Technology Market Summit
May 14, 2012

Case Study Primer for Participant Discussion: Automotive Supply Chain

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Introduction

The U.S. Environmental Protection Agency is committed to exploring environmental technology opportunities that cooperatively engage the investment, business, technology, government, nonprofit and academic communities. EPA's roadmap, Technology Innovation for Environmental and Economic Progress[1], outlines EPA's vision:

> *The EPA will promote innovation that eliminates or significantly reduces the use of toxic substances and exposure to pollutants in the environment and that also promotes growth of the American economy. Building upon the EPA's history of scientific and technological expertise, the Agency will seek out prospective technological advances that have the greatest potential to achieve multiple environmental goals. Consistent with its statutory and regulatory authorities, the EPA will partner with a diverse set of new and existing stakeholders to speed the design, development and deployment of the next generation of environmental technologies, creating a cleaner environment and a stronger economy for our nation and the world.*

The Technology Market Summit on May 14, 2012 supports EPA's vision by bringing together representatives of diverse sectors to come up with ideas and actions to support a cleaner environment, new technology markets, and new jobs. The Summit is designed to yield specific, short and long term steps that government, business, nonprofit and academic communities can take to facilitate private investment in sustainable environmental technologies.

The Summit provides participants with the opportunity to engage in dialogue on one of three case studies: fenceline air quality monitoring, the automotive supply chain, and biodigesters and biogas.

This primer serves as a foundation and guide for discussions on the supply chain specific to the automobile manufacturing sector.

The substantial environmental impacts of automobile manufacturing and the need for significant capital to finance investments in cleaner facilities and technologies make the automotive supply chain instructive in the way new partnerships and new technologies might be advanced. This primer provides a broad overview with a focus on specific components of the supply chain – the paint finishing and powertrain manufacturing processes. These processes have been identified as having significant potential for environmental improvements and industry cost savings. It is the hope of the Summit sponsors and participating industry and other experts that solutions developed from the Summit proceedings and the resulting successes will be broadly applicable to other U.S. manufacturing industries.

Makeup of the Supply Chain

In a simplified version of the automotive industry, the supply chain is comprised of the following members:

[1] Technology Innovation for Environmental and Economic Progress: An EPA Roadmap, available at http://www.epa.gov/envirofinance/innovation.html.

- **Original Equipment Manufacturers (OEM) –** OEMs manufacture end products from components they purchase from suppliers and then sell such products under their own brand. In the automotive industry, OEMs are the highly-visible “car and truck companies.”

- **Tier 1 Suppliers –** Tier 1 companies make products specifically for the OEMs.

- **Tier 2 Suppliers**- Tier 2 companies make products specifically for the Tier 1 Suppliers.

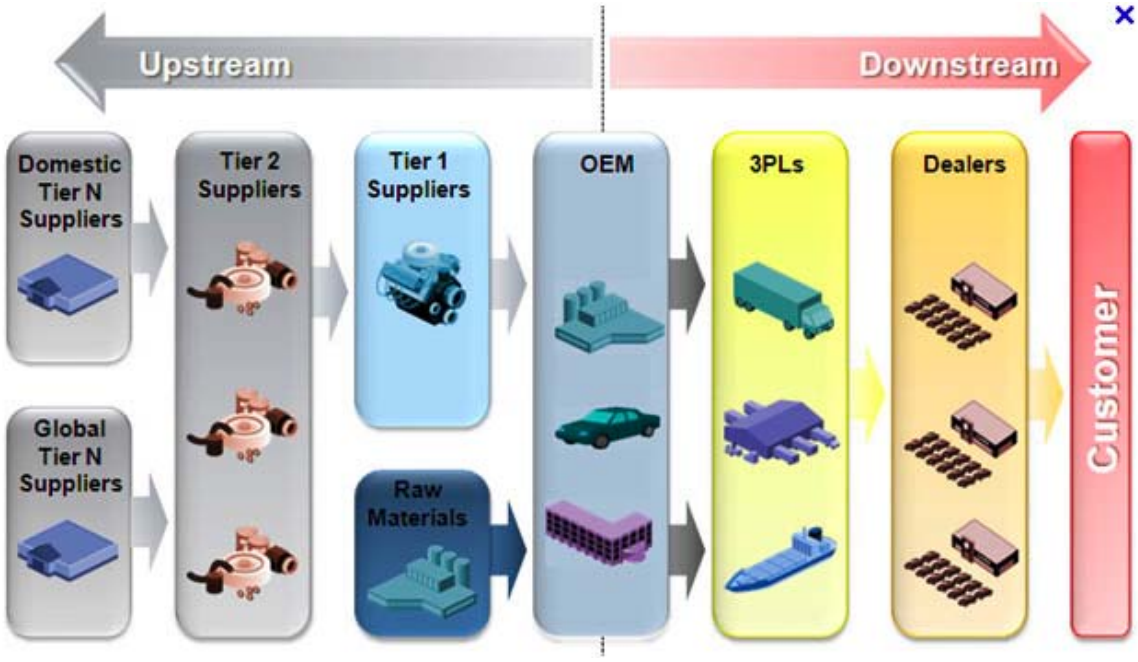
- **Tier 3 Suppliers**- Tier 3 companies make products specifically for the Tier 2 to x-1 Suppliers. Various companies supply Tier 3 suppliers; however, this primer will not define those beyond Tier 3.

- **Third Party Logistics Provider (3PL) -** 3PL providers service customers of outsourced (or "third party") logistics services for part or all of their supply chain management functions. 3PL providers specialize in integrated operation, warehousing and transportation services that can be scaled and customized to customers' needs. These needs may include factors such as market conditions and the demands and delivery service requirements for products and materials.

- **Dealerships –** Dealerships sell the final products, automobiles, to customers.

Together, the industry is structured as depicted in Figure 1, where OEMs and dealers are downstream toward customers, and suppliers are upstream.

Figure 1



The entire automotive supply chain, like that of any industry, has an environmental footprint.

Manufacturing, the Environment, and the Supply Chain

Public discussion on automobiles and the environment has largely focused on reducing dependence on oil, particularly through vehicles with greater fuel-efficiency, hybrid systems, all-electric, plug-in hybrids, and lightweight technologies. While these advancements are allowing automobile OEMs to meet the challenges and demands of consumers and new Corporate Average Fuel Economy (CAFÉ) standards, pollution within the automotive supply chain also greatly impacts the environment and requires attention. To further environmental protection, the sector must reduce pollution emitted throughout the entire production of vehicles.

Automobile manufacturing demands significant amounts of energy, water, and resources; they are consumed throughout all processes, from iron and steel production, painting and metal coating to assembly. It takes an estimated 39,090 gallons of water to make a car.[2] Additionally, chemicals, some of which are toxic or volatile organic compounds (VOCs), are used in the painting and coating processes and for adhesives, sealants, cleaning solvents, and plastics. This includes those which create what some consumers recognize as the "new car smell." All can have environmental impact along the supply chain.[3] To "green" the supply chain means to minimize the release of toxic chemicals to the environment as well as to reduce the use of natural resources such as water, metals and energy of which extraction and use results in additional environmental impacts. The process of studying the consumption of such resources during the manufacturing of products, from production, distribution, use, possible re-use or recycling, and disposal is known as life cycle analysis (LCA).

Industry Moves Toward Life Cycle Analysis

Life Cycle Analysis (LCA) enables manufacturers to understand where pollution is emitted throughout the supply chain (from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling) and evaluate, on a step-by-step basis, the impacts of different approaches for better "greening" of various dimensions. Feasibility studies can be performed to understand the internal impact (including financial costs) and pollution reduction potential throughout the LCA to determine if an investment should be made. To the extent improvements in technology take place (e.g. lighter vehicles), LCA can be used with financial analysis to help companies make investment decisions according to their sustainability or environmental impact goals, industry regulations, or other business requirements.

LCA shows the effect that various propulsion systems for automobiles have on the overall environmental impact i.e. electric vehicles, hybrid vehicles, and internal combustion vehicles (powered by either diesel or regular fuel). In Figure 1 above, impact starts on the left with the "N" suppliers and extends to use (customers) on the right.

As OEMs increasingly move toward using life cycle analysis to evaluate environmental impacts and reduce costs, greener facilities have become more commonly used in manufacturing, along with other sustainability efforts. Throughout different aspects of an automobile's life cycle, OEMs have been working on various sustainability programs with their suppliers.

[2] http://water.usgs.gov/
[3] http://www.calvert.com/nrc/literature/documents/BR10074.pdf

Life Cycle	Environmental Impacts	Industry Sustainability Initiatives	Government Partnerships
Product development	GHGs, exhaust emissions, VOCs, raw materials	Fuel efficiency improvements; exhaust reductions; alternative fuels	US DRIVE
Purchasing Manufacturing	GHGs, raw materials, water, waste, wastewater, chemicals	"Green Purchasing" Zero emission initiatives by suppliers; Promotion of "Green Factories"	Suppliers' Partnership for the Environment
Transport	GHGs, Waste	"Green Logistics" Using less packaging; Improving transportation efficiency	SmartWay
Sales & Services	GHGs, Old Parts, CFCs, Waste	Promotion of "Green Dealers" and energy efficiency	None known at this time.
Product recycling and reuse	GHGs, end-products	Greater recovery of parts for reuse and recycling; Technical Support for recycling	None known at this time.

A Need for Cleaner Painting and Machining Processes—Two Examples

Successful collaboration between the public and private sectors is built from actions that benefit both business and society. For this reason, EPA and its partners have selected one area that has significant potential for environmental improvements and industry cost savings—the paint finishing and powertrain (machining) processes.

Significant amounts of chemicals and toxics are used in the broad coatings and paints market, which includes liquid and powder-based paints, varnishes, and related products used for protective and decorative industrial, automotive, specialty, or other purposes. In this market, customers are driving demand for coatings with expectations of greater sustainability and environmental properties, as well as improved performance, ease of application, quality, and functionality. Several industry trends cited among paint and coatings business leaders include[4]:

- Increased raw materials costs
- Increased investment in research and development (R&D)
- A focus on solutions that are both environmentally friendly and economically efficient

[4] http://coatingsworld.com/issues/2011-07/view_features/2011-state-of-the-industry-review/ *2011 State if the Industry Review*, Coatings World (7/13/11)

- A focus on innovative and sustainable solutions that "either will reduce the use of harmful substances or deliver new products that contribute to improving the environment"[5]
- Special attention given to significant markets in geographic regions with stringent regulatory requirements. An example cited is California's South Coast Air Quality Management District, which enforces the most stringent regulations for paint coatings.

Advances in paint and coatings technologies and processes are helping meet the demand for more environmentally friendly products. Examples include:

- New, high performance ultra-low VOC coatings using raw materials based on renewable resources, particularly waterborne alkyd resins derived from vegetable oils.[6]
- Painting processes that take advantage of polymer technology to eliminate a number of conventional paint application steps. This new technology and process was first employed at a plant in the United States. The facility reports resulting energy savings of up to 30 percent, a 43 percent drop in carbon-dioxide emissions, and a 7 percent decline in VOCs since implementation.[7]

Like the Paint Finishing segment, significant amounts of chemicals, toxics, water, energy and air are used to develop the powertrain segment of vehicles (engine and transmission). The powertrain segment also requires considerable levels of capital and a long-term strategy in developing facility designs. Advanced process technologies are creating options for:

- Reductions to air volume and energy costs associated with mist and dust capture and removal
- Elimination of water, emulsion, and coolants as a vehicle for removing chips, and minimizing cooling costs
- New technologies for finer filtration for reaching greater levels of precision and improved surface conditions
- Improvements to recycling equipment to extract higher amounts of desirable recoverable materials from waste streams

Existing Government and Private Sector Environmental Improvement Efforts

Collaboration between business and government in the automotive supply chain has largely focused on operational improvements since they allow for financial gains through cost-savings as well as environmental benefits. There are several programs organized through the federal government to assist and reward manufacturers in making their operations cleaner. Programs like EPA's Green Suppliers Network,[8] a collaborative effort between EPA's Pollution Prevention program and the National Institute of Standards and Technology's Manufacturing Extension Partnership (MEP) provide the supply chain with direct technical assistance aimed at identifying waste and improving efficiency and environmental performance through process modifications. The Green Suppliers Network program has led to the establishment of a trade association called the Suppliers' Partnership for the Environment.[9] Members

[5] http://www.coatingsworld.com/issues/2011-07/view_features/2011-state-of-the-industry-review/
[6] *Ibid*
[7] http://wardsauto.com/suppliers/ppg-says-new-paint-process-reduces-energy-cost-environmental-impact *PPG Says New Paint Process Reduces Energy Cost, Environmental Impact*, WardsAuto (3/9/12)
[8] www.greensuppliers.gov
[9] www.supplierspartnership.org

include General Motors Corporation, Chrysler LLC, Ford Motor Company, Subaru, Hyundai, Honda, and Nissan, though its membership largely comprises the small- to medium-sized suppliers to these companies. One focus of this association is to bring to light opportunities for assimilation of cleaner technologies into the automotive supply chain.

More recently, with the Green Suppliers Network at its core, the Department of Energy, the Small Business Administration, the Department of Labor, and the Department of Agriculture have joined ranks with the EPA and the MEP program to launch a new "Economy, Energy and Environment" (E3) framework designed to bring together the services of these agencies and provide technical assistance more uniformly to America's manufacturers and the communities in which they operate.[10] The E3 framework is already having a positive impact on the automotive supply chain, especially in Detroit, Michigan and northern Alabama. The Alabama E3 program includes a workforce training and education component, specifically an innovation engineering "green" module that focuses on assisting companies to identify new innovative "green" processes, products and/or marketing plans/materials to reduce waste and improve sustainability.[11]

Another public private program, EPA's Waste Wise, helps organizations achieve cost savings and improve efficiency through waste reduction by encouraging and supporting efforts to prevent waste production, to recycle and to purchase materials with recycled components.

As a WasteWise member, organizations have access to a number of useful resources including:

- The WasteWise website that contains a variety of resources, such as publications, program news, and links to additional waste reduction websites; and
- WasteWise Re-TRAC, a free data management and reporting system that allows organizations to track waste generation and reduction activities. Through this automated, secure system, members can input data, track waste reduction activities, and generate customized reports. Organizations can also calculate GHG emission reductions and environmental impacts.

Subaru of Indiana Automotive, a WasteWise member, has implemented extensive waste prevention and recycling initiatives. Subaru is now able to recycle 99.9 percent of waste generated from its manufacturing process, reducing its GHG emissions by approximately 46,000 metric tons of carbon equivalents .[12]

Challenges to Greening the Supply Chain

An Investment Perspective, Cost and Financial Return Issues

Cleaner supply chains require cleaner technology, and technology requires investment. However, longer term, uncertain payback can discourage investment in greener technologies. This cost pressure applies equally to automotive suppliers and is particularly difficult for smaller suppliers in the second and third tiers. As described in a May 2011 report prepared by a research consortium of the Indiana, Michigan and Ohio Labor Market Information offices and their strategic partners, lower-tier suppliers have struggled to meet recent production volume demands.[13] The need to focus on eliminating supply chain

[10] www.E3.gov
[11] http://www.e3.gov/accomplish/alabama.html
[12] http://www.epa.gov/epawaste/partnerships/wastewise/pubs/fact-sheet.pdf
[13] "Driving Workforce Change: Regional Impact and Implications of Auto Industry Transformation to a Green Economy,"

disruptions, and to ensure that basic quality objectives are maintained even at higher production volumes, inhibits the ability of smaller, lower-tier providers to make investments in technologies and workforce skills that might be necessary for successful integration of new technologies. In fact, 74 percent of small firms surveyed postponed investment in equipment after the 2008 financial crisis.[14] Investment horizons have also shrunk to the point that desired payback periods typically range from 1-2 years. As a result, firms in the supply chain have yet to fully embrace new and innovative technologies that already exist and, when successfully deployed, that can help companies all along the automotive supply chain reduce costs and reach sustainability targets.

Lack of Awareness of Existing Technology

Another challenge to the investment in, and adoption of, cleaner technologies and facilities is a lack of awareness. Many technologies exist that can have a significant positive impact on the environmental footprint of the automotive industry. This technology goes beyond fuel efficiency to improved process efficiencies, including the more efficient use of energy, water and other resources, and material re-use and remanufacturing. However, lack of awareness of such technologies inhibits their adoption. Additionally, even when the market is aware of specific technologies, multiple OEM and larger Tier suppliers often create order specifications that impede technology selection and process options for plant layouts.

OEMs rely on effective and efficient supply chains to compete in the global automotive market through business relationships that extend beyond traditional business boundaries and seek to organize entire business processes throughout a value chain of multiple companies.[15] Paramount to the OEM is the ability of its supply chain to meet quality, technology, cost, and delivery criteria while at the same time meeting sustainability criteria of equity, credibility, and environmental stewardship. The International Organization for Standardization issued revised ISO 9001/ISO TS 16949 standards that develop a quality management system to provide for continual improvement, defect prevention and the reduction of variation and waste in the automotive supply chain.

The automotive supply chain is faced with increasing risks (e.g., raw materials and workforce shortages), some of which may be ameliorated by sustainable supply chain management strategies.[16] Given the constant pricing pressures placed on suppliers, along with a reluctance to make capital investments due to low profit margins in the industry and short investment horizons, OEMs and their suppliers will need to work together to improve the environmental performance of their supply chains while maintaining product quality and affordability.

Potential Solutions

To address the challenges previously mentioned, several questions have been developed to begin the automotive supply chain discussion at the Technology Market Summit.

[14] http://www.drivingworkforcechange.org/reports/DrivingWorkforceChange.pdf
[15] Peter Drucker (1998) *Management's New Paradigms. Forbes.*
[16] Ernst & Young, Automotive Supply Chain Europe 2011 Conference

General Discussion Questions:

- What will attract capital (internal to and external from the automotive supply chain) to help catalyze the greening of the entire supply chain?
- Are there existing or new standards that can be adopted to encourage the greening of the automotive supply chain on a voluntary basis?
- What is the most effective role which the government can play in greening the automotive supply chain?

Specific Discussion Questions:

- To facility managers in the audience --What barriers exist that limit the acceptance of greener technologies? How can these barriers be broken down? Who is in the best position to effect change?
- For producers of a product in the audience – what barriers exist when working with facility managers? purchase managers? How can these barriers be broken down? Who is in the best position to effect change?
- What can be done to improve the speed of technology adoption? Who can best respond to these questions?
- Can actions be implemented relatively quickly i.e. within a year?
- What other key questions have been missed?
- How can the process to obtain third party validation of innovative technologies be improved, especially those developed by small companies and entrepreneurs?
- How can the perceived high risk by OEMs pertaining to small technology companies be reduced? Who can best respond to the issue?
- What, if any, investor expectations, fiduciary responsibilities or other financial issues may be creating barriers to full expression of innovative technologies? Who can best respond to the issue?

Additional Key Terms

Battery: In a gasoline-powered vehicle, a battery is the initial source of power that allows the engine to be started. Once the engine is running, an alternator supplies the car's electrical needs and restores energy to the battery. The battery of hybrid or electric vehicles is rechargeable and can serve as the partial (as in the case of the hybrid vehicle) or complete (as in the case of the electric vehicle) power source for the vehicle. Hybrid vehicles do not need to be plugged into an electrical outlet to charge their batteries, whereas electric vehicles do.[17]

Chlorofluorocarbons (CFCs): CFCs are volatile organic compounds once widely used as refrigerants, propellants, and solvents. The Montreal Protocol, effective since 1989, has since phased out CFCs because they contribute to ozone depletion.

Corporate Average Fuel Economy (CAFE) standards: These U.S. regulations were first enacted in 1975 to improve the average fuel economy of cars and light trucks in an effort to decrease demand for oil and improve human and environmental health. The CAFE standards were updated in 2011 to express required fuel economy levels as a mathematical function of a vehicle's size.

Electric Vehicle: Electric vehicles are powered by batteries or fuel cells and are limited to shorter ranges than hybrid vehicles. A typical system involves a group of lead-acid batteries connected in a series that propels the vehicle by way of an electric alternating-current (AC) induction motor; however, substituting nickel–metal hydride batteries for lead-acid batteries can double the driving range. Batteries may be recharged using a domestic electrical outlet in as little as three hours, and technological advancements are continuously decreasing charge time. [18]

Fuel Efficiency: Fuel efficiency refers to the efficiency with which a device or process converts the stored chemical potential energy of fuel into kinetic energy. For vehicles, this concept is typically expressed as fuel economy, or the distance that can be traveled with one unit of fuel (e.g. kilometers per liter, miles per gallon).

Greenhouse Gas (GHG): A gas that greatly affects the temperature of the Earth and contributes to the Earth's greenhouse effect by absorbing and emitting infrared radiation.

Hybrid Vehicle: Hybrid vehicles combine the benefits of an electric vehicle with those of an internal combustion vehicle by coupling an efficient gasoline engine with a lightweight, high-output electric motor that produces extra power when needed. When a hybrid vehicle is being operated conventionally (i.e. driving is powered by the gasoline engine), the motor recharges the battery pack. This mechanism eliminates the need to plug the car into an electrical outlet for recharging, as is required for an all-electric vehicle. The primary advantage of hybrids is that the "system permits downsizing the engine and always operating in its optimum efficiency range through the use of advanced electronic engine and transmission controls."[19]

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[17] "Battery." *Automotive Definitions.* Inner Auto Parts. Web. 18 Apr. 2012. <http://www.innerauto.com/Automotive_Definitions/>.

[18] "Automobile." *Encyclopædia Britannica. Encyclopædia Britannica Online*. Encyclopædia Britannica Inc., 2012. Web. 18 Apr. 2012. <http://www.britannica.com/EBchecked/topic/44957/automobile>.

[19] "Automobile." *Encyclopædia Britannica. Encyclopædia Britannica Online*. Encyclopædia Britannica Inc., 2012. Web. 18 Apr. 2012. <http://www.britannica.com/EBchecked/topic/44957/automobile>.

Internal Combustion Vehicle: This vehicle is characterized by its internal combustion engine, which uses the heat produced during the combustion of oxidizer and fuel to power the vehicle. This heat is transferred into useful work when the hot gaseous products of combustion act on moving surfaces within the engine, such as the face of a piston or a turbine blade. Currently, the internal combustion engine (e.g., gasoline engines, diesel engines) is the most widespread power-generating method for motor vehicles in existence.[20]

Lightweight vehicles: Vehicles that are built with lighter materials such as automotive aluminum instead of steel. These lightweight vehicles have better fuel economy over their standard weight counterparts.

Powertrain: The powertrain of an automobile is comprised of an engine, transmission (manual or automatic), and driveshaft. The energy produced in the engine is then transferred into the transmission, which uses gears and a clutch to convert the power into torque, allowing the vehicle to propel itself forward (or backward) as the torque is transmitted to the wheels of the car through the driveshaft.

Volatile Organic Compounds (VOCs): VOCs are organic chemical compounds that have high vapor pressure and which are both man-made and naturally occurring. There are various types of VOCs, but many are dangerous to human health and cause environmental harm. Anthropogenic emissions of VOCs are regulated in several industrialized countries.

[20] "Internal-combustion engine." *Encyclopædia Britannica. Encyclopædia Britannica Online*. Encyclopædia Britannica Inc., 2012. Web. 18 Apr. 2012. <http://www.britannica.com/EBchecked/topic/290504/internal-combustion-engine>.

Appendix – Acronym List

3PL.....third party logistics
CAFÉ ..... corporate average fuel economy
EPA ..... U.S. Environmental Protection Agency
GHG.....green house gas
LCA ..... life cycle analysis
OEM .....original equipment manufacturer
R&D ..... research and development
VOC .....volatile organic compound

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