# **3.63 Sustainable Materials Management**

**Project Number and Title**

3.63 - Sustainable Materials Management

**Project Lead and Deputy**

Thabet Tolaymat (interim NRMRL SHC MI / (Ed Barth – interim PL)

**Project Period**

FY16-FY19

**Project Summary**

This project will enable communities and the Agency to better protect and enhance human health, well-being and the environment for current and future generations, through the reduction in material consumption, reuse, and recycling of the materials to minimize the environmental impacts associated with products and materials. The projected integrated approach addresses the management of materials throughout their life-cycle in a cost-effective manner while minimizing negative environmental and socioeconomic impacts and incorporating community values. This Project consists of three major tasks that will result in the development of several products involving materials management resource tools to further advance the notion of integrative, sustainable materials management in cooperation with the Office of Solid Waste and Emergency Response (OSWER). This project addresses 3 of the 5 Agency Goals: Goal 1 - addressing climate change and improving air quality; Goal 2 - protecting America’s waters; Goal 3 - cleaning up communities and advancing sustainable development. This project addresses climate change aspects resulting from material flow, management, and handling by evaluating alternatives from both an energy and greenhouse gas emissions perspective. Furthermore, this project addresses the following cross-cutting Agency strategies: (1) Working Toward a Sustainable Future,(2) Working to Make a Visible Difference in Communities,(3) Launching a New Era of State, Tribal, Local and International Partnerships, and (4) Embracing EPA as a High-Performing Organization.

**Project Description**

Problem and Decision Context

To reduce the threat of and impact of materials to public health and the environment, a sustainable approach for materials management will encourage the minimization and extraction of raw materials, reducing pressure on the use of non-renewable materials, recycling materials for beneficial reuse, substituting more benign materials into commerce, and maximizing quality of life and prosperity, or in closed-loop manufacturing. The framework for Life Cycle Management of Materials (LCMM) developed in this project will catalyze a shift from end-of-life thinking (*waste* management) towards a more integrated life-cycle approach (*materials* management) by developing and demonstrating life cycle assessment paradigms and material, product, and process design strategies that lead to reduced environmental impacts while preserving natural capital.

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Outputs

This project will directly contribute to three SHC Outputs:

3.63.1 Sustainable materials management options for industrial, construction / demolition, and municipal materials including reduction, reuse, and recycling/repurposing to protect community public health and the environment (FY17)

3.63.2 Strategy for sustainable materials management (FY18)

3.63.3 Tools for evaluating temporal and spatial impacts of materials management on public health and the environment, for use in restoration and revitalization decision making (FY18)

Focus Areas

Three focus areas will support the key outputs of the project and address the stated needs of client program offices by conducting systems oriented research and delivering products:

* Life Cycle Management of Materials (LCMM)
* Reuse of Organics and Other Materials
* Regulatory Support

Figure 1 shows the overall linkages between the three research focus area to the OSWER Priority Areas and key products that will be produced and available.



Figure 1. Project linkages between products and known research priorities

*Focus Area # 1: Life Cycle Management of Materials -* As States and communities move towards sustainability, they must consider how to identify and reduce potential sources of environmental impact within their realm of influence, such as waste and water infrastructure, transportation systems, and industrial commerce. These decisions are made with the understanding that effective and sustainable environmental protection is linked to human health and quality-of-life, economic opportunity, and community vitality. In its 2009 report “Sustainable Materials Management: The Road Ahead[[1]](#footnote-1)”, EPA outlines its approach for sustainable materials management (SMM) as fulfilling human needs and prospering while using less materials, reducing toxics and recovering more of the materials used.

Life cycle assessment (LCA), as defined by the ISO 14000 series, has emerged as an invaluable tool for identifying the impacts associated with the environmental emissions and mass/energy flows of products and services. While life cycle thinking is a key part of SMM, careful consideration of how best to apply a product-centric tool like LCA to answer material-centric questions is needed to maximize the effectiveness of this approach. These considerations include not only the effects of the numerous methodological choices for LCA, but understanding the various types of decision that can be involved with SMM and the information needed to support these decisions. Such decisions might include top-down management of materials based on policy or bottom-up approaches promoting sustainable material use through the development of viable material and process alternatives.

The LCMM focus area will develop a framework to support decision making within the nexus of LCA and SMM by integrating LCA methods being developed throughout ORD’s national research programs (Air, Climate and Energy (ACE), Chemical Safety and Sustainability (CSS), Sustainable and Healthy Communities (SHC), Safe and Sustainable Water Resources (SSWR) and Homeland Security Research (HSR)) with approaches for the design of sustainable alternatives. Other methodologies for community material management will also be explored including urban metabolism. The intended outcome of the framework will be the identification of an optimum SMM strategy given the numerous options for impact reduction within a material life cycle. The initially proposed Framework for Life Cycle Materials Management (LCMM) envisions a 5-step process, including material prioritization, baseline assessment, alternatives development, alternatives assessment, and decision support that will enable users to identify materials of concerns and mitigate/eliminate associated impacts. The LCMM framework will provide process or product-oriented knowledge and will be complementary to community-level decision tools being developed within SHC.

In order to evaluate life cycle impacts, life cycle inventory (LCI) data that describe the manufacture, use, end-of-life management of high impact industrial and consumer materials is needed. LCI development within the context of this project will concentrate on end-of-life materials management processes (landfilling, recycling, etc.) because there are currently large data gaps for this life cycle stage for most materials. This work will also include development of a methodology to characterize the composition and volume of leachate from landfill processes. EPA has a unique capacity to provide these data and is already a leader as a data provider in the area of GHG emissions and characterization of MSW management through the WARM tool. Although the traditional use of landfilling for end-of-life is not the most desirable form of materials management in SMM, research on it is included in this project to provide more accurate models and data when establishing baseline scenarios in the framework. The data developed in this project should support not only in the tools developed by the Agency, but also the tools developed by other organizations. Therefore this project will include the design and implementation of an EPA portal to the Federal LCA data commons in collaboration with USDA, who has already launched a similar portal, and other federal agencies. The development of an EPA portal to the Federal LCA data commons is one of OSWER's top priorities.

Collaboration with state and local decision makers via stakeholder relationships established by OSWER and one or more Regional Offices will provide LCMM tools that can assist state and local governments in making effective materials management decisions. This will include adapting the current national level material prioritization tool (OSWER’s SMM IO Tool) for state (and possibly community) level analysis and migrating this tool, as well as the EPA Waste Reduction Model (WARM), to an open platform that can incorporate all of the LCI or materials information being generated in SHC Project 3.63. Non-expert user interfaces will be implemented in LCMM tools to help decision makers easily obtain results that answer their specific questions regarding materials of concern. During the process of tool development, stakeholder groups will provide feedback on the tools so that they are made more meaningful and useful to the various types of decision support in SMM.

Considering how national, state and local government policy makers might influence materials cycles, additional information is needed for tracking flows of high impact or high volume materials to aid in prioritization of SMM strategies. In particular construction and demolition debris (C&DD) is poorly characterized and tracked. Research in this focus area will include assistance for ORCR in developing a methodology to track C&DD at the national level. This research will support development of inventories for materials currently available in our nation’s infrastructure, including old landfills and abandoned buildings. These inventories will assist stakeholders in devising local and national strategies to increase recycling and the potential “mining” of materials from landfills and brownfields.

The ultimate impact of the LCMM focus area will be the ability to assist stakeholders in decision making and implementation of effective and affordable materials management strategies at the product level to advance community sustainability, fostering improved public health, economic stewardship of resources and minimization of climate change impacts. As communities assess the future direction for SMM, they must also continue to evaluate the ramifications of legacy decisions. To that end the project will aim at addressing the issue of post closure care requirements for both subtitle C and D landfills.

The key products for the Lifecycle Management of Materials focus area are:

* National Generation Estimate of Construction and Demolition Debris following a bottom-up methodology
* Side By Side Evaluation of Life Cycle Tools for Waste Management
* Framework for Life Cycle Materials Management
* Life Cycle Inventory Databases of Materials Management
* Demonstrations of Life Cycle Materials Management
* Adaptation of Waste Reduction Model (WARM) to Open LCA
* Materials Management of Low Level Radiological Waste
* Life Cycle Materials Management Tools for Government and Industry Stakeholders.

*Focus Area # 2: Reuse of Organics and Other Materials -* Beneficially using spent materials and waste streams as a feedstock, including those associated with organics for energy recovery options, provides an opportunity to reduce their life cycle impacts and improve the sustainability of the overall process.. Reuse of materials (e.g. industrial, agricultural and organic and inorganic sources) may contribute to benefits including offsetting the use of virgin materials in products or processes and potentially lead to reducing their adverse effects on the environment and human/ecosystem health. To address the key objectives of the SHC research program, this focus area will develop dynamic methods, data, strategies and tools to assist communities in framing sustainability goals to enhance energy generation and materials recovery from existing waste streams or underutilized material flows.

Thus, there is a need to optimize materials reuse and recycling while minimizing their environmental impacts and facilitating effective economic and social outcomes. Strategies to develop opportunities for materials reuse and valorization are based on our extensive knowledge of chemistry and engineering in designing more sustainable alternatives. It is the goal of this approach to demonstrate the opportunities that exist for producing useful and needed products from waste or spent material streams as well as ensuring these approaches have a minimal impact on the environment. It is also important to evaluate the utilization of biomass and food waste, especially the most abundant, natural and biodegradable biopolymers such as cellulose (from wood waste and agricultural residues) and chitin (from shrimp shells, crab and sea foods) for the synthesis of various mesoporous carbon materials. The biochar and magnetic versions of such carbonaceous materials could be used to make high-value products and in sustainable removal of contaminants from the environment. To extend on this focus area, another objective is to improve the effectiveness and efficiency of methods and guidance to address land and groundwater contamination sources (e.g. land application of specific outputs of anaerobic decomposition processes including digestate) and to encourage the use of innovative approaches to reduce new sources of contamination.

To assist society in fully utilizing these industrial and organic materials, this focus area involves the development and evaluation of technologies. In the case of organic materials, this research will provide reports and tools to make better use of currently available infrastructure at Waste Water Treatment Plants (WWTP) for organic materials management. A portion of this effort is to update a Region 9 tool (Co-EAT) and migrate it into open LCA platform to allow it better integration with other materials management models and approaches. This opportunity aims at tapping the currently unused capacity in the WWTP anaerobic digesters for processing non-wastewater organic material (pre- or post-consumer food waste). Furthermore, the focus area would assess innovation at local wastewater treatment plants related to beneficially using (and extracting energy from) organics, quantify the economic and environmental benefits of these practices, and determining the roadblocks to acceptance at non-innovating plants. There is a need for evaluation of methods to prepare collected gas for community use as well as targeting organic materials not traditionally evaluated for energy recovery. Part of this research may intersect with some biosolids work in SSWR.

Another example will include risk informed materials management models (RIMM) supporting the LCMM framework. The RIMM collection of interoperable models, databases and will form the overall base RIMM system including the establishment of the base HE2RMES v1.0 modeling domain in FRAMES v2.0, establishing a fully implemented D4EM-4-HE2RMES solution (as SDPProjectBuilder v1.0), servicing all of HE2RMES' science models, and improving and expanding upon the suite of natural science models in HE2RMES. The project is designed to be inclusive of OSWER technical staff who will provide ongoing consultation and design input on software development approaches, beta-testing efforts (as a future user), and demo uses of RIMM software technologies, and ultimately available to the public.

This focus area supports all three identified key outputs for this project by providing data, reports and tools for communities and regulatory officials to evaluate options for sustainable materials management at the national and local level.

The key products for the Reuse of Organics and Other Materials focus area are:

* Utilization of Organics and Biomass – Demonstration and Evaluation
* RIMM module HE2RMES demonstrations, OSWER in-house desktop operations, OSWER parallel computing/clustering capabilities, ORD-OSWER software/results exchange capabilities. Final RIMM module HE2RMES v1.0 with documentation
* RIMM Module D4EM Complete Application Assistance and Hand-Off to OSWER
* RIMM Module Landfill and Roadway Components
* Beneficial Use of Materials Portal (BUMP)
* Evaluation of Beneficial Use Impact on Climate Change

*Focus Area #3: Regulatory Support -* This focus area will provide technical support regarding questions concerning regulatory aspects of SMM. This focus area will also benefit from associated research in the project, but is somewhat different in scope than the other two focus areas. For example, ORD’s ongoing support for coal combustion residues (CCRs) and answering technical questions with regards to the use of the leaching environmental assessment framework (LEAF) is focused here as well as the evaluation of the empty container rule for pharmaceuticals.

E-waste is another high impact research for OSWER and an EPA commitment under the National Strategy for Electronics Stewardship. Although a variety of data sources are available to quantify used electronic waste, there is a lack of coherent sets of information on used electronics and their domestic movement. To address this need a multiyear research approach is being developed, building upon the inadequacies of existing systems. The outcome of the research would identify methods for domestic tracking of quantity of used electronics and their flows. Develop, publish, and implement tracking methods that containing electronics quantities and flows. Depending on the method developed, ultimately ORD would implement it online for communities use.

In the short term, ORD would conduct a detailed characterization of the sources and quantities of used electronics flows that would assist decision makers especially at the EPA. Furthermore, states have their own used electronics management and recycling programs that provide more complexity to any effort aimed at quantifying E-waste generated. ORD’s research would identify and quantify the potential effects of the state-level electronics recycling requirements. The evaluation should also address the inherent benefits and drawbacks for the states requirements. The evaluation should also address the economic effects of e-waste regulations and the impact of enacting similar regulations at the national level.

Depending on the type and quality of data currently available for electronic waste tracking (gap analysis), ORD researchers may be able to evaluate and summarize both top down and bottom up methods, using mass flow or process models, for quantifying and tracking used electronics. Based on those results, ORD would develop a method for the estimates of used electronic waste generation, recycling and disposal within the U.S.

The key products for the Regulatory Support focus area are:

* Coal Combustion Residues Rule Regulatory Support
* Source Term Calculations for Coal Combustion Residues
* Electronic waste inventory and tracking system

**Nature of the Work**

Approximately 70% of the funds will be placed into extra-mural funding vehicles for specific task activities and managed by ORD technical staff. The remaining 30% being used for in-house research activities.

**Collaboration**

Program office partners: OSWER (ORCR), OCSPP, OAR, OW (OGWDW), OP, OSC

Regions: Region 4 for developing an SMM approach applicable at the state level , Region 3 development of secondary applications for spent industrial solvents FY14 RARE Project), Region 5 application of EPA pollution prevention and sustainability software. Region 9 development of SMM approaches for communities.

State(s): The State of Georgia for conducting a pilot study of a state SMM tool

Other federal agencies: USDA ARS for developing and publishing materials life cycle data consistent with the federal LCA data commons

Other SHC projects:

SHC 1.61 – Guidance for model development and interoperability will inform development of stakeholder SMM tools

SHC 1.62 – Incorporate Enviro Atlas as possible into the SMM support tools regarding location-specific impacts to ecosystem services related to material production or disposal

SHC 2.62– Utilize C-FERST in SMM support tools to identify location-specific health concerns that may be effected by changes to material cycles

SHC 2.63: Assessing Environmental Health Disparities in Vulnerable Groups

SHC 2.64 Indicators, Indices and the Report on the Environment

SHC 3.61 – Will provide this project ground water modeling for the LCMM support

SHC 4.6.1 – Demonstrate how life cycle approaches can be used to supplement TRIO assessments

SHC 4.6.2 – Will provide this project examples of tools that use systems approaches and consider multiple sectors to address community decisions.

Other ORD research collaborations:

ACE Sustainable Energy Evaluation (SEE) 1 – Regionalized air impact models based on spatially-resolved emissions, community-ACE SEE 1 – Community focused energy models and underlying electricity life cycle inventory data;

CSS 11.01 Lifecycle and Human Exposure Modeling (LC-HEM)–LCA data structure and software platform, models incorporating human exposure into the life cycle approach, rapid LCI modeling methods, Use of SHC-developed LCI data in CSS LC-HEM project.

CSS 9.01 Sustainable Chemistry – application of developed strategies/guidance for sustainable molecular design which could potentially be used for designing products that are readily biodegradable, possess physical or chemical properties that allow the molecule to be “taken apart” when an action is place on it and the resulting “two pieces” can be used for secondary application and for use in identifying opportunities for design of alternative products or processes.

ACE - climate change and impacts on materials management operations, historical operations as well locations TBD

SSWR – location of MM operations and impacts on water supplies/water quality

**Assumptions/Constraints**

An additional Life Cycle Assessment / Life Cycle Inventory (LCA/LCI) methodologist position has been advertised to supplement the existing team research team structure.

**Project Charter Team Members**

NRMRL

Ozge Kaplan

Susan Thorneloe

Richard Snow

Jennifer Goetz

Mark Kemper

Todd Luxton

Souhail Al-Abed

Derrick Allen

Ed Barth

David Carson

Chunming Su

David Meyer

Endalkachew Sahle-Demessie

Jane Bare

Leland Vane

Michael Gonzalez

Rajender Varma

Wesley Ingwersen

Kirk Scheckel

Steven Rock

Thabet Tolaymat

NERL

Justin Babendreier

Fran Kremer, NPD Representative

Thabet Tolaymat, MI Representative

1. [↑](#footnote-ref-1)