSP). Crowe included this section in the report because we believe that a full evaluation of the CARE models should occur within the context of a broader program perspective. The models themselves are tools to enable CARE to more proactively manage the program. In this section we consider how the models support the program objectives. We provide recommendations for improvement in the final section of the report. This section is organized as follows:

A. Legislative Intent and Program Goals
B. Factors Driving Increased Recycling
C. Relationship Between CARE Models and Increased Recycling.

A. Legislative Intent and Program Goals

The CCSP was established in 2010 by AB2398 (Perez, Statutes of 2010) and further defined in 2017 with the passage of AB1158 (Chu, Statutes of 2017). Together, these statutes comprise the California carpet stewardship laws. AB2398 provides the foundation and the structure of the CCSP, while AB1158 provides additional program requirements.

The need for the CCSP, as outlined in AB2398, was based on the findings that identified:

- Discarded carpet was one of the ten most prevalent waste materials in landfills, at 3.2 percent of volume
- The weight and bulk of discarded carpet result in a significant solid waste management cost on local governments
- There are numerous products that can be manufactured from recycled carpets
- The vast majority of companies in the United States carpet industry have established a non-profit organization (CARE) to work with state governments to increase the recycling and reuse of carpet
- In 2008, 5.2 percent of carpet was diverted from landfills and 4.3 percent was recycled nationwide

As defined in statute, the purpose of AB2398 was to “increase the amount of postconsumer carpet that is diverted from landfills and recycled into secondary products or otherwise managed in a manner that is consistent with the state’s hierarchy for waste management practices pursuant to Section 40051.”

AB2398 further specified that “it is in the interest of the state to establish a program, working to the extent feasible with the carpet industry and related reclamation entities, to increase landfill diversion and recycling of postconsumer carpet generated in California.”

AB1158 added specificity to the program and established the 24 percent recycling rate to be achieved by January 1, 2020. In addition, AB1158 included provisions such as:

- Requiring a carpet stewardship plan to achieve that goal, with quantifiable 5-year and annual goals
- Providing data for CalRecycle to evaluate the effectiveness of the program
- Prohibiting subsidies for engineered solid waste conversion (cement kilns and waste-to-energy)
- Creating an Advisory Committee
- Requiring the Department of General Services to recycle carpet and purchase carpet with PCC
- Specifying requirements for the assessment
- Specifying a subsidy/grant structure that incentivizes highest recyclability, a concept not defined by statute or regulation.

1 Section 40051 identifies the priority of waste management practices as: 1) source reduction; 2) recycling and composting; 3) environmentally safe transformation and environmentally safe disposal.
The requirements of the Carpet Stewardship Plan provide further insight into the legislative intent behind AB1158. The Carpet Stewardship Plan is to describe how CARE will:

• Increase PCC recycling and reduce PCC disposal
• Increase collection of PCC and improve convenience of collection
• Expand and incentive markets for products made from PCC
• Increase processor capacity, including within California
• Increase the recyclability of carpet.

Ultimately, the Carpet Stewardship Laws are intended to create an industry-driven effort to reduce landfill diversion of post-consumer carpet and increase the recycling rate to 24 percent by January 1, 2020, with potential increases thereafter. The added specificity in the statutes are intended to further support those objectives.

B. Factors Driving Increased Recycling

There are many approaches to increasing recycling. There are also many factors that incentivize or dis-incentivize recycling. These approaches and factors vary at different stages of the post-consumer carpet recycling process.

1. Collection

To start, PCC must be diverted from the waste stream if it is to be recycled. Key factors to support collection of PCC include:

• Awareness – Installers, homeowners, flooring companies, etc. must know that there is an alternative to disposal (we use disposal generically to refer to landfill or transformation)
• Economics – It must be less expensive to recycle carpet than to dispose of it.
• Convenience – It must be easier to recycle carpet than to dispose of it.
• Storage capacity – There must be somewhere to store PCC before moving it to the next level of recycling.
• Regulation – There could be requirements that restrict disposal.
• Environmental consciousness – A strong environmental ethic can help make up for economics and convenience, citizens might be more willing to recycle, even if it costs more or is less convenient.

The first three items above: awareness, economics, and convenience are essential if enough carpet is to be collected to meet the 24 percent recycling goal. CARE’s drop-off collection and installer education programs, among others, address the collection of PCC.

2. CSEs/Processors/Manufacturers

At each of the next three stages of the PCC recycling process: Collector/Sorter/Entrepreneurs (CSEs), Processors, and Manufacturers, the key factors driving recycling are similar. These factors are significantly different from those at the collection stage:

• Supply of PCC – There must be an adequate supply of PCC from the prior stage of recycling to generate enough throughput to support the operation.
• **Quality** – The PCC must be of adequate quality to be used in the recycling process (clean and dry).

• **Throughput capacity** – The facility must have adequate throughput capacity to handle the PCC coming into the facility.

• **Economics** – The labor and operating costs to recycle or utilize PCC must be less than the revenue generated by the sale of PCC recycled output.

• **Technological capability** – The recycler must have the technological capability to process PCC into recycled output products.

• **End-user demand** – There must be markets for PCC fiber, pellets, products, PC4 (calcium carbonate), and backing at each phase of the recycling process.

• **Regulation** – There could be requirements that require use of PCC in various products (difficult to enforce and not the case for carpet).

• **Goodwill** – A strong environmental ethic can help make up for economics, companies might be more willing to recycle or utilize PCC products to support broader sustainability goals, even if it costs more.

CARE has programs in place to address a number of these factors, as described in the Stewardship Plan. The first six factors are all necessary at the CSE, processor, and manufacturer steps in order to support PCC recycling. We examine how the models inform or support these factors below.

**C. Relationship Between CARE Models and Increased Recycling**

As management tools, the CARE models are intended to help inform decision-making to support the CCSP and program goals. The key goal, particularly at this time, is the 24 percent recycling rate. The CARE models provide estimates, projections, and data that primarily address the economics of PCC recycling. Exhibit 4-1 provides a summary of how each of the CARE models supports increasing PCC recycling.

The CARE models also inform program operations and decision-making more broadly. Data from the Financial Model on carpet sales is necessary to calculate discards, which is necessary to calculate the recycling rate. The Financial Model also summarizes recycled output data.

### Exhibit 4-1  
**Role of CARE Models in Supporting Increased PCC Recycling**

<table>
<thead>
<tr>
<th>Model</th>
<th>Recycling Factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Supply of PCC</td>
<td>The model utilizes California GDP and housing start data to develop projections of carpet sales, which can be compared to carpet sales data generated by CARE’s carpet mill surveys and quarterly reporting data</td>
</tr>
<tr>
<td>Economic</td>
<td>Economics</td>
<td>The model utilizes data such as U.S. GDP and oil prices to estimate virgin and post-industrial (PI) fiber and pellet prices, which in turn inform PCC fiber and pellet prices</td>
</tr>
<tr>
<td>Cost Conversion</td>
<td>Economics</td>
<td>The model utilizes operating data and assumptions to calculate costs to recycle PCC and the associated return at various stages</td>
</tr>
<tr>
<td>Financial</td>
<td>Supply of PCC</td>
<td>The model incorporates CARE’s carpet mill surveys and CARE’s PCC recycled output and processing data to quantify availability of PCC</td>
</tr>
<tr>
<td>Financial</td>
<td>Economics</td>
<td>The model utilizes estimated sales and recycling data, in combination with the subsidy payments, to inform the level of assessment needed to support the program; budgeted volumes and subsidies are compared on a monthly basis</td>
</tr>
<tr>
<td>Subsidy</td>
<td>Economics</td>
<td>The model combines the prices of PCC from the Economic model and market data and the cost to recycle PCC from the Cost Conversion model to determine the subsidy level needed to incentivize use of PCC</td>
</tr>
</tbody>
</table>
[This page intentionally left blank.]
5. Evaluation and Recommendations

This section provides Crowe’s critical evaluation of each of the four CARE models and recommendations for improvements in future iterations of the models. Our evaluation and recommendations are provided with the intent of furthering the development of these models in support of the CCSP. For each model, we consider the following questions:

1. Does the model meet the intended purpose?
2. What are the strengths of the model?
3. What, if any, are the weaknesses or concerns related to the model?
4. Recommendations.

The remainder of this section is organized as follows:

A. Economic Model
B. Cost Conversion Model
C. Financial Model
D. Subsidy Justification Model
E. Overall Recommendations

A. Economic Model

To present an objective review and analysis of the economic model, Crowe has performed an evaluation and developed recommendations in this subsection.

1. Meeting the Purpose

The purpose of the economic model is to detail, describe and provide transparency on the economic pricing variables of post-industrial fibers. Exhibit 5-1 summarizes the extent to which the economic model meets the intended purpose.

2. Strengths

The economic model is quite robust and accounts for the major economic factors and costs involved with the pricing of post-industrial fibers. The model framework captures the economic conditions that impact the recycled fiber markets and provides general guidance on price volatility of fiber component prices. The component price guidance is based on historical price ranges and lends insight into the effects on recycled fiber pricing within the scenarios for stable, high and low component price movements. The model also acknowledges that the component and fiber industry is affected by force majeure events at a greater rate than other industries and that those events may increase the price volatility and pricing of recycled fibers.

Exhibit 5-1

<table>
<thead>
<tr>
<th>Economic Model Purpose Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose, Goal, Objective</td>
</tr>
<tr>
<td>Provides context on macroeconomic factors of the recycled fibers market</td>
</tr>
<tr>
<td>Provides transparency on post-industrial fiber pricing methodology</td>
</tr>
<tr>
<td>Provides insight into recycled fiber Pricing if and when Energy prices change</td>
</tr>
<tr>
<td>To capture changes in GDP, Construction, Oil and Component prices to inform CARE’s subsidy decisions</td>
</tr>
</tbody>
</table>
3. Weaknesses

The economic model was developed to provide transparency and context regarding recycled fiber pricing factors and its value as a recycled fiber future pricing tool may be limited. While the model is economically robust and captures the major factors of recycled fiber markets, it is based on current and historical price benchmarks and will be limited in providing insight into probable future market prices. Historical models are highly useful within shorter future periods, but have limited ability to predict future outcomes due to the possible change in variable relationships. Historical models assume that correlations between variables remain static. The accuracy of the model can be improved by updating regression coefficients and equations. However, the predictive value of the model is limited by its structure as a historical model rather than a predictive model. The economic model does utilize predicted oil prices from Woods Mackenzie, which can improve the model’s projections. A predictive model would be of greater value in forecasting component pricing and recycled fiber pricing. Crowe recognizes that increasing the predictive nature of the economic model would require extensive work.

4. Recommendations

Crowe agrees to the general outline of the economic model as provided to CARE. Ultimately, making the economic model more predictive could give better price guidance for recycled fiber pricing and a better input for the other models. A predictive model that integrates the current economic model, Cost Conversion Model, Financial Model and the Subsidy Justification Model in a single model would provide greater value while likely be simpler to use. Predictive models take historical, or descriptive, models a step forward by accounting for the relationships between variables in addition to the relationships between variables and outcome. Predictive models offer greater value regarding predictive outcomes as they model the likely outcomes. Predictive modeling would better account for the stochastic nature of variables while limiting the “noise” created by less significant variables or non-principal components.

The use of forward market prices, such as futures and option prices, in the model would also provide better price forecasting guidance than the use of historical price forecasts. The current economic model provides for price guidance as a range of forecasted prices based on spot WTI crude oil prices. The economic model is based on regression relationships over the past three years. While this guidance provides a reasonable expected price range it does not offer guidance on the probability that those prices may occur at the desired point in time. As a descriptive economic model, the model analyzes the economic conditions that caused the historical component prices and assumes that the same historical conditions will persist.

The economic model notes that force majeure events are also more common with the component and fiber industries than other industries due to its direct impact in raw production materials. While force majeure events such as natural disasters, weather events, warfare or an act of God are random and therefore cannot be predicted, they can be statistically described. Many of the more common force majeure events that affect the component and fiber industries include weather events such as hurricanes and warfare. Hurricanes have a seasonality to their occurrence and warfare concerns are often preceded by geopolitical tension in areas such as the Middle East. These common force majeure factors can be factored by predictive modeling and are also reflected in forward market prices. That said, many force majeure events in the plastic industry are the result of unplanned changes in capacity that cannot be easily predicted. Still, it could be useful to evaluate forward market pricing to provide a better benchmark measure than spot prices for model validation.

B. Cost Conversion Model

To present an objective review and analysis of the Cost Conversion Model (CCM), Crowe has performed an evaluation and developed recommendations in this subsection.

1. Meeting the Purpose

The purpose of the CCM is to support the Subsidy Justification Model by providing cost per pound and return on cost conversion results to validate current subsidy levels and to suggest adjustments to properly
incentivize recycling of carpet. Its goal, along with all other models, is to boost to carpeting recycling; the results from the CCM may help keep existing recyclers in business and encourage entrepreneurs to get into the carpet recycling industry through reasonably profitable subsidy levels. Exhibit 5-2 provides a summary of how the CCM meets its purpose, goals, and objectives.

<table>
<thead>
<tr>
<th>Purpose, Goal, Objective</th>
<th>Purpose, Goal, Objective Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides cost per pound</td>
<td>✓</td>
</tr>
<tr>
<td>Provides return on cost conversion</td>
<td>✓</td>
</tr>
<tr>
<td>Validates current subsidy levels</td>
<td>✓</td>
</tr>
<tr>
<td>Informs adjustments to subsidy levels</td>
<td>✓</td>
</tr>
<tr>
<td>Informs decisions for new types of subsidies</td>
<td>✓</td>
</tr>
<tr>
<td>Supports increased carpet recycling</td>
<td>✓</td>
</tr>
<tr>
<td>Provides transparency in the subsidy justification process</td>
<td>✓</td>
</tr>
<tr>
<td>Supports overall goals of CARE</td>
<td>✓</td>
</tr>
</tbody>
</table>

2. **Strengths**

With the lack of actual data, the CCM does a good job of utilizing assumptions made by CARE’s carpet recycling experts. The model works well for a processor as the inputs/outputs makes sense for this phase of recycling. The current version of the model represents a positive step forward to fully meet its intended purpose. As the model is under an iterative process, improvements are expected, and the current version provides a solid foundation. Exhibit 5-3 summarizes the overall strengths of the CCM.

3. **Weaknesses/Concerns**

As a result of Crowe’s thorough review of each component of the CCM and the interactions between each, we identified several areas of improvement, detailed within a series of exhibits below. We note that many of these weaknesses would require minor adjustments to the model. Our intent is to provide a comprehensive evaluation and suggested improvements. In addition, the model’s existing flexibility could be improved to more easily incorporate unique inputs and outputs of all phases in carpet recycling (collection, processing, and manufacturing). Most notably, the model assumes that all material is sold and no material is passed from one phase to another. This is especially important when not all phases are equal in profitability. We believe there is a need to combine multiple phases together to truly see the net effect. However, probably the most important, and difficult, area of improvement is the limited amount of actual data available. Actual data from recyclers is proprietary and sharing it would negatively disrupt the recycled carpet industry. If it was possible to incorporate more actual data to replace current assumptions, it would enhance the CCM’s ability predict a range of recycling costs.

Areas of improvements are summarized within Exhibit 5-4.
**Exhibit 5-3  
CCM Strengths**

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall accuracy</td>
<td>• The CCM transforms decision-making involving costs, revenue, and profitability from a complete guess to an educated estimate.</td>
</tr>
<tr>
<td>Decision-support tool</td>
<td>• Overall, the CCM is accurate as it can be with currently available information.</td>
</tr>
<tr>
<td>Predictive tool</td>
<td>• The CCM functions well as a predictive tool to determine the level of revenues, costs, amount of material, and throughput needed to be profitable.</td>
</tr>
<tr>
<td></td>
<td>• The CCM can give a carpet recycling entrepreneur who is thinking about starting up a good idea of what it takes to make it in this industry. Ultimately, the model will help decide if getting into this business is ‘worth it.’</td>
</tr>
<tr>
<td></td>
<td>• The CCM can give existing carpet recyclers many ways to optimize their profitability by pinpointing unnecessary costs, adjusting their operating schedule to maximize throughput with differing levels of material, the amount and types of material needed, all in order to achieve a profit to sustain or expand the business. Ultimately, the model will help answer the questions, ‘what do we need to make it?’ or ‘what do we need to grow?’</td>
</tr>
<tr>
<td></td>
<td>• Additionally, the CCM will help an existing carpet recycler identify and focus on the critical bottlenecks (amount of material, operating efficiency, etc.) to overcome profitability challenges.</td>
</tr>
<tr>
<td>Cost per pound</td>
<td>• Cost per pound results from the CCM are consistent with Crowe’s survey results when depreciation is excluded.</td>
</tr>
<tr>
<td>Flexibility and Functionality for a processor</td>
<td>• The inputs and outputs as a processor are flexible and function well enough to handle almost all situations within this phase.</td>
</tr>
<tr>
<td>Benchmarking tool</td>
<td>• The CCM can be used as a benchmarking tool by plugging in data from recyclers with differing efficiency and profitability levels to compare the strengths and weaknesses between each.</td>
</tr>
<tr>
<td>Boost recycling of carpet</td>
<td>• As the CCM is described as a predictive tool, if the model is released to an entrepreneurial community, it would educate budding business developers about the uncertainties and provide a level of confidence, which may ultimately promote more to join the carpet recycling industry.</td>
</tr>
<tr>
<td></td>
<td>• Given enough available PCC carpet, adding more recyclers to the industry would boost overall recycling of carpet through more PCC being collected, processed, and manufactured (into end-products or feedstock).</td>
</tr>
<tr>
<td>Subsidy level justification</td>
<td>• In conjunction with the Economic Model, the CCM can be used to derive a reasonable cost per pound per material type that will help determine proper subsidy levels.</td>
</tr>
</tbody>
</table>

**Exhibit 5-4  
CCM Areas of Improvement**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Depreciation</td>
<td>• The cost per pound calculation does not incorporate depreciation, which is a real cost to consider. For some recyclers, this makes no difference. However, for those who are actively investing in equipment, including depreciation would better reflect their costs.</td>
</tr>
<tr>
<td>Variable</td>
<td>Shipping Costs</td>
<td>• Shipping is handled as a reduction in revenue and should be handled as an expense.</td>
</tr>
<tr>
<td>Variable</td>
<td>Revenue</td>
<td>• Assumes all processed material is sold (after factoring % unsold).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Does not easily account for when material is sent to in-house manufacturing.</td>
</tr>
</tbody>
</table>
3. Recommendations

Identifying strengths and weaknesses provides an opportunity for improvement. More importantly, how can the CCM be improved to better meet its stated purpose, goals, and objectives? This subsection is broken down into recommendations for the current version of the model as well as a conceptual recommendation to enhance future versions. This approach gives CARE the ability to address more immediate needs, while working towards long-term improvement.

Because actual data from recyclers is extremely difficult to obtain, CARE must rely on other means to improve assumptions. One approach would be to perform an anonymous survey to seek key metrics, like pounds of carpet in/out per hour, types and quality levels of materials/products being sold. With the survey results, CARE could leverage in-house expertise to use the collected information to refine assumptions. Recyclers that choose to participate would benefit because justifying subsidy levels will skew towards them, encouraging participation especially for those who need the subsidy to meet the target return.

Current Version

To address identified improvement areas of the current version of the CCM, several quick and easy adjustments can be made to add value, traceability, streamline, flexibility, and functionality.

Recommendations for the current version of the CCM are summarized within Exhibit 5-5. The focus of the recommendations are to make the model more user-friendly and make it easier to make the most of the flexibility that was built into the model.

Exhibit 5-5
Current Version Recommendations

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per pound per material type</td>
<td>• Existing inputs makes it possible to add additional outputs to display cost per pound by material type.</td>
</tr>
</tbody>
</table>
| Revenue and expenses | • Keep revenue and expenses completely separate.  
  • Enhances ability for adjustments.  
  • Allows maximum visibility for revenue and expense totals. |
| Depreciation | • The version of the CCM that Crowe reviewed did not utilize depreciation in the cost per pound calculation because it was prepared as an operational cash cost model. Depreciation was incorporated within overall expenses, but not the cost per pound. Crowe believes that an updated version of the CCM could include depreciation within the cost per pound because equipment purchases are a significant cost for many PCC recyclers, particularly given that many are newly investing in carpet recycling technologies. |
| User-friendliness and flexibility | • Add ways for the user to more easily make adjustments through drop-down menus or dedicated tabs for input, outputs, and key metrics. |
| Total carpet materials processed and sold | • Incorporate an adjustable efficiency multiplier (in a drop-down menu) to allow a user to incorporate efficiency differences between the variety of machinery and processes. |
| Carpet materials | • Include a carpet type selector to toggle different inputs/outputs of using carpet tile vs. broadloom. |
| Recycler type | • Include a recycler type selector that will generate different inputs/outputs to fit each recycler type. |
| Face fibers out | • In addition to face fibers out per hour, also display PP backing and calcium out per hour. |
Future Versions
To develop an enhanced version of the CCM will likely require adapting to a modified process flow. The conceptual framework illustrated in Exhibit 5-6 provides the schematic for a more flexible approach. This approach would require several major changes, most notably, the inclusion of multiple worksheets to incorporate unique inputs and outputs of CSEs, Processors, and Manufacturers. This would convert the single phase approach within the current version to a multi-phase approach. This framework would allow for flexibility to start at any phase, allow multiple ways to receive material, to sell material, or moving material from one phase to another. Note that such a model could be further combined with the other CARE models, as described in the Economic Model section and overall recommendations. CARE has chartered a Model Team to begin the significant work of model integration.

Exhibit 5-6
Conceptual Framework for Future Versions

C. Financial Model
The Financial Model calculates the total and budgeted monthly output for different subsidy tiers represented in the Plan. The Financial Model is an internal tool used to predict current and future financial scenarios for the length of the 5-year Plan.

1. Meeting the Purpose
The FM meets the intended purpose of tracking the Plan budget in regards to industry trends, revenue/expense data, as well as assessment fees received. As an internal tool to assist CARE Executives in making budgetary decisions, the model’s inputs must accurately reflect the proper scenarios to determine where to allocate costs and how to plan for fluctuations in revenue. For internal purposes, the model aids in meeting the needs as intended by breaking down actual and budgeted monthly income data.
for the Plan. The model also provides insight to support planning over the lifespan of the Plan given current market environments.

2. Strengths
The FM provides a straightforward, month-to-month outline of the Program’s budget and accrued fund balance to inform program management within evolving market conditions. The model uses direct market insights as well as historical data to predict potential fluctuations in revenue and expenses in the coming years.

3. Weaknesses/Concerns
The FM draws on historical data from Aprio and CARE financial reports. As with all models, a potential weakness of the FM relates to the assumptions regarding data inputs and calculations. Another area to consider is future forecasts, and how CARE leverages historical data and industry knowledge to predict future PCC use and the resulting subsidies. However, our observation is that CARE is drawing on the Economic Model and extensive industry knowledge to develop solid estimates in an uncertain market. Ongoing evaluations of budget to actual in the model serve to validate projections and inform course corrections, if necessary. The economic and market variables that are applied to the scenarios can determine the future potential costs as well as the reserve fund.

4. Recommendations
Crowe recommends that CARE continue to utilize and evolve the Financial Model as a working tool for the program. For example, CARE could develop different scenarios to evaluate subsidies, fund balance, and assessment levels based on varying assumptions of expansion of PCC recycling and markets.

D. Subsidy Justification Model
The Subsidy Justification Model (SJM) brings together information from the CCM and Economic Models to calculate the per pound subsidy levels that are necessary to incentivize recycling of each of eight PCC material types.

1. Meeting the Purpose
The SJM meets the intended purpose of identifying per pound subsidy levels needed provide adequate incentives to recycle for each of the eight PCC materials. As a decision-making tool, the model must reflect typical or average inputs and outputs. As such, the SJM is an effective and valuable tool for the CCSP to justify current subsidy levels and inform future subsidy levels.

2. Strengths
The SJM provides a straightforward, logical, and transparent series of calculations that illustrate an appropriate subsidy level for each of eight PCC recycling outputs. The model framework clearly identifies sources, assumptions, and calculations.

3. Weaknesses/Concerns
The potential weaknesses of the SJM relate to the assumptions regarding data inputs and calculations. None of these assumptions represent major issues or concerns with the model. Exhibit 5-7 summarizes the SJM’s key assumptions and their implications for the model results.
Exhibit 5-7
Subsidy Justification Models Assumptions and Implications

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>A PCC discount of 10 cents per pound as compared to PI pellet prices</td>
<td>The 10 cent per pound discount for PCC as compared to PI is a relatively standard value in the plastic recycling industry. While this number could change over time, it is a reasonable value for purposes of the SJM.</td>
</tr>
<tr>
<td>A market price of PET PI bottle flake that is representative for PCC PET fiber prices</td>
<td>In the absence of other sources, using the price of PET PI bottle flake to represent PCC PET fiber prices is reasonable. The data is readily available, and can be compared to actual PCC PET fiber prices.</td>
</tr>
<tr>
<td>CCM model conversion costs provide reasonable estimates of the cost to recycle</td>
<td>As described above, the CCM provides “typical” conversion costs. While these numbers could vary over time and between recyclers, Crowe’s research validated the results of the model under a few different scenarios; however, without depreciation and shipping, the CCM may underestimate conversion costs. While the costs will likely vary and change (increase) over time, they represent reasonable costs for the purposes of the SJM in their current iteration and can be updated in the future.</td>
</tr>
<tr>
<td>A small but positive subsidy difference reflects an adequate subsidy level to incentivize recycling</td>
<td>The conversion costs and market prices in the SJM represent industry averages or typical values. The cost structures for individual recyclers may vary considerably. It is not reasonable to expect that the model and resulting subsidies be customized to each recycler. While the program must recognize that a given subsidy level may be “too high” or insufficient for individual recyclers, it is reasonable to utilize “average” inputs for purposes of modeling and decision-making.</td>
</tr>
<tr>
<td>That a 15 percent return on conversion cost (ROCC) is reasonable</td>
<td>The 15 percent ROCC is higher than the rate of return typically provided in solid waste and recycling rate setting and the return currently proposed by CalRecycle for beverage container recyclers. While we do not consider 15 percent return on conversion costs as excessive, it is worth noting that the subsidy calculation will vary under different ROCC assumptions.</td>
</tr>
</tbody>
</table>

4. Recommendations

Crowe identified two recommendations or suggestions to further refine and evaluate the SJM.

- Our primary recommendation is to conduct ongoing sensitivity analyses by varying a reasonable range of SJM inputs and assumptions to evaluate the impact on the subsidy required and subsidy difference. This analysis could provide a range of PCC market prices and costs that would be supported by the subsidies. Factors that could be further evaluated include:
  - Testing the implications of a range of ROCC values, such as 10 percent and 20 percent
  - Testing a range of market prices and resulting PCC prices for each of the materials. At what market price is a given subsidy no longer adequate to incentivize recycling for a given cost?
  - Testing a range of recycling costs that reflect variability in the industry, building on existing CCM analyses, with different subsidy levels. What recycling cost and subsidy levels incentivize recycling at a given market price?
- Prepare separate versions of the model for processors and manufacturers. While the current combined model is applicable to some program participants, there are a number of processor-only and manufacturer-only program participants. For these recyclers, the subsidy differences in the current SJM do not apply.
E. Overall Recommendations

Crowe recognizes that the CARE models are not “final” versions. CARE has developed these models over the last few years, with multiple iterations and refinements occurring in parallel on an ongoing basis. These models represent a significant body of work on the part of CARE and their modeling team. Crowe’s overall recommendations and our recommendations on individual models are intended to support the further refinement and development of the models, simplify them where possible, provide better insight into carpet recycling economics, and support the goals of the CCSP.

Our primary overall recommendation is to combine the models into one comprehensive workbook. As noted above, CARE has implemented a Modeling Team to evaluate integrating the models. At this point, we recommend combining the Economic, Cost Conversion, and Subsidy Justification Models, and leaving the Financial Model as a separate tool. In combining models, we recommend simplifying and streamlining each model to minimize duplication. We also recommend clarifying the linkages between models and improving traceability. We recognize that integrating these models would be challenging, and do not recommend combining models until they are more fully developed to avoid unnecessary work and revisions.

As part of the combination of models, we recommend creating a reporting dashboard. The dashboard would clearly summarize results of each model component. The dashboard could be developed to illustrate ranges and results of sensitivity analyses.

Crowe also considered whether there are additional models, model components, factors, or analyses that would support the CCSP increasing PCC recycling. Our evaluation of additional models/components will be further refined as we complete the cost analyses. One model that could be developed is a materials flow analysis that identifies and compares current quantities by fiber type at each of the key steps of carpet recycling (collection, sorting, processing, manufacturing) with those necessary to achieve the 24 percent recycling goal under a variety of scenarios. This type of model could help identify focus areas that would help achieve higher recycling rates.

Discussion of Additional Analyses of Models

Below, we summarize additional findings related to our technical evaluation of the models. The models used to determine subsidy levels derives from inputs from four separate models: the economic model, the financial model, the cost conversion model and the subsidy justification model. Since many of the models rely on input variables that are either the same or similar, it would potentially be better to create a single predictive model rather than use four stand-alone models to derive the subsidy cost. This could increase the usefulness of the model as it may simplify the operational use of the model as well as increase the accuracy of the model.

A simpler predictive model could be of greater value as it might be easier to use and therefore used more often. A model that takes less time to use would be easier to run, reference pricing and cost less to maintain, update and train users. A single predictive model would likely be simpler as it would likely reduce the total number of input variables. Currently, there are over 70 input variables used to generate the subsidy level. Many of the input variables are related to each other and therefore exhibit some correlation both to each other as well as to the calculated subsidy level. See Exhibit 5-8 for inter-correlation visualization between just the economic model and the cost conversion model. Appendix A provides a glossary of modeling terminology.

The visualization between the economic and cost conversion models demonstrates the relationship between both variables within each separate model and between the separate models. The variables of the four separate models likely exhibit inter-correlated behavior. Predictive models account for the inter-correlation of variables and through the concept of data summarization. This is meant to capture the most important variables or factors of the model while ignoring others that do not influence the outcome significantly. This effectively simplifies the model and may reduce the “noise” in the predictive outcome.

One example would be the use of both the US GDP and the California GDP. Although Crowe did not run the regressions, it is likely that the variables US GDP and California GDP numbers exhibit a high degree of multi-collinearity or are highly correlated between themselves and the outcome. One of these factors could be dropped from the factor analysis because the variables behave very similarly most of the time and the model would not lose significant “information” or predictive accuracy if one variable was dropped from the analysis.
Exhibit 5-8
Correlation Interactions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>US GDP</td>
<td>Economic Model</td>
</tr>
<tr>
<td>California GDP</td>
<td></td>
</tr>
<tr>
<td>Crude Oil Prices</td>
<td></td>
</tr>
<tr>
<td>Natural Gas Prices</td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>Cost Conversion Model</td>
</tr>
<tr>
<td>Input Carpet Volumes</td>
<td></td>
</tr>
<tr>
<td>Facilities Expense</td>
<td></td>
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<tr>
<td>Utilities Expense</td>
<td></td>
</tr>
<tr>
<td>Labor Expense</td>
<td></td>
</tr>
<tr>
<td>Number of Shifts Expense</td>
<td></td>
</tr>
</tbody>
</table>
Appendix A
Glossary

**Co-integration** – An econometric technique for testing the correlation between non-stationary time series variables.

**Correlation** – A statistic that measures the degree to which two variables move in relation to each other.

**Covariance** – A measure of how much two random variable change together.

**Cross-Loading** – See Factor Cross-Loading.

**Descriptive Models** – A mathematical process that describes real-world historic events and the relationships between factors responsible for them.

**Factor Analysis** – A statistical technique used to estimate factors and/or reduce the dimensionality of a large number of variables to a fewer number of factors.

**Factor Cross-Loading** – Occurs when a variable is found to impact or load on two or more factors in the factor loading matrix.

**Factor Loading** – The correlational relationship between the variable that can be directly observed and the variable that can not be directly observed.

**Factor Loading Matrix** – A matrix of weights or coefficients for a group of linear equations linking the observed variables to the factors.

**Multi-collinearity** – The phenomenon in which two or more predictor variables in a multiple regression model are highly correlated, meaning that one can be linearly predicted from the others with a substantial degree of accuracy.

**Predictive Analytical Models** – The process of creating, testing and validating a model to best predict the probability of an outcome.

**Regression** – A measure of the relation between the mean value of one variable and corresponding values of other variables.

**Stochastic** – Describes an event that is random and therefore cannot be predicted but can be described statistically.

**Standard Deviation** – A statistic that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance.

**Variance** – A measurement of the spread between numbers in a data set.