Maximizing the Benefits of Circular Economy and Sustainable Materials Management Models For Product-Packaging Systems

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Disclaimer:
This paper was developed by an AMERIPEN working team consisting of packaging and materials management experts from across the public and private sectors. The conclusions and views expressed in this document do not necessarily reflect the views of every AMERIPEN Member Company or Affiliate.

Executive Summary

The concepts of Sustainable Materials Management (SMM) and the Circular Economy (CE) have recently grown in popularity. Businesses, governments, non-profit organizations, and concerned citizens are becoming more acutely aware of the challenges expected in the years ahead due to the combination of population growth and rapidly increasing economic prosperity which is expected to put an even greater strain on the limited resources available to support growing global consumption.

Sustainable Materials Management and Circular Economy offer powerful frameworks to drive improvement: That improvement should ultimately be the key focus, not the particular approach that is applied to any specific problem. The ideas behind SMM and CE have been practiced for as long as businesses have been trying to optimize their operations. But as specific business approaches with specific methodologies, both are relatively new concepts, and so many of the particular details are not yet well defined or universally accepted.

Various interpretations of SMM and CE may differ greatly in some of the specific approaches they use to address and solve the problem of resource scarcity, but at their core they share a common goal of improving efficiency and capturing more value from resources in order to create a more sustainable society. That goal is shared by AMERIPEN.

Specific to the packaging market, AMERIPEN believes that taking a lifecycle approach to maximize system performance for the entire product-package system, while applying frameworks such as the Circular Economy and Sustainable Materials Management, will yield the most well rounded set of benefits and the most positive outcomes. Common fundamental goals such as reducing waste, capturing greater value from resources, providing increased economic and social value, and optimizing the environmental performance of product-packaging systems across their lifecycles can be achieved through the use of these tools.

This whitepaper will seek to clarify some of the concepts that many have suggested be included as part of these approaches and discuss the means for achieving the most optimal results from their application.

Materials Management: A Strategy for Enhancing Environmental Performance

The way society uses material resources determines, to a significant extent, the types of environmental pressures that will be faced as a result of their use. Wastes occur all along the lifecycle of a product—not just at end of life. Air, soil and water may be contaminated with waste generated during harvesting or mining activities, the transportation of goods results in emissions, and energy is consumed and material discarded during manufacturing and use. Additionally, there is an increasing recognition that the decisions made as a result of design, processing, manufacturing and transportation processes will significantly impact the potential for material reuse, remanufacturing, recycling or discard. The delivery of goods through a product-package system has many inputs and many impacts across the lifecycle of the system. Also, different product-package combinations may have very different impacts.

From a materials perspective, waste becomes re-conceptualized as a challenge of resource constraints, rather than simple discard management; and systems of production are re-designed as a means to keep materials in motion and retain their value, while at the same time reducing externalities. Viewing material use in this manner significantly shifts the ways in which sustainable production is evaluated.

Two models are rising to the forefront, both of which offer promising new ways to help improve our impact by viewing materials as valuable, and limited, resources. Circular Economy (CE) and Sustainable Materials Management (SMM) help us evaluate the consumption and use of materials, and encourage us to innovate for sustainability. While there are many similarities between these models, there are also differences which require further understanding to ensure how best to understand applicability, and how to leverage them for the greater good.

It should be noted that both CE and SMM are broad, flexible models not designed for a specific industry. Thus, when evaluating them for adoption in work related to packaging, AMERIPEN believes that a "one model fits all approach" will not produce optimal functional, economic, or environmental results. This paper has been developed to help clarify various concepts associated with these two models and to define how, and where, they can best be leveraged to encourage and support the development of packaging systems which enable sustainable supply chains across North America.

CE and SMM Defined

Sustainable Materials Management refers to the "use and reuse of materials in the most productive and sustainable way across entire lifecycles by minimizing the amount of materials involved and minimizing associated environmental impacts."[1] SMM requires the evaluation of material impacts involved in sourcing, harvesting, processing, manufacturing, transportation, use and end of life in order to identify where, and how, resources are being consumed and where, and how, pollution and other wastes are occurring. It requires mapping out environmental impacts both by material type, and industrial process. In doing so, SMM helps identify 'hotspots'—materials and processes with the greatest environmental challenges and most significant opportunities to drive change. SMM builds upon previous work from environmental and policy models such as lifecycle analysis, systems-thinking, material flow analysis, and

[1]United States Environmental Protection Agency (US EPA). (Sept 2011). "Creating an EPA Sustainable Materials Management Program: The Road Ahead." [Powerpoint slides] Retrieved from: www.ecy.wa.gov/programs/swfa/w2rac/docs/2011septepa.pdf

integrated policy. Driven by the Organization for Economic Co-operation and Development (OECD) and embraced by the Group of Seven (G7) nations, SMM has become the primary model for sustainable development within the US Environmental Protection Agency (US EPA).

Another model generating widespread interest is Circular Economy. A Circular Economy model re-conceptualizes economic and production systems in order to retain products and materials at their highest utility and value at all times[2]. Creating new business models which permit the design of materials and processes in order to create continuous looping of material goods, or to use materials and systems which utilize regenerative natural cycles, are key objectives within a CE model. Citing nature's tendency to reuse waste in order to create new life, CE draws heavily upon frameworks such as cradle-to-cradle, biomimicry and industrial ecology. The Circular Economy model is being embraced by global companies, and more recently, both the European Union and China have developed policy frameworks to help support the development of new business models and policy incentives to encourage the adoption of CE principles and models.

Interpreting Circular Economy and Sustainable Materials Management

At the macro level, Circular Economy and Sustainable Materials Management are both designed to help rethink the relationship to waste, resource demand and material use. Both seek to decrease negative environmental impact, reduce toxicity and use materials longer. As a result, they are often viewed as similar or comparable, and in fact they do share many objectives. But just as there is no single solution to every problem, CE and SMM users may apply the principles differently. Differences in prioritization of specific objectives within a complex multi-variable system may lead to a significant difference in the path, and the considerations, they take towards their common end goals. Thus, it is important to recognize these considerations, in order to ensure that achieving the most positive outcome remains the top priority, rather than the implementation of a particular protocol or framework.

The nuances and subtle differences in approaches can have a significant impact on outcomes and goals. Without seeing the full picture, opportunities and challenges may be missed. Setting the wrong goals or attempting to optimize too small a sub-set of the overall system may cause focus to be on what cumulatively may be minor impacts. In essence, actions taken based upon micro understandings can create unintended consequences. Being clear about these differences in approach and overarching objectives will be essential towards developing the most effective policy and business environments to enable sustainable packaging systems.

[2] Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/

Table 1: Interpreting CE and SMM Models – Typical Elements Seen with the Approaches

	Circular Economy	Sustainable Materials Management
Definition of Waste	Direct material use—preservation of materials used in production.	All externalities associated with material use –preservation of natural capital.
Key Tools	Cradle-to-cradle thinking, systems-thinking, biomimicry, industrial ecology, supply-chain analysis, stakeholder engagement.	Material flow analysis, integrated policy, systems-thinking, lifecycle analysis, stakeholder engagement.
Objective	Create new business and economic models.	Build analytical and integrated policy frameworks to evaluate and support tradeoffs.
Goals	Waste is 'designed" out. Every material can be repurposed towards continuous use or multiple uses.	Waste is multi-attributed. Need to evaluate tradeoffs and hotspots to identify most sustainable choice.
Metrics	Focused on material use and reuse. Applies a Material circularity indicator which focuses on metrics such as: - Reuse - Recycled content - Duration of use Will require establishment of new tools to evaluate use metrics and by component.	Focuses on cumulative impact of material consumption. Requires comprehensive lifecycle map to identify where greatest impacts lay. Encourages application of traditional metrics but within a cumulative assessment: - GHG emissions - Soil and Water quality - Toxicity
Design Focus	Recover, reuse, refurbishment, products as a service	Source reduction, design for recovery, integrated systems
Perspective/Vision	Production and consumption cycles – "forward thinking" analysis Evaluate and design within a system. Aspirational/Future State.	Extraction, production, consumption cycles – "current state" analysis. Evaluate and design across the lifecycle. Current State.
Key Audience	Predominately promoted as business models which can be supported through policy alignment.	Predominately applied as tool to inform policy. Although is equally applicable for informing business decisions and potential legislative aspirations.

Relating the Models to Packaging Industry

Packaging is designed to provide protection to another product. Because its primary purpose is to preserve that product, packaging cannot be viewed in isolation: Rather, in evaluating the environmental impact and sustainable design opportunities of packaging, we must evaluate the choices that best enable the optimization of the product-packaging system. When we acknowledge packaging as part of a larger system and not as an isolated product, we begin to see why there may be tradeoffs behind the packaging materials and processes used in order to ensure the longevity and value of other products.

For example, when buying food, consider how the packaging influences the product's lifespan when compared with alternatives. Over 40 percent of the food produced in the United States is wasted.[3] Growing food requires land for farming, fertilizer and water to be applied to the land, and energy consumed during harvesting and processing. When that food goes to waste, so too do all the resources invested into its production. Considering that these resources contribute more to the cumulative environmental demand than packaging—which is generally considered to be 10 percent or less—we must consider the advantages the most appropriate type of packaging may play in reducing food waste.[4]

Figure 1: Energy for One Person's Weekly Consumption of Food (MJ/Person/week)

Energy Demand	**51%**	**6.5%**	**3.5%**	**3.5%**	**3.0%**	**1.5%**	**17%**	**15%**
Lifecycle Process	Food Supply	Primary Packaging	Secondary & Tertiary Packaging	Transport from Factory	Retailing	Selection	Storage	Cooking

Source: RMIT

Unintended consequences occur when multiple dimensions involved in a course of action are not considered. The same risks apply when seeking to apply models for sustainability. As the packaging and waste communities seek to find solutions to drive sustainable supply chains, evaluation must be made to understand how these models, and the policies that may result from their application, could engage with the unique characteristics of the package-to product system. Table 2 explores a few of these areas from the perspective of both the CE and SMM models.

Table 2: How CE and SMM Models Interpret Unique Challenges Inherent to the Packaging Industry

Packaging Issue	Circular Economy Model	Sustainable Materials Management Model
Packaging and product relationship	By taking the broadest systems view, CE would see packaging as part of a bigger system. If sub-optimized, it may also see packaging as a discreet product and may not always evaluate its broader role in protecting and preserving other products.	As part of a broad materials framework, sees packaging as a segment of a larger system. Would evaluate packaging against its role in product protection to identify if increased material demand creates less impact than product protection. If applied on too fine a scale could view packaging as a material separate from the product, resulting in sub-optimization
Source Reduction	Prioritizes material re-use over usage efficiency. Seeks to achieve efficiency through re-use of materials, avoiding extraction. Implies source reduction is best achieved through material reuse. Prefers any associated energy demand be addressed through the application of renewable energy sources. Would thus generally discourage material usage reduction if that material results in discard.	Prioritizes material usage efficiency over re-use. Recognizes current efforts at source reduction may require non-recyclable material choices. Evaluates the tradeoffs between material reuse and other environmental impacts, including energy but also water, soil degradation and others, in order to identify best way to reduce overall material and resource demand.

[3] Gunders, Dana, for NRDC. (August 2012). "Wasted: How America is Losing Up to 40 Percent of its Food from Farm to Fork." Retrieved from: https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf

[4] Verghese, Karli, Helen Lewis, Simon Lockrey & Helén Williams. (June 2013). "The Role of Packaging in Minimising Food Waste in the Supply Chain of the Future." Retrieved from: mams.rmit.edu.au/ie9rn2ifqca.pdf

Technical Feasibility	Aspires that innovation will address the technical challenges associated with material reuse.	Would require the identification and evaluation of current technical and environmental restrictions which may limit the application of material reuse. Evaluates the impacts of increased material reuse against virgin use.
Health and Safety Policies/Regulations	Aspires to have innovation in green chemistry address current health and safety concerns and any potential policy restrictions regarding material reuse. In encouraging the development of new systems, would assume to include policy amendments as needed to support desired change.	Would encourage dialogue across stakeholders to understand the regulatory and policy environments that discourage material reuse for certain food and health related products and potential impacts on chemical restrictions and use. Policy and regulatory analysis would be included in initial evaluation.
Quality	Does not inherently address the risk of quality degradation or contamination, but rather prioritizes the use of materials whose quality can be maintained. Seeks to avoid potential additional impacts of feeding virgin material back into the system.	Would calculate the need for virgin material as needed and degradation of quality to ascertain best value.
End Markets	Infers local end markets. Does not evaluate impacts of global market flows or resource demands required to ship and transport material. Because you are building the system, believes the markets will naturally grow.	Evaluates the flow of material, and weighs the impacts of resource demand and material movement between processes and across geographies. Includes evaluation of disruptions to, or lack of existing markets.

As Table 2 summarizes, there are challenges unique to product-packaging systems that will require further evaluation before one can conclusively adopt any particular model for broad deployment. Both Sustainable Materials Management and Circular Economy offer innovative and comprehensive models through which society can strive towards material and resource efficiency. However, unless we explore exactly how these models will interplay with the overall product-packaging system, simple adoption of one or the other, or even individual elements of these or other frameworks, may result in unintended consequences.

The Importance of Establishing the Right Goal

The way we measure our sustainability performance is also important. Both Circular Economy and Sustainable Materials Managament can help us set goals, but the way we measure progress against those goals it critical to achieving the right outcome. Consider a goal to reduce the use of fossil fuels with the intended outcome of reducing greenhouse gas emissions. A simple way to measure progress would simply be to measure the amount of renewable energy used. Perhaps a more common way to assess progress is to measure the percentage of energy supplied by renewable sources. But as shown in the table below, if the metric isn't set properly, using the right measurement, it could have unintended outcomes.

Table 3: How the Metric is Defined, Reflects What Gets Measured

Metric measurement	Ways to Achieve	Possible Negative Outcome	Net Result
Increase amount of renewable energy used	Substitute renewable energy for fossil energy OR add renewable energy usage to the existing use of fossil energy OR both	More total energy used, so a less efficient system	May be positive (a reduction in GHG emissions) or may be negative (an increase in GHG emissions)
Increase percentage of renewable energy used	Add the use of renewable energy OR decrease the use of fossil energy OR both (substitution of renewable for fossil energy)	More total energy used, so a less efficient system	May be positive (a reduction in GHG emissions) or may be negative (an increase in GHG emissions)
Decrease the amount of fossil energy used	Decrease the use of fossil energy OR substitute renewable energy for fossil energy OR both		You must always decrease the use of fossil energy to satisfy this metric, so either action will result in a reduction of GHG emissions

In choosing either of the metrics around renewable energy, one risks the possible outcome of inadvertently increasing greenhouse gas emissions as the focus is not on reducing fossil energy so increases in production etc. may offset any decreases as a result of using more renewable sources. Most people choosing these metrics surely intend to provide a benefit by implementing the types of action that yield positive results, but this is not assured. Similarly, while increasing recycle rate of a packaging material generally yields reductions in energy usage and emissions these benefits must be confirmed by measuring the impact on the entire package-product lifecycle. Defining the goal and subsequent metrics matters!

Putting it All Together—Case Studies

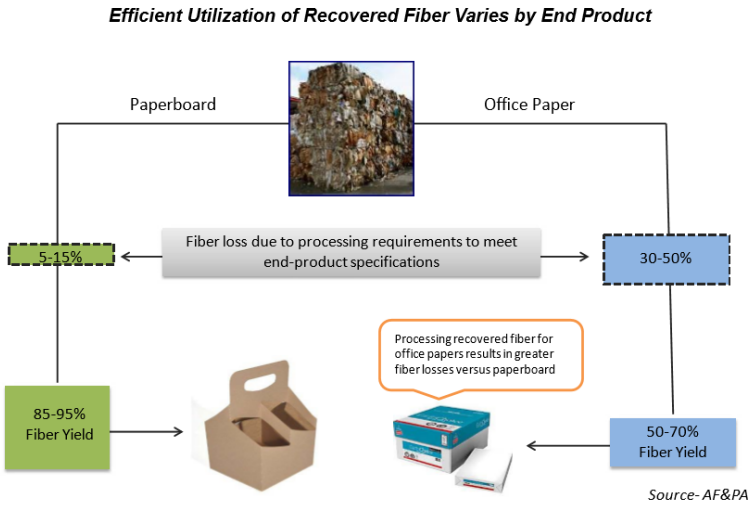
Recycled Content Mandates

A common policy currently used to promote recycling and the development of viable end markets for recycled material is the application of recycled content mandates. It is argued that a mandate will stimulate markets by increasing demand for recycled content. This would therefore create more jobs and encourage a virtuous loop of material reuse. Mandates are an example of a supportive Circular Economy policy. However, a deeper analysis utilizing Sustainable Materials Management tools such as lifecycle analysis (LCA) suggests that mandates would need to be more specific in order to achieve maximum result. While using recycled content may generally be assumed to provide an environmental benefit there may be cases where the result is the opposite.

In examining the application of recycled content mandates to paper recovery, the risk of unintended consequences emerges when broad based policies are adopted. For example, according to the *American Forestry and Paper Association* (AF&PA), paper recovery occurs within a hierarchy. Printed papers, versus alternative fibers such as tissue or paperboard, require additional filtering, cleaning and brightening. This additional processing requires more energy, more chemical use and creates more

overall waste.[5] In fact, redirecting recycled paper towards office paper would result in a loss of 30-50 percent fiber versus directing that same recycled product towards paperboard packaging where less processing is required and more than 85-95 percent of the fiber would be recaptured.

Figure 2: Efficient Utilization of Recovered Fiber Varies by End Product



A further study by *SAPPI Fine Papers* found that adding ten percent recycled content to their magazine paper increased their carbon footprint by sixteen percent compared to the same product made with one hundred percent virgin fiber[6].

In this case, a Circular Economy model, with its vision of reuse, offers an ideal aspirational state. However, the Sustainable Materials Management model, by helping to explain the circumstances by which mandates would result in the greatest benefits and least environmental impacts, would be a necessary complement to ensure the most sustainable course of action.

<u>Source Reduction—Coffee Packaging</u>

Coffee packaging has undergone a significant shift in the past decade. Today, there are three primary package types for use with bulk brewing:

1.) a steel container with high post-consumer recycling rate,
2.) a lighter rigid plastic container and lid made from HDPE making it completely recyclable but achieving a lower recycling rate, and
3.) a flexible multi-layered pouch which is significantly lighter, uses much less material but which is not currently broadly recyclable, either mechanically or thermally.

[5] American Forest & Paper Association. (August 2013). "EPA Product Specific Mandates for Recovered Fiber Content Ignore Paper Industry Economic and Environmental Realities".
[6] Ibid

Table 4: Coffee Packaging Choices and Associated Environmental Impacts[7]

Based upon an 11.5oz product

	Steel Can 	Rigid Plastic Container 	Flexible Pouch 
Package weight, oz./11.5oz of coffee	4	3	0.4
Recycling rate by consumer	72.5%	28.2%	0%
MSW landfilled after recycling (lbs./100,000oz of coffee)	598	1171	217
Packaging GHG emissions, lbs. CO2e/11.5oz of coffee	0.77	0.28	0.05
GHG benefit of packaging recycling, lbs. CO2e/11.5oz of coffee	-0.45	-0.16	-0.02
Packaging net GHG emissions, lbs. CO2e/100,000 oz. of coffee	3,800	1,996	413
Packaging energy consumption, MJ/11.5oz of coffee	7.5	11.5	0.9
Energy benefit of packaging recycling, MJ/11.5oz of coffee	-5.0	-9.4	-1.3
Packaging net energy consumption, MJ/100,000 oz. of coffee	33,489	76,721	7,722

Source: USEPA

Based upon the data shown in Table 3, if one adopted a packaging material based solely on recycling rate, the steel can would be the preferred material of choice, as it has an established closed loop system and steel can be recovered indefinitely. However, this overlooks the advantages seen with source reduction offered by the flexible film pouch. Although not recoverable, the film pouch results in significant energy savings via material reduction, transportation and retail. Although it is likely that the film pouch package will be landfilled in its entirety, once one looks at the wastes accumulated across the lifecycle, the study still suggests cumulative landfill waste is less with the pouch than it is with the recyclable alternatives. These additional impacts would be captured with the application of an SMM model but depending on the boundary applied, may likely be overlooked in the CE model.

A further study examining single use vs. bulk brewing coffee systems suggests that single use may be an environmentally preferable option[8]. Although single use coffee requires more packaging, and utilizes material with limited recycling options, the lifecycle assessment suggested that less coffee and water are wasted, and less energy is used, in the production and consumption phases of single use systems. Under the Circular Economy model, where the packaging is likely to be considered independent of the product, the relationship of coffee packaging to the product's use and consumption would not be explored. Only by including consideration of both product and packaging, would a comprehensive understanding of impacts be achieved. For CE this would mean establishing the product-package system in establishing boundary conditions. For the SMM approach, that boundary is already defined and would include consideration of both product and package permitting tradeoffs across the entire system to be explored.

[7] Resek, Elizabeth. (February 2015). "Sustainable Materials Management." [PowerPoint presentation] Retrieved from: http://nrcrecycles.org/mobius/nrcwp-content/uploads/2015/02/Liz_powerpoint.pdf

[8] Quantis International. (June 2015). "Lifecycle Assessment of Coffee Consumption: Comparison of Single Serve Coffee and Bulk Coffee Brewing." Retrieved from: www.pac.ca/assets/pac0608-full-lca.pdf

Packaging to Reduce Food Waste

Approximately sixty percent of household food waste arises from products not used because of perishability or shelf life that is too short. One of the most effective ways to extend shelf life and reduce food waste is through packaging.[9] Since food production results in 80 percent of all US freshwater use, 10 percent of total energy demand and 50 percent of land use in the US, reducing food waste would significantly reduce our environmental impact. Whether applying a circular economy or sustainable materials management approach, care must be taken to consider all impacts across the lifecycle in order to assure the most positive outcome.

Innovations in meat packaging have resulted in a significant extension of shelf life, and assisted in reducing portion sizes. This has had a substantial impact on supply chain waste as shown in Table 5 for a retail case study for fresh red meat.

Table 5: Environmental Impacts of Different Meat Packages

Based upon 330g of Sirloin Steak

	Sirloin Steak in Sealed Tray with Modified Air. 	**Sirloin Steak in Vacuum Sealed Pack** 
Primary Package Weight	16 grams	19 grams
Recyclable Components	Polystyrene Tray may be recyclable	None
Shelf Life	6 days	16 days
Food Waste	34%	18%
Packaging GHG Emissions, grams CO2e	100	94
Food Waste GHG Emissions, grams CO2e	4,900	3,800

Source: Denkstatt

The data above[10] illustrate the significant environmental net benefits that food packaging can deliver where it helps to avoid the waste of resource intensive food products. By optimizing the packaging, the net carbon footprint of the packaging was reduced by 6 grams. However, by reducing the amount of wasted food, the net carbon impact of the packaged product was reduced by 2,100 grams, or 350 times the benefit of the package optimization alone.

Assuming a Circular Economy model with a packaging only boundary, would infer that the packaging which is more easily recovered would be preferable. A CE model that only looks at packaging in isolation from its role, would not account for the benefit realized by decreasing the amount of food wasted as a result of shorter shelf life.

When applying a Sustainable Materials Management model to this example, both the packaging and the product would be included and environmental tradeoffs would need to be taken into account. The

[9] WRAP. (2016). "Reducing Food Waste - How Packaging Can Help." Retrieved from: http://www.wrap.org.uk/fresherforlonger

[10] Denkstatt. (2014). "How Packaging Contributes to Food Waste Prevention." [Powerpoint presentation] Retrieved from: http://denkstatt.at/files/How_Packaging_Contrinutes_to_Foof_Waste_Prevention_V1.2.pdf

package choice which minimizes product loss is the better alternative since it reduces total waste (packaging plus product) and significantly reduces total environmental impact. Therefore, using the right packaging is one which is optimized to provide better product protection and less total waste.

Policy Implications

As society begins to embrace new models for material sustainability, AMERIPEN urges businesses and policy makers to do so from a systems perspective. Without the big picture, well intentioned strategies may result in unanticipated outcomes. Thus, the most sustainable packaging is the one which looks across the entire system of product and packaging and minimizes the collective negative impacts while maximizing benefits.

AMERIPEN notes that although both models have similar objectives, the data they evaluate and the lifecycle phases they emphasize differ significantly. In the absence of a clear starting point, without knowing clearly what it is one wants to achieve, or which model to use and how to apply it, unintended consequences are likely to result. By focusing on the establishment of circular systems, Circular Economy can help drive recovery, energy usage and raw material extraction for the materials that are recovered, potentially resulting in decreased GHG emissions. Sustainable Materials Management will likely achieve the same outcomes but also delivers an understanding of where, and when tradeoffs will result in the best overall environmental outcomes.

While these broader approaches can help reflect the true value of packaging, they can be costly and burdensome. For CE and SMM models to have significant impact within industry specific parameters, it is critical that approaches capture the important impacts of that industry, and also simplify the processes involved in doing so.

Conclusions

Circular Economy and Sustainable Materials Management are powerful tools to improve sustainability. Both approaches provide useful frameworks which can result in the innovation of new systems, increased value capture from “waste” materials, development of new materials, and improved ways of doing business. Attention to principles of CE and SMM can help the packaging industry increase the benefits that packaging provides to society while minimizing the overall environmental burden associated with the product-packaging delivery system; however, we must understand that they are not the same and how they define the parameters, goals and objectives under which they operate, will set the tone for where actions towards sustainable packaging systems are focused.

Goals such as minimizing waste, reducing raw material consumption, and minimizing energy usage are likely to provide both environmental and economic benefits and should be pursued aggressively, but understanding how to achieve this must include a perspective on the full-system on not just a subsection of material, product of lifecycle phase. Rather than focusing on individual metrics, the specific process, or framework deployed, we urge careful consideration of the entire packaging system—including its primary role in protecting products.