Nos. 12-15131 and 12-15135

IN THE UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

ROCKY MOUNTAIN FARMERS UNION, et al.,
Plaintiffs-Appellees,

v.

JAMES N. GOLDSTENE, in his official capacity as
Executive Officer of the California Air Resources Board, et al.
Defendants-Appellants,

ENVIRONMENTAL DEFENSE FUND, et al.,
Intervenor-Defendants-Appellants.

On Appeal from the United States District Court
for the Eastern District of California
Fresno Division Case Nos. 1:09-cv-02234-LJO and 1:10-cv-00163-LJO
The Honorable Lawrence J. O'Neill, Judge

BRIEF OF *AMICI CURIAE* MICHAEL WANG, Ph.D., THOMAS L. THEIS, Ph.D., GREG THOMA, Ph.D., MATTHEW ECKELMAN, Ph.D., and KIMBERLEY MULLINS, Ph.D CANDIDATE IN SUPPORT OF DEFENDANTS-APPELLANTS

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INTEREST OF *AMICI*

Pursuant to the consent of all parties and in accordance with Federal Rule of Appellate Procedure 29 and Circuit Rule 29-3, Dr. Michael Wang, Dr. Thomas L. Theis, Dr. Greg Thoma, Dr. Matthew Eckelman, and doctoral candidate Kimberley Mullins respectfully submit this *amicus curiae* brief in support of Appellants' Opening Brief and reversal of the district court decision. *Amici* are individual scientists with expertise in the field of lifecycle analysis ("LCA") who believe that LCA is and must continue to be an important scientific tool for state environmental regulatory authorities and that LCA is the best means of assessing the full range of environmental impacts from consumption of transportation fuels. *Amici* therefore have a strong interest in the subject matter of this lawsuit and bring a unique perspective to bear on the use of scientifically-grounded LCA in assessing the carbon intensity of the State's transportation fuels.[1]

<u>Michael Wang</u> holds a Ph.D. in Environmental Studies from the University of California at Davis and is a senior scientist and the manager of the Systems Assessment Section of the Center for Transportation Research at Argonne National Laboratory, specializing on energy and environmental impacts of motor vehicle

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[1] *Amici* submit this brief in their personal capacities. All statements contained herein are the professional opinion of individual *Amici* and do not necessarily represent the views of their employers or any other organization with which they are affiliated, including Argonne National Laboratory and U.S. Department of Energy.

technologies and transportation fuels. Dr. Wang has been working in the area of evaluating emission and energy impacts of new transportation fuels and advanced vehicle technologies for over 22 years. He has developed Argonne's GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model for lifecycle analysis of advanced vehicle technologies and transportation fuels. At present, there are more than 18,000 registered GREET users worldwide. Dr. Wang has collaborated with governmental agencies, automotive companies, energy companies, universities, and research institutions in the U.S., China, Japan, Brazil, Canada, South Africa, Europe, and Southeast Asia. His research and the GREET model have been used by governmental agencies in North America, Asia, and Europe to develop transportation fuel policies such as low-carbon fuel standards and vehicle greenhouse gas emission regulations. Dr. Wang is an associate editor of one international journal and on the editorial board of another, and he has authored 201 publications.

Thomas L. Theis holds a Ph.D. in Environmental Engineering from the University of Notre Dame and has been Director of the Institute for Environmental Science and Policy at the University of Illinois at Chicago since 2002. Professor Theis' areas of expertise include, among others, industrial ecology and lifecycle assessment. He has been the principal or co-principal investigator on over fifty funded research projects and has authored or co-authored over one hundred papers in peer-reviewed research journals, books, and reports. Dr. Theis served as a member of the U.S. EPA Chartered Science Advisory Board (2003-2009) and is past editor of the Journal of Environmental Engineering.

Greg Thoma holds a Ph.D. in Chemical Engineering from Louisiana State University and is the Bates Teaching Professor in the Department of Chemical Engineering at the University of Arkansas College of Engineering. He is a Registered Professional Engineer in the State of Arkansas. Dr. Thoma is Senior Advisor to The Sustainability Consortium, a joint effort of the University of Arkansas and Arizona State University with membership of over 75 national and multinational corporations, governmental organizations and NGOs. He currently represents the Sustainability Consortium on the United Nations Environment Program/Society of Environmental Toxicology and Chemistry Lifecycle Initiative board of directors assisting in coordination of international efforts to mainstream lifecycle management in the consumer goods sector. Dr. Thoma is currently lead investigator for a number of lifecycle initiatives in the food and agriculture sector, and he consults on other LCA work at the University of Arkansas, focusing on rice, cotton, corn, and sweet corn.

Matthew Eckelman holds a Ph.D. in Chemical and Environmental Engineering from Yale and is an Assistant Professor at Northeastern University in Civil and Environmental Engineering. Professor Eckelman's research covers lifecycle assessment, environmental systems modeling, and industrial ecology, with a focus on emerging technologies, including algae-based transportation fuels. He consults regularly on chemicals and materials LCA projects with a range of businesses, institutions, and government agencies. Dr. Eckelman co-chairs the International Symposium on Sustainable Systems and Technology.

Kimberley Mullins is a Ph.D. candidate at Carnegie Mellon University whose work focuses on Engineering & Public Policy and Environmental Engineering in the areas of lifecycle analysis, bioenergy, and decisionmaking under uncertainty. She has expertise in applying LCA to greenhouse gas emissions from transportation fuels and from biofuels in particular. Her work on transportation fuels LCA has been published in scientific journals such as *Environmental Science & Technology* and *Energy Efficiency*, and her research has been presented at numerous national and international LCA conferences, including the International Society for Industrial Ecology 2011 Conference in Berkeley, California and the 2010 Gordon Conference in Industrial Ecology in New London, New Hampshire.

INTRODUCTION[2]

In developing its Low Carbon Fuel Standard, California employed a lifecycle analysis ("LCA") approach to evaluate the contribution of transportation fuels to the State's greenhouse gas emissions and the reduction in that contribution as a result of using low-carbon transportation fuels. An LCA approach to evaluating the carbon intensity of fuels is necessary because greenhouse gas emissions from the use of fuels – and their impacts on California – are not limited to what comes out of the tailpipe. LCA's purpose is to provide an objective, systematic, and quantitative accounting of the inputs to and outputs from complex products and systems. It is the best scientific method available for quantifying the environmental effects of products such as transportation fuels, employed by individual consumers, companies, and agencies to pursue environmental goals on a holistic basis.

To take a simplified example, a fully electric vehicle, such as a Tesla Roadster, does not have a tailpipe. But that does not mean that, when a person replaces his gas-burning (but relatively efficient) Ford Focus with a Tesla, he avoids 100 percent of the greenhouse gas emissions that would have come from his driving the Ford. The electric car is fueled by significant amounts of electricity

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[2] Pursuant to Federal Rule of Appellate Procedure 29(c)(5), *Amici* state that no party or counsel in this case and no person except counsel of record for *Amici* authored or contributed money to fund the preparation of this brief.

that would not have been used for a gas-powered car. As the driver’s gas bill shrinks, his electricity bill grows, and his additional electricity use produces emissions of its own when it is generated. Emissions at the tailpipe are replaced with different emissions at the power plant. Without investigation beyond the tailpipe, it is unclear whether the hypothetical driver has reduced the amount of carbon dioxide he emits by switching from a car with some tailpipe emissions to a car with no tailpipe at all. It is, however, clear that the absence of a tailpipe in the Tesla emphatically does not mean that use of the car causes no greenhouse gas emissions – or that it does not contribute to climate impacts in California.

To determine whether our hypothetical driver has reduced his carbon emissions, we would need to investigate the source of the electricity powering the Tesla. The amounts and types of emissions associated with electricity production will be different depending on how the electricity is generated. Electricity that comes from a coal-burning plant will generate different emissions than electricity that comes from a combined-cycle natural gas plant. Electricity that comes from solar panels will generate yet different emissions than either of the fossil fuel-fired power plant scenarios. Lifecycle analysis, backed by more than 30 years of intensive and extensive global research and resulting scientific models and software, provides a scientific method to quantify the difference in environmental impacts between these technologies.

The concept of LCA is relatively simple: If we want to know the true environmental impacts of using a product such as transportation fuel, we should consider the impacts of both producing and using the product, and we may compare those impacts to the impacts of using an alternative product instead. To understand the full effects of a product on the environment, we must count everything that goes into – and comes out of – making, using, and disposing of it. Gathering this information requires looking at what happens at each stage of the product lifecycle, from the product's cradle (when the raw materials to make the product are extracted) to its grave (when the product is consumed or disposed of).

Whether we are aware of it or not, we consider impacts from multiple phases of products' lifecycles in our own decisions almost every day. Careful business managers and accountants assess full product supply chains and long-term costs and benefits as a matter of routine. Sometimes we consider product lifecycles for economic reasons – Will I save enough money on electricity by installing new windows to make it worth the cost of replacing the old ones? Other times, we may be more explicitly concerned with the impact our actions have on the environment – Should I buy a re-usable grocery bag or continue to recycle paper bags that the store provides? Often it is a mix of both – Will my manufacturing process be more cost effective if I use the waste from one part of the process as raw material for another part? As soon as we recognize that the impacts associated with what we consume go beyond just our use and disposal of a product, we have begun to consider its broader lifecycle impacts. LCA addresses these impacts in a quantitative, neutral, scientific and transparent way.

Assessing a product's impacts at only one part of its lifecycle, such as the moment that fuel is combusted in a car's engine, paints an incomplete picture. This incomplete picture can lead to the exact opposite conclusion of what a more comprehensive and accurate analysis would reveal. In the absence of LCA, fuels that produce no tailpipe emissions (such as electricity and hydrogen) would be incorrectly considered emission-free, entirely ignoring emissions that occur during the production of these fuels. Following the practice of scientific bodies, governments, and institutions all over the world, California recognized that it needed to employ a lifecycle approach in the Low Carbon Fuel Standard to assess and reduce the carbon intensity of transportation fuels consumed in the state.

As this brief explains, LCA is an established and accepted scientific practice for making comparisons between the emissions and environmental impacts associated with different products or process choices. It is the necessary and best available framework for determining whether and to what extent one transportation fuel has a lower greenhouse gas emissions profile than another.

DISCUSSION

I. The Purpose of LCA

Lifecycle analysis is a physical accounting and environmental modeling technique that accounts for the full range of impacts of a product or process. In order to get a complete picture of these impacts, it is necessary for an LCA to evaluate all stages of the product's lifecycle from "cradle to grave." The lifecycle "begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth."[3]

The major phases of a typical product lifecycle include raw materials acquisition, manufacturing, distribution, use, end-of-life, and transportation during and between phases. In order to produce a physical newspaper, for example, raw materials may be acquired by growing and harvesting trees. The wood is transported to one or more processing facilities, such as a paper mill, where the paper is manufactured and eventually printed. The manufactured newspaper is then transported through a series of distributors, eventually ending up at a

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[3] Mary Ann Curran, U.S. Environmental Protection Agency, Lifecycle Assessment Principles and Practice, EPA/600/R-06/060, 1 (2006) (hereinafter "LCA 101"). *See also* International Organization of Standards, Environmental Management – Lifecycle Assessment – Requirements and Guidelines, ISO 14044 at 3.1, (2006), (hereinafter "ISO 14044") (defining "lifecycle" as "consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal."); Jeroen B. Guinée, et al, eds., M.A.J. Handbook on Life Cycle Assessment. Operational guide to the ISO standards, Final Report (2002), *available at* http://www.cml.leiden.edu/research/industrialecology/researchprojects/finished/new-dutch-lca-guide.html.

consumer's doorstep. The consumer may then read the paper and perhaps re-use it for other purposes before disposing of it. At the end of the paper's useful lifetime, it may either go to a landfill or be recycled. If it is recycled, it re-enters the supply chain as raw materials for another newspaper or other products. A comprehensive lifecycle analysis will look at the material, energy, labor, and capital inputs at every stage of this process, and it will quantify environmental emissions at each stage.

In the example of the newspaper, virtually all of the emissions associated with the product occur outside of the use phase. But to claim that buying a newspaper has virtually no impact on the environment would be extremely misleading. The extraction of raw materials to make paper and ink, the processing of those raw materials, the delivery of the paper, and even the disposal and recycling of the paper all have significant and measurable environmental impacts. These impacts could include deforestation, air and water pollution, and possibly the emission of toxic chemicals.

While some products, like newspapers, produce the majority of their impacts in the pre-use phases of their lifecycles, others may have the majority of their impacts during use or disposal. Examples of products whose use phase dominates impacts include refrigerators, light bulbs, camp stoves, computers, and other products that continue to use electricity or burn fuel as long as they are used.

For this reason, if an LCA sought to determine whether a one-year newspaper subscription would have greater or lesser impacts than reading the same paper online every day for one year, it would be important to look beyond the use phase. The same function,[4] reading the news for one year, can be achieved by either system, and both systems have associated emissions. But where in the system's lifecycle those emissions occur is very different. For the physical newspaper, the emissions are almost all "upstream" of the use phase, in manufacture and distribution, or "downstream" of the use phase in the paper's incineration, decomposition, or recycling. For reading online, the emissions are distributed throughout the lifecycle, including the electricity required for the use phase, as well as the raw materials extraction and manufacturing upstream and the disposal and recycling of the computer at the end of its useful life.[5]

One of the most common uses of LCA is to provide decisionmakers with information about the relative environmental burdens associated with competing options, such as reading a printed newspaper versus reading the news online. In

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[4] *See* Section III(A)(1), *infra*, discussing the selection of the appropriate functional unit for an LCA study.

[5] For a quantitative study of this comparison, *see* Michael Toffel & Arpad Horvath, *Environmental Implications of Wireless Technologies: News Delivery and Business Meetings*, 38 Environmental Science and Technology, 2961 (2004) (finding significantly fewer lifecycle greenhouse gas emissions from reading the news on a handheld personal electronic device than from subscribing to a printed newspaper).

order to provide the necessary information for a meaningful comparison between alternatives, LCA can be used to analyze a wide range of emissions and impacts or can focus on a single impact of particular importance to the decisionmaker.[6] Because California's Low Carbon Fuel Standard is concerned with reducing greenhouse gas emissions associated with the use of transportation fuels, its LCA focuses on measuring those emissions.[7] The only way to assess the greenhouse gas emissions of multiple fuels in an even-handed fashion is to apply the lifecycle approach across the total fuel lifecycle. This means examining the fuel from the well or field (where the raw materials are extracted) to the wheel (where the fuel is converted into kinetic energy to move the vehicle).

II. Who Uses LCA?

Modern LCA had its beginnings in the 1960s, but savvy industrialists have long recognized that it pays to look beyond the gates of the factory when

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[6] *See* LCA 101, at 49 (listing commonly used impact categories, including Global Warming, Stratospheric Ozone Depletion, Acidification, Eutrophication, Photochemical Smog, Terrestrial Toxicity, Aquatic Toxicity, Human Health, Resource Depletion, Land Use, and Water Use); Jane Bare, et al, *The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts*, 6 Journal of Industrial Ecology, 49 (2002) (describing the TRACI impact assessment tool employed by U.S. EPA).

[7] Calif. Exec. Order No. S-1-07, (January 18, 2007). The order calls for the creation of the Low Carbon Fuel Standard and a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. The LCA was, therefore, carried out in order to accurately measure the greenhouse gas emissions associated with each fuel coming into the California market.

considering how to make their production systems more efficient. When Henry Ford opened his Model T assembly line at the River Rouge plant in Detroit, he also opened a disassembly plant for the vehicles' end of life, so that the "waste" materials from a retired vehicle could become the feedstock for new vehicles.[8] Reducing waste by taking advantage of the full product lifecycle was, for Ford, just good business.

As global concerns about resource depletion and environmental impacts grew, researchers began to look for ways to account for energy use and forecast future supplies.[9] In 1969, The Coca-Cola Company commissioned an internal study comparing the impacts associated with different beverage containers. The Coca-Cola study went far beyond the common-sense intuition that drove Ford's decisions at River Rouge, examining with unprecedented scientific rigor the impacts and benefits of using glass bottles, aluminum cans, and other containers for its products. This study "quantified the raw materials and fuels used and the environmental loadings from the manufacturing processes for each container," and it thereby "laid the foundation for the current methods of lifecycle inventory

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[8] *See* Tom McCarthy, *Henry Ford, Industrial Conservationist? Take-back, Waste Reduction and Recycling at the Rouge*, 3 Progress in Industrial Ecology 302 (2006).

[9] LCA 101, at 4.

analysis in the United States."[10] Since that time, increased interest in LCA has led the International Standards Organization ("ISO") to develop its 14000 Series, which delineates internationally accepted standards for eco-labeling (at ISO 14020) and for LCA more generally (at ISO 14040). These guidelines prescribe standard practices for ensuring the objectivity and impartiality of LCA studies.

Today, companies that wish to employ the most trusted and reliable eco-labels routinely seek outside certification by third-party labeling authorities for their claims regarding low environmental impact or environmentally responsible manufacturing processes. In order to meet the most rigorous ISO standard (a "Type III eco-label"), a company must carry out a comprehensive LCA that examines all impacts. But companies that wish to make more limited claims relating to parts of their process or particular impacts (such as carbon footprint) may obtain certifications that examine only these particular facets of the lifecycle. Two well-known labels that take such an approach are the ENERGY STAR label for home appliances and the Forest Stewardship Council ("FSC") label for sustainably-managed forest products. *See* Figures 1 and 2 below.

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[10] LCA 101, at 4. The research group that carried out the study went on to form the firm Franklin Associates, which provides LCA services to numerous governmental agencies, including the U.S. Environmental Protection Agency, the U.S. Department of the Interior, and the Nebraska Department of Environmental Quality, as well as major industrial players, such as the American Chemistry Council, Daimler/Chrysler, and Dow Chemical Company. *Clients*, Franklin Associates, http://www.fal.com/clients.html (last visited Mar. 31, 2012).

Figure 1: ENERGY STAR Logo

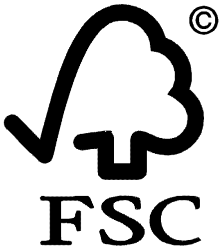

Figure 2: Forest Stewardship Council Logo

The purpose of the ENERGY STAR labeling program is to help consumers identify products that "offer savings on energy bills without sacrificing performance, features, and comfort" and to help "reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy."[11] In order to be eligible for the label, products must meet certain lifecycle requirements. In the design and manufacture phase, the label requires that products achieve efficiency through "broadly available, non-proprietary technologies offered by more than one manufacturer."[12] In the use phase, products must deliver performance equivalent to or better than competing products while using less electricity. Thus, the label aims to reduce the broader environmental and economic impacts by reducing the use-phase emissions and energy bills caused by inefficient appliances.

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[11] U.S. Environmental Protection Agency, *How a Product Earns the Energy Star Label*, Energy Star, http://www.energystar.gov/index.cfm?c=products.pr_how_earn (last visited Apr. 7, 2012).

[12] *Id.*

The Forest Stewardship Council, whose label can be found on many lumber and paper products, is an "an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests."[13] The FSC label is based upon a number of lifecycle factors, including, among other requirements, responsible "reduction of environmental impact of logging activities and maintenance of the ecological functions and integrity of the forest," maintenance of forests with particularly high conservation values, monitoring and assessment of the forest's condition and the environmental and social impacts of forest management, and continuous supply-chain monitoring to ensure that products bearing the label come from a certified source.[14] All FSC accreditation bodies – parties that audit forestry operations and provide FSC certification – must comply with ISO standards.[15]

Notably, the biofuel industry itself uses LCA to examine biofuel carbon dioxide ("CO_2") emissions in comparison with petroleum fuel emissions, in much

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[13] *About FSC*, Forest Stewardship Council, http://www.fsc.org/about-fsc.html (last visited Apr. 7, 2012).

[14] *FSC Principles and Criteria*, Forest Stewardship Council, http://www.fsc.org/pc.html (last visited Apr. 7, 2012).

[15] *FSC Accreditation Program*, Forest Stewardship Council, http://www.fsc.org/accreditation.html (last visited Apr. 7, 2012).

the same manner that the Low Carbon Fuel Standard does.[16] Auto companies and transportation energy companies also use LCA to examine energy and environmental impacts of new vehicle technologies and new transportation fuels that are under serious research and development consideration.[17]

As governments begin to take seriously the challenge of mitigating global climate change, many jurisdictions are turning to LCA to provide comprehensive carbon accounting for their transportation fuel supply. Most notably, the U.S. Environmental Protection Agency ("EPA") has consistently employed an LCA approach to measuring greenhouse gas emissions.[18] Beyond merely using LCA as a tool for gathering information on the carbon intensities of fuels, EPA has

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[16] *See, e.g.*, Renewable Fuels Association, Building Bridges to a More Sustainable Future: 2011 Ethanol Industry Outlook (2011); Renewable Fuels Association, Accelerating Industry Innovation: 2012 Ethanol Industry Outlook (2012).

[17] *See, e.g.*, General Motors Corporation, Argonne National Laboratory, BP, ExxonMobil, and Shell, Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems – North American Analysis (2011); Concawe, EUCAR, and the Joint Research Centre of the European Commission, Well to Wheels Analysis of Future Automotive Fuels Powertrains in European Context (2007).

[18] For example, EPA employed LCA in finding, consistent with the findings in the Low Carbon Fuel Standard, that "for every 100 lb of CO_2 emitted from the burning of conventionally derived gasoline, another 20 to 25 lb of CO_2-equivalent gases is emitted during fuel production and distribution." Transportation Research Board of the National Academies of Science, Special Report 307: Policy Options for Reducing Energy Use and Greenhouse Gas Emissions from U.S. Transportation, 32 (2011).

mandated in its most recent version of the Renewable Fuel Standard that, by 2022, the nation's fuel supply include "at least 16 billion gallons [of biofuels] produced from cellulosic feedstock that achieves at least a 60 percent reduction in [greenhouse gas] emissions in comparison with gasoline and diesel fuels."[19] EPA currently applies LCA to measure the greenhouse gas emissions associated with biofuels in order to implement this requirement. Similarly, the European Union is moving toward a Low Carbon Fuel Standard through its Fuel Quality Directive.[20]

These efforts build on previous regulatory efforts that consider impacts from multiple phases of products' lifecycles, including minimum recycled content laws,[21] product stewardship laws,[22] government procurement guidelines

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[19] *Id.* at 158.

[20] *Id.* at 159, n.20.

[21] *See, e.g.*, Oregon Recycling Act, Or. Rev. Stat. § 459A.550 (requiring a minimum of 50 percent recycled glass in glass containers sold in the state); Wis. Stat. Ann. 100.297 (requiring a minimum recycled content of 10 percent for all plastic containers sold in Wisconsin).

[22] *See, e.g.*, Fla. Stat. § 403.7192 (requiring manufacturers to develop and implement a plan for the collection, transportation, and proper disposal or recycling of rechargeable batteries); and N.J. Stat. Ann. 13:1E-99.85 (requiring automakers to develop a mercury minimization plan and bear the cost of that plan, paying $2.25 for each mercury switch removed from junked cars); Vt. Stat. Ann. tit. 10 § 7116 (requiring manufacturers of mercury-added thermostats to provide a collection program to wholesalers, retailers, and municipalities, and to offer $5 cash incentive for each mercury thermostat turned in).

emphasizing waste reduction and paper purchasing from recycled sources,[23] and tax credits for products that have earned the ENERGY STAR label.[24] To be effective, each of these policies relies upon the transparent and rigorous quantification of the impacts from multiple product life stages.

III. The Structure of LCA

Although techniques continue to evolve and develop, as they do with any scientific endeavor, the international scientific community of LCA practitioners generally agrees on the formal structures that an LCA should follow to best provide for consistency and ensure scientific rigor. These international guidelines, published by the ISO, require that an LCA (1) transparently define its goal and scope, (2) produce an inventory of inputs and outputs of the system, and (3) analyze the impacts related to the consumption of the inputs and emission of the outputs. At each stage of the LCA process, the practitioner analyzes the process in order to identify ways to improve the study and to communicate its results

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[23] U.S. Environmental Protection Agency, *Comprehensive Procurement Guidelines,* http://www.epa.gov/epawaste/conserve/tools/cpg/index.htm#paper (last visited Apr. 7, 2012).

[24] U.S. Environmental Protection Agency, *Federal Tax Credits for Consumer Energy Efficiency*, Energy Star, http://www.energystar.gov/index.cfm?c=tax_credits.tx_index (last visited Apr. 7, 2012).

effectively.[25] The study's methodology and data should be transparent and available for peer review.

A. The Goal and Scope

The goal and scope portion of the LCA lays out what question the study plans to answer and what information it will use in answering that question. Some typical goals of an LCA could include gathering and organizing supply chain information, identifying which of several options is environmentally preferable, achieving particular improvements in environmental performance, or identifying operational inefficiencies that are costing a firm money. Walmart Corporation, for example, has recently undertaken a large-scale LCA initiative with the goal of transitioning to a 100 percent renewable energy supply for its cargo transportation.[26] For California's Low Carbon Fuel Standard, the State has established as its goal reducing carbon emissions from transportation fuels by 10 percent by the year 2020.[27]

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[25] *See* ISO 14044(2006) at 4.1, "General Requirements."

[26] *Walmart's Approach to Reducing Dependency on Fossil Fuel-Based Transportation Fuels*, Walmart, http://walmartstores.com/Sustainability/10365.aspx (last visited Mar. 27, 2012).

[27] Cal. Code Regs. tit. 17, § 95482; *see also* Calif. Exec. Order No. S-01-07 (January 18, 2007) (setting a statewide goal to "reduce the carbon intensity of California's transportation fuels by at least 10 percent by 2020").

An LCA study's scope sets the parameters for what kind of information is needed in order to answer the question set by the goal of the project. When undertaking an LCA, "there is perhaps no more critical step . . . than to define as precisely as possible the evaluation's scope."[28] Defining the scope of the LCA requires determining (1) the appropriate functional units of measurement or comparison and (2) the system boundaries for the project.

1. Functional Units

When comparing different products, the LCA practitioner determines a functional unit of measurement in such a way that the study bases its comparison on the delivery of equal amounts of product or equivalent service to the consumer across products. Functional units must be carefully defined to allow for an "apples to apples" comparison between products or systems "to provide a reference to which the input and output data are normalized."[29] For example, an LCA that compares liquid hand soap to bar soap could take as its functional unit an equal number of hand-washings.[30] A consumer does not purchase hand soap for the sake of the soap's weight or volume, but for the sake of its function. So a fair

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[28] Thomas Graedel & Braden Allenby, Industrial Ecology 186 (2d ed. 2003).

[29] ISO 14044(2006) 4.2.3.2.

[30] *See* LCA 101, at 11.

comparison should be based on comparing equivalent functions, rather than other metrics such as volume or weight.

In the case of transportation fuels, the function is to allow vehicles to move. For this reason, it is sensible to define the fuel's functional unit in terms of how far a certain amount of that fuel will allow a vehicle to travel. California follows this approach in the Low Carbon Fuel Standard, basing its comparison on the functional unit of grams of carbon dioxide equivalent[31] per megajoule of useful energy in the fuel ("gCO_2e/MJ"), adjusted for the efficiency of major vehicle powertrain technologies in using that energy – in other words, the amount of greenhouse gas emissions per unit of useful energy in the fuel.

2. System Boundaries

Identification of system boundaries is essential to any lifecycle analysis. The LCA study should take into account all parts of the product system that have a significant role in contributing to the impacts that the study is designed to examine. For example, a study that seeks to compare one type of screw to another might need to consider every aspect of the screw's resource extraction, manufacture, use, and disposal. A study that is comparing the impacts of cars versus buses, on the

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[31] Various greenhouse gases, such as methane, nitrous oxide, and carbon dioxide, have different capacities for producing global warming. For the sake of ease of communication, they are frequently referred to in terms of their aggregate global warming potential, taking the potency of carbon dioxide as a common unit. Thus, multiple greenhouse gas emissions may be described collectively in terms of "CO_2 equivalent" or "CO_2e."

other hand, might find that the effect of producing a screw is similar enough to the effect of producing other steel components to allow consideration of a more general category, such as "steel fasteners" or even "machined steel by weight." The scale and scope of the system being analyzed affect the scale and scope of the analysis itself.

A study that seeks to measure the carbon intensities of transportation fuels must, in order to provide meaningful results, measure every part of a fuel's lifecycle that results in a non-negligible change in the amount of greenhouse gases in the atmosphere. By way of contrast, imagine a study measuring the carbon intensity of a corn-based ethanol fuel where the system boundary begins with mature corn ready for harvest and ends with combustion of the ethanol in a car. Such a study would count all of the carbon emissions associated with refining and consuming the fuel, but it would completely miss the substantial carbon "credit" that comes from the fact that, as the corn grows, it pulls CO_2 out of the atmosphere through photosynthesis. (It would also miss the emissions involved in planting and fertilizing the corn.) The only reason that corn ethanol might be environmentally preferable to petroleum is that one part of ethanol's lifecycle (growing the corn) removes as much CO_2 from the air as another part (burning the fuel in the car) adds. By failing to include the growing of the corn in the system boundary, the study would find no relative greenhouse gas emissions reduction benefit from using ethanol as compared to using gasoline.

Similarly, if ethanol is produced in a refinery adjacent to the cornfield where its feedstock is grown, the corn will not need to travel as far before being processed, when compared to ethanol produced at a refinery thousands of miles from the field. To ignore this transportation phase would distort the results of the study, masking a quantifiable difference in the amount of carbon associated with the two products. One result of including transportation-related emissions is that, because California-based ethanol producers import their corn from the Midwest, and because corn is more emissions-intensive to transport than ethanol, ethanol produced in California has a higher carbon intensity associated with its transportation than does ethanol refined in the Midwest.

If the corn were grown on land that was previously used for growing cotton, the process of farming corn might produce emissions equivalent to or possibly lower than the process for cotton, potentially rendering the effect of the land-use transition environmentally positive. But if an old-growth forest is cleared to make room for the crop, many tons of carbon dioxide stored in the trees and soil would be released, making the effect very emissions-intensive and environmentally negative. The Low Carbon Fuel Standard follows the standard practice of biofuel LCAs by taking land-use change emissions into account.[32]

The effects of these sorts of land-use changes are not negligible. There is broad agreement among LCA scientists that land-use change creates different emissions profiles for different fuels. To ignore land use impacts is equivalent to assigning them a value of "zero," ensuring that the LCA misses a source of environmental impacts. This omission would render the policy less effective in seeking to reduce emissions from transportation fuels. The Low Carbon Fuel Standard provides relatively conservative assessments of the greenhouse gas emissions caused by the land-use changes associated with transportation fuels.

In sum, to ensure that all emissions credits and debits are objectively accounted for, the system boundary of a transportation fuel LCA should include the full lifecycle of the fuel. The appropriate lifecycle system boundary includes production of raw materials (including effects of land-use change if the fuel is

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[32] For analysis of the potentially large impacts from land-use change on a biofuel's greenhouse gas emissions profile, *see* Joseph Fargione, et al, *Land Clearing and the Biofuel Carbon Debt*, 319 Science, 1235 (Feb., 2008). EPA also has recognized the importance of this emissions category, including it in the LCA that underlies the Renewable Fuels Standard, while scientists at the California Air Resources Board, multiple federal agencies, in the European Union, and at numerous research institutions work assiduously to further refine the calculation of land use change impacts.

derived from plant materials), manufacture, refinement, distribution, and finally the combustion of the fuel.

B. Lifecycle Inventory and Impact Assessment

Once the parameters of the study have been defined, an LCA scientist (1) gathers data on the quantitative inputs and outputs for each part of the system in a lifecycle inventory, and then (2) quantifies and communicates the environmental impacts associated with those inputs and outputs in an impact assessment. The lifecycle inventory analysis "uses quantitative data to establish the levels and types of energy and materials used in an industrial system and the environmental releases that result."[33] The impact assessment relates the identified outputs to the effects they have or the burdens they place on the environment.[34]

A large number of high quality database tools for developing lifecycle inventories, developed by commercial LCA consultants, government bodies, academics, and professional organizations of LCA scientists, are available commercially or for public use.[35] Where datasets are outdated or based upon conditions different from those present in the practitioner's present study, labor-

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[33] Thomas Graedel & Braden Allenby, Industrial Ecology 187 (2d ed. 2003).

[34] *Id.*

[35] For a list of some of the most widely-used database tools, see *Software*, LCA Links!, http://www.lifecycle.org/?page_id=125 (last visited Apr. 1, 2012); *see also* U.S. Environmental Protection Agency, Public Data Sources for the LCA Practitioner, EPA530-R-95-009 (April 1995).

intensive original research and calculation is often required and undertaken. Due to the complexity and variation inherent in our manufacturing systems, virtually no new comprehensive study can meet ISO standards without starting from scratch to some degree. Nevertheless, by building on publicly available and reviewable LCA tools and datasets, such as the U.S. Department of Energy's GREET tool (which provided the basis for California's CA-GREET tool employed in the Low Carbon Fuel Standard), practitioners can help to ensure both transparency and consistency in their treatment of the system under study.

Lifecycle inventories begin by counting the inputs for all of the processes included within the system boundaries. Having counted up the inputs to the system, the lifecycle inventory also measures the associated outputs, or emissions. The emissions are then categorized and reported. Once the lifecycle inventory has produced this emissions profile for the product, the LCA can finally assess the impacts of these emissions on the environment.

Energy inputs are particularly significant because they are implicated at every stage of materials production and extraction, throughout the manufacturing and distribution process, and with all of the associated transportation between stages. The same is true for downstream recycling and disposal processes. The source of the energy is important because the emissions from coal, nuclear, natural gas, hydroelectric, wind, solar, and other energy sources are all very different in terms of the types and quantity of emissions. For this reason, an assessment of the emissions from energy inputs is an important feature of virtually all lifecycle inventories and impact assessments.

Rather than examining every possible environmental impact, most LCA studies of transportation fuels focus on (1) the total energy required to produce the fuels and (2) the fuels' contribution to global warming, which is itself affected by the source and amount of the energy input required. Impact on global warming is generally measured in terms of the amount of greenhouse gas emissions for which the fuel is responsible over the fuel's lifecycle.[36] Although this measure is often called "carbon intensity," the analysis actually measures multiple greenhouse gasses, such as carbon dioxide, methane, nitrous oxide, and others, and reports their impact in terms of CO_2-equivalent.

Energy inputs from different sources have very different emissions profiles, and consequently fuels derived from different kinds of energy sources may have very different carbon intensities. These differences can be seen in studies of ethanol production, not just in the Low Carbon Fuel Standard itself, but from a

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[36] For detailed calculations relating to the global warming potential of various greenhouse gasses, *see* Susan Solomon, et al (eds.), Global Warming Potentials and Other Metrics for Comparing Different Emissions, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, (2007) *available at* http://www.ipcc.ch/publications_and_ data/ar4/ wg1/en/ch2s2-10.html.

large number of peer-reviewed scientific studies.[37] While careful and responsible scientists have still not reached agreement on all issues, some relatively unsurprising trends emerge across studies:

> (1) Ethanol produced in refineries that run on bagasse (an agricultural co-product of growing ethanol feedstocks, which is used in the refinement of Brazilian sugar cane ethanol) has the smallest refinery energy emissions contribution. Ethanol produced in a refinery powered solely by renewable energy sources would have similarly low emissions for that lifecycle stage. Fuels produced in refineries powered by coal tend to have the highest associated emissions. Fuels produced with other forms of power generation fall somewhere in the middle.
>
> (2) Feedstocks grown in tropical climates with relatively less intensive farming practices and less nitrogen-based fertilizer use tend to have fewer emissions related to producing the feedstock than their more-intensively farmed counterparts in cooler climates.
>
> (3) Emissions due to transportation of fuels, feedstocks, and other materials are a function of multiple factors, including the mode of transport, distance traveled, and the weight and volume of the product transported. Of these emissions the mode of transportation is often the most significant factor, with transport by ship being far less emissions-intensive than travel by rail, which is, in turn, far less emissions-intensive than travel by diesel truck. Overall, however, transport emissions tend to represent a small fraction of total fuel-cycle emissions.

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[37] For surveys and analysis of some recent relevant studies, *see* Harro von Blottnitz & Mary Ann Curran, *A Review of Assessments Conducted on Bio-ethanol as a transportation fuel from a net energy, greenhouse gas and environmental lifecycle perspective*, 15 Journal of Cleaner Production 607 (2007) (reviewing 47 LCAs on bio-ethanols); Eric D. Larson, *A Review of Lifecycle Analysis Studies on Liquid Biofuel Systems for the Transport Sector*, 10 Energy for Sustainable Development 109 (2006); Markus Quirin, et al, *CO2 Mitigation Through Biofuels*, Main Report, Institute for Energy and Environmental Research Heidelberg (2004) (taking into account more than 800 studies and reviewing 63 biofuel LCA studies in detail).

By quantifying and accounting for emissions associated with the full lifecycle of transportation fuels consumed in California, the LCA employed in Low Carbon Fuel Standard reflects the standard practice for this type of study, and its findings fit within the mainstream of accepted LCA studies on the greenhouse gas emissions of transportation fuels. No responsible LCA for those fuels could ignore significant sources of greenhouse gas emissions without undermining the integrity of LCA as an objective and even-handed measurement technique. LCA does not take emissions into account based on geopolitical boundaries; it takes them into account because they are emissions that increase climate impacts on California.

CONCLUSION

In order to apply a meaningful and even-handed policy for assessing the carbon intensity of transportation fuels, it is necessary to understand the fuels' greenhouse gas emissions over the course of their full lifecycles. Ignoring parts of these lifecycles based on geographic or political boundaries would distort our understanding of total impact on global warming from each fuel type and frustrate efforts to achieve real emissions reductions. Lifecycle analysis is the appropriate means for evaluating the full range of emissions across multiple types of fuels, and it is therefore a necessary component of California's Low Carbon Fuel Standard.

Dated: June 15, 2012

Respectfully submitted,

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