WHITE PAPER
The Low-Carbon Diet Initiative:
Reducing Energy Use and Greenhouse Gas Emissions in the Food System from a Life Cycle Assessment Perspective

Sonja Brodt, Gail Feenstra, Thomas Tomich, UC Davis Agricultural Sustainability Inst.

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Introduction: A Need for Action

Amid growing concerns about climate change and long-term petroleum reserves, the food system looms large as a major user of fossil fuels and producer of greenhouse gases. The most recent studies suggest that the food system is responsible for up to 29 percent of global warming generated by the consumer economy in industrialized nations.[1] A growing segment of "green" consumers is becoming aware of the need to reduce their individual carbon footprints through lifestyle changes and environmentally responsible purchasing decisions. State governments, also, are taking action to reduce greenhouse gas emissions and improve energy efficiency. California, for example, recently passed a sweeping new law requiring a 20 percent reduction in GHG emissions across all sectors by 2020 and an 80 percent reduction by 2050. Changes in consumer food choices, as well as in upstream production, processing, and distribution technologies, could contribute substantially to meeting such targets, since individual foods vary tremendously in their carbon footprint.

Issues At a Glance:
Six Major Factors Responsible for High Energy Use and GHG Emissions in the Food System

- Livestock-related methane and nitrous oxide emissions
- Synthetic nitrogen fertilizers
- Air freight
- Heated greenhouse production
- Post-retail, consumer transport and food storage
- Food waste at multiple points along the supply chain

The intent of this paper is to frame the issues relevant to reducing greenhouse gas (GHG) emissions in the food system in order to inform actions by policy makers, consumers and other players in the food industry. We summarize here the discussions of researchers, industry representatives, and government representatives that took place at a symposium convened by the UC Davis Agricultural Sustainability Institute on October 8-10, 2007 (see Appendix for a list of symposium participants).

Critical Issues

Concerns about greenhouse gas emissions and energy intensity in the food system can be organized into five key issue areas. Framed as questions, they embody typical dilemmas faced by concerned consumers, policy-makers, and food-related industries.

A. Trade-offs Between Sustainable Production Systems and Food Miles

Sample question: *Is it better to buy organic vegetables that are imported from out of state or conventionally grown vegetables sourced locally?*

[1] European Commission. 2006. *Environmental Impact of Products: Analysis of the Life Cycle Environmental Impacts Related to the Final Consumption of the EU-25*. Technical Report EUR 22284 EN. Spain: European Comission, Joint Research Centre, Institute of Prospective Technological Studies.

Key Factors:

Some of the key factors that shape this issue include:

- The high energy requirement, and therefore GHG emissions, to produce the synthetic nitrogen fertilizer used on conventional but not on organic crops typically outweighs the fuel needed to manage manure, compost, and other organic sources of soil fertility.
- Reduced tillage methods can lower overall energy requirements of farming.
- Availability of irrigation water, inherent soil fertility, and other geographically specific variables allow farming in some regions to be more energy-efficient than in other regions.
- Yields of organic crops typically vary from 60 to 100 percent of conventional yields, depending on the crop and growing conditions.
- Long-distance transportation modes, such as sea and rail, tend to be more efficient per unit of freight than short-distance transportation modes, such as trucks. For example, container ships use approximately one-thirteenth or less the amount of fuel energy of trucks per ton of freight. The exception is air freight, which uses about 50 times the amount of fuel energy used by sea transport to carry a ton of cargo over the same distance.[2]

Factors Needing Further Research:

Clarifying trade-offs between production system efficiencies and transportation mode efficiencies will help buyers define food sourcing limits. These geographic limits would be based on the break-even points in terms of energy use and emissions for foods produced in different production systems. For example, with more complete information, we might determine that particular types of produce grown in conventional, high-input systems could only be sourced from a fraction of the distance as the same foods grown organically or under low-input systems, depending on transport mode. Accordingly, a consumer purchasing produce from such low-input systems would be able to source foods from further away, with the same overall energy use and emissions, than someone purchasing conventional produce. Increasing use of renewable fuels over time will likely change the relative distance limits.

Bottom Line:

Intensive use of synthetic nitrogen fertilizers substantially increases the energy intensity and GHG emissions of crop production systems, but this factor must be considered in concert with relative yields and regional advantages in production, as well as relative efficiencies of different transport modes.

B. Trade-offs Between Local Scale and Larger-Scale Production, Processing, and Distribution Systems

Sample question: *Is it better to purchase local produce at the neighborhood farmers market or globally sourced produce at the large supermarket?*

Key Factors:

- Small trucks used for farmers markets and other local enterprises typically use more fuel per ton-mile than the modes of transport used in mainstream, large-scale food distribution

[2] Weber C.L.,H.S. Matthews. 2008. "Food miles and relative climate change impacts of food choices in the United States." *Environmental Science and Technology* 42(10): 3508-3513.

systems, including larger trucks, rail, and ships, with the exception of air freight (see Item A, above).
- Processing plants benefit from efficiencies of scale – larger plants typically use less energy and produce fewer GHG emissions per pound of food processed.
- Foods with certain characteristics, such as high perishability or high water content (e.g. fresh and frozen produce), require substantially more energy for transportation than counterpart foods with opposite characteristics (e.g. dried, condensed, or canned foods).

Factors Needing Further Research:

Clarification is needed on the degree to which food processing alters the relative efficiency of a large-scale food distribution system compared to the efficiency of a small-scale system. With such information, one could determine which foods (i.e., unprocessed and highly perishable fresh produce and dairy products) should be concentrated in local food systems, and which ones (more processed, concentrated, non-perishable products) would benefit from increasing efficiencies of scale in larger-scale distribution systems. In addition, very little is known about the relative efficiencies of developing country agriculture, which increasingly serves as the source of off-season produce and other commodities destined for U.S. markets. Many developing country systems make greater use of hand labor as opposed to machine labor, potentially saving substantially in fuel input and GHG emissions relative to U.S. agriculture.

Bottom Line:

With current modes of production and transportation, local food systems cannot be assumed to be more energy and GHG efficient than mainstream, larger-scale food systems in all instances. Their relative advantage depends on the relative efficiencies of transport modes used (with use of air freight in larger-scale systems being a "hotspot") and degree and type of processing.

C. Trade-offs Between Seasonally Available Foods, Processed Foods, and Fresh Foods Distributed Long-Range

Sample question: *In winter, is it better to buy local (or domestic) canned tomato paste that has undergone a lot of processing, or to cook with fresh tomatoes shipped from overseas?*

Key Factors:

- Production of produce in fossil fuel-heated greenhouses typically adds substantially to the life cycle energy use and GHG emissions of food items compared to the equivalent field-grown crops.
- Processing methods that reduce weight (drying or paste production) and/or eliminate refrigeration requirements (canning) substantially decrease fuel consumption during transport compared with fresh foods, while frozen foods increase fuel consumption.

Factors Needing Further Research:

Differences in management strategies of processing plants can produce very large differences in energy efficiencies, even for the same types of processing. A few key studies to highlight the causes of some of the largest differences could gain the attention of the food industry and catalyze significant change. In the area of consumer food choices, it is uncertain

how willing consumers will be to change current purchasing patterns. For example, with more information about environmental impacts, would they be willing to eat fewer of the most popular out-of-season fresh foods, such as lettuce and tomatoes, and switch to either processed foods or lesser known winter foods, such as root crops, during the off-season?

Bottom Line:

Relying more on seasonally appropriate fresh foods and on processed forms of foods when they are out of season, as opposed to fossil fuel-heated greenhouse production or long-distance shipment of fresh products, may save energy and GHG emissions. However, additional research is needed to show how far a fresh food can be shipped relative to a processed version of that food before transportation-related emissions break even with processing-related emissions.

D. Impacts of Different Meat and Dairy Production Systems and Plant Based Protein Sources

Sample questions: *How much are GHG emissions reduced when legumes and other plant foods, or eggs and dairy, are substituted for meat in a meal? Is it better to buy meat from free-range animals or from conventionally raised animals?*

Key Factors:

- The global livestock population is one of the largest anthropogenic sources of GHGs, producing about 18 percent of global emissions,[3] primarily methane and nitrous oxide.
- Researchers agree that a large-scale shift to eating "lower on the food chain" would produce significant results in reducing GHG emissions.
- Ruminants, including goats, sheep, and cattle, especially range-fed cattle, produce significantly more methane than other livestock.
- Increasing feed efficiency among ruminants can reduce overall methane production.
- Depending on intensity of production methods, chickens are among the most energy and GHG efficient, due to their physiologically efficient feed conversion and to intensive rearing systems that allow them very little physical activity.

Factors Needing Further Research:

More research is needed to clarify the trade-offs between energy intensity of feed production relative to lower methane production. While intensive livestock operations provide concentrated feed that is digested more efficiently, resulting in less methane production, these savings may be offset by higher carbon dioxide and nitrous oxide emissions generated in intensive feed crop production and by higher nitrous oxide emissions resulting from a greater amount of nitrogen deposited in manure.

Bottom Line:

Given that animal-based foods are responsible for a disproportionate amount of GHG emissions, consumer reductions of portion sizes, choosing products from the most efficient, non-ruminant livestock, and reducing "hotspots" within the supply chains of meat and dairy products can each make substantial impacts on GHG emissions in the food system.

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[3] Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, C. De Haan. 2006. *Livestock's Long Shadow: Environmental Issues and Options*. UN Food and Agriculture Organization.

E. Impacts of Retail-Level Decisions for Shopping and Food Preparation

Sample questions: *Is it better to drive further to a large-scale outlet store and buy large quantities of groceries all at once to keep in the freezer, or is it better to shop more than once a week at a local farmers market and other small shops? Is it better to buy a ready-made meal or to buy the individual ingredients and cook them at home?*

Key Factors:

- Use of personal vehicles for consumer shopping trips can overshadow the impacts of transportation in all previous stages of the food's life cycle, depending on the type of vehicle, the number of separate trips, and the amount of food purchased each time.
- Long-term storage of products in home refrigerators and freezers can account for a large portion (approximately one-third, according to one study[4]) of total life cycle emissions.
- Energy efficiency of consumer appliances varies greatly, with newer, Energy Star-rated appliances up to 10 to 50 percent more efficient than older appliances still commonly in use.
- A University of Arizona study estimated that households waste 14 percent of the food they purchase and that some retail shops, such as convenience stores, waste up to 26 percent.[5]

Factors Needing Further Research:

The trade-offs between large suburban supercenters and smaller, neighborhood-based specialty shops need to be better understood. Land use planning and zoning decisions that take neighborhood food retail into account need to be studied for their impacts on shopping-related emissions. More research is needed on the impacts of home deliveries and ready-cooked meals.

Bottom Line:

Consumer choices in transportation to retail, food storage, and preparation have the potential to make very significant impacts on the overall energy use and GHG emissions in the food system. Reducing the substantial amount of waste that occurs at all stages of the supply chain, and especially at the consumer stage, can also make a large difference in emissions.

Conclusions

Given the complexity of the food system, sound policy needs to be based on standardized protocols for measuring emissions and on standardized life cycle assessment methodology that can account for emissions along the whole supply chain. Furthermore, policy must be combined with strong social marketing for maximum impact on the public and retail sectors. For example, current dietary guidelines provided by organizations such as the American Cancer Society and American Heart Association already recommend eating more fruits and vegetables and less meat. Messages about the importance of "lower-carbon" food alternatives could complement these existing guidelines. Finally, government agencies must coordinate to design complementary policies that further the dual goals of achieving a healthy populace and a healthy planet. Ultimately, energy and climate impacts must be integrated with other environmental, social, and economic impacts when considering food choices and designing food policy.

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[4] Andersson, K., T. Ohlsson, and P Olsson. 1998. "Screening life cycle assessment (LCA) of tomato ketchup: a case study". Journal of Cleaner Production 6: 277-288.)

[5] Jones, T.W. "Using contemporary archeology and applied anthropology to understand food loss in the American food system." University of Arizona Bureau of Applied Research in Anthropology and USDA. http://www.communitycompost.org/info/usafood.pdf.

Appendix

Symposium Participants and Contributing Authors:

Ricardo Amon, California Energy Commission
Sonja Brodt, UC Davis ASI & Dept. of Agricultural and Resource Economics
Tim Crosby, Growing Washington & Northwest Agriculture Business Center, Washington
Jamie Dean, Packard Foundation, California
Todd English, ClimOzone, California
Gail Feenstra, UC Davis ASI & UC Sustainable Agriculture Research and Education Program
Ben Finkelor, Institute for Transportation Studies & Energy Efficiency Center, UC Davis
Ryan Galt, Department of Human and Community Development, UC Davis
Andrew Haden, Ecotrust, Oregon
Niels Halberg, International Centre for Research in Organic Food Systems, Denmark
Shermain Hardesty, Department of Agricultural and Resource Economics, UC Davis
Niels Jungbluth, ESU-services, Ltd., Switzerland
Alissa Kendall, Department of Civil and Environmental Engineering, UC Davis
Klaas Jan Kramer, Lawrence Berkeley National Laboratory, California
Pablo Päster, ClimateCHECK, California
Nathan Pelletier, Dalhousie University, Canada
Rich Pirog, Leopold Center for Sustainable Agriculture, Iowa State University
Steve Shaffer, California Department of Food and Agriculture
Guy Shrubsole, Department of Environment, Food, and Rural Affairs, United Kingdom
Johan Six, Department of Plant Sciences, UC Davis
Daniel Sperling, Institute of Transportation Studies, UC Davis
James Thompson, Department of Biological and Agricultural Engineering, UC Davis
Thomas Tomich, UC Davis ASI & UC Sustainable Agriculture Research and Education Program
Helene York, Bon Appétit Management Company Foundation, California

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