

**Assessment of Energy Use and Greenhouse Gas Emissions in the Food System: The Low Carbon Diet Initiative**  
*Proposed Research and Outreach Program: Abbreviated Version*

**UC Davis Agricultural Sustainability Institute**

In collaboration with the UCD Energy Efficiency Center, UCD Institute of Transportation Studies, and Bon Appetit Management Company Foundation

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Contacts: Sonja Brodt, [sbrodt@ucdavis.edu](mailto:sbrodt@ucdavis.edu) and Gail Feenstra, [gwfeenstra@ucdavis.edu](mailto:gwfeenstra@ucdavis.edu)

**Introduction**

Amid growing concerns about climate change and long-term petroleum reserves, the food system looms large as a major user of fossil fuels and, as a result, producer of greenhouse gases (GHG). Indeed, these twin problems may be the significant drivers that catalyze change in the food system in the 21<sup>st</sup> century. Already we are witnessing a stream of new policies aimed at reducing greenhouse gases, including a sweeping new law in California that requires a 20% reduction in greenhouse gas emissions across all sectors by 2020 and 80% by 2050.

The most recent energy studies available suggest that the food system consumes close to 16 percent of the total energy use in the U.S. (Hendrickson 1996). Since fossil fuels serve as the dominant energy source driving the U.S. economy, significant greenhouse gas emissions emanate from the food system, creating a large “carbon footprint”. Individual foods, however, vary tremendously in how they are produced, processed, packaged, and transported, and therefore vary tremendously in their carbon footprint. For example, Eshel and Martin (2006) demonstrate that, in a hypothetical American diet in which 35 percent of calories originate from animal sources, choosing primarily poultry products instead of primarily red meat can reduce the annual greenhouse gas emissions associated with producing, processing, and distributing that diet by 1.52 tons CO<sub>2</sub> –eq per person annually. They point out that this difference is similar to the difference between driving an average sedan (Toyota Camry) and an ultraefficient hybrid (Toyota Prius) when calculated at average U.S. annual driving distances, and that on a national scale, this difference would amount to over 6 percent of total annual U.S. GHG emissions. Changes in consumer food choices, therefore, hold the potential to make a substantial impact on the overall energy audit and GHG emissions of our food system.

In order to make such choices, however, food services providers and consumers require guidelines that are based on a systematic analysis of the detailed differences in energy use and GHG emissions of individual foods, taking into account variables such as differences in production systems (e.g. organic versus conventional) in different locations, different processed forms of food, transport distances from farm to processor to retail, and so on. Such overall guidelines are not currently available in the U.S.; nor, in many cases, are the comprehensive data sets needed to construct such guidelines.

It is the goal of this program to set the stage and stimulate research projects that will collect the necessary data, construct general, consumer-oriented guidelines where feasible, and begin to implement the guidelines in the food services industry. These data and the guidelines

will also facilitate the understanding needed to implement broader energy- and climate change-related policy and planning. For example, this research will help to identify how the added costs associated with the cap-and-trade system, which is currently under consideration by state leaders to regulate GHG emissions, will likely be allocated across the food system and how this distribution of costs will affect consumers.

## **Research Program Objectives**

We propose to launch a multi-stage research initiative to examine the global warming potential of the food system in California and other parts of the nation. The ultimate goal of this initiative is to steer consumer food choices towards those that entail relatively lower fossil fuel use and greenhouse gas emissions, i.e. a “low-carbon diet”. A secondary goal is to build research and implementation capacity in California to address climate change issues in the food system. To this end, the program objectives are as follows:

- 1) Project planning and preliminary work
  - a) Conduct a general literature review of studies on energy use in agriculture and the food system to identify the key, unresolved issues and formulate guiding questions. (already completed – see below)
  - b) Identify gaps of basic data needed as input to a wide range of food LCA studies, such as updated energy coefficients of common agricultural production inputs, greenhouse warming potentials for different inputs and fuels, etc. (in progress)
  - c) Formulate a list of required LCA studies that will be chosen strategically for their focus on foods widely used in American cuisine and their potential to address the guiding questions listed above. (in progress)
  - d) Formulate general research guidelines for conducting LCA of food products to foster a degree of uniformity, and thus comparability of results, among individual research projects. (in progress)
  
- 2) Funding and coordination of primary research
  - a) Perform necessary research to calculate and update energy coefficients and global warming potentials (in CO<sub>2</sub>-equivalent units) for common agricultural inputs, fuels, and transportation modes, and fill additional common life cycle inventory data needs.
  - b) Perform the strategically-chosen LCA studies to test specific hypotheses and identify principles for choosing low-carbon foods.\*  
*\*Expanded below.*
  
- 3) Identify major energy issues in each sector of the food chain
  - a) Perform extended sensitivity analyses of individual modules selected out of comprehensive life cycles to assess energy impacts of specific changes in production, storage, processing, transportation, and consumer technologies. Identify key areas to focus future research.
  
- 4) Synthesize data and formulate general guidelines
  - a) Use the data outcomes from #2 and #3 to clarify the defining issues and address the guiding questions identified previously (see below). Where feasible, identify some general principles that can guide consumers to low-carbon food choices.

- b) Formulate the above principles into practicable guidelines for end-buyers and consumers to use in making choices conducive to a low-carbon diet.
- 5) Outreach, education, and implementation
- a) Disseminate information and conclusions generated to other researchers, students, and relevant institutions concerned with the sustainability of our food systems in order to stimulate further work in this area.
  - b) Disseminate information and recommendations to consumers, policymakers, and the food industry, including producer associations, processors, and food services companies.
  - c) Implement low carbon guidelines in the food services industry.

## Guiding Questions

The following five questions outline the primary issues that will shape how the specific LCA research projects will be defined. These questions embody typical dilemmas that currently characterize the thinking of concerned members of the consumer public and food services industry. These dilemmas are all based on uncertainties in comparing energy use and GHG emissions across multiple sectors of the food system, and therefore fundamentally require LCA in order to be addressed adequately. Each of the five questions is followed by several key within-sector issues arising out of the literature. While these issues identify some of the most critical variables within particular sectors of the food system that will shape the responses to the guiding questions, and thus point the way towards specific research efforts, it will only be in comparing the magnitude of these variables across multiple sectors that the answers to the guiding questions will begin to emerge.

1. ***Production System and Transport:***

Under what conditions, and for which commodities, are perishable foods grown under conventional methods and sourced regionally or locally more energy- and GHG-efficient than the same perishable foods grown using alternative production methods (such as organic farming, conservation tillage, or other low-input approaches) but sourced globally?

*Within-sector issues:*

- a. *Production:* Organic farming generally uses less energy per unit area than conventional industrial farming, but relative energy use per unit of food produced depends critically on comparative crop yields in organic versus conventional systems.
- b. *Production:* Agriculture in some regions requires substantially larger fossil fuel inputs than in other regions, due to biophysical and infrastructure variables such as climate conditions, irrigation systems, sources of electricity, soil conditions which affect tillage, etc.
- c. *Transport:* Food miles can have differing impacts on fuel use and GHG emissions, depending on the modes of transport chosen. Some long-distance modes, such as ship and rail, are much more fuel efficient per unit of distance traveled compared to some short-distance modes such as light trucks and cars.

2. ***Scale of Production, Processing, and Transport Systems:***

Under what conditions and for which commodities are small-scale local food systems, involving small farms and short distribution distances, or regional-scale food systems, involving mid-sized farms and regional distribution networks, more energy- and GHG-efficient than national- or global-scale food systems involving large farms selling into global distribution networks?

*Within-sector issues:*

- a. *Production:* Farms within a certain size range (small to mid-sized) generally produce higher yields per unit area and may utilize farm resources, including energy resources, more efficiently than very large farms.
- b. *Processing:* Economies of scale may achieve significant fuel efficiency gains for certain processing methods more than for others (such as tomato paste production and canning versus sun-drying).
- c. *Transport:* Regional-scale distribution networks may use less fuel overall and have lower GHG emissions than long-distance, highly centralized distribution networks (and possibly also less than very localized, small-scale distribution networks).

3. ***Seasonality of Production, Processing and Transport:***

Under what conditions and for which commodities are processed foods transported through a national- or global-scale distribution network more energy- and GHG-efficient than fresh foods transported locally or regionally?

*Within-sector issues:*

- a. *Production:* Out-of-season greenhouse production can substantially reduce energy- and GHG-efficiency of fresh commodity production systems.
- b. *Processing:* Some forms of processing require less fossil-fuel input than others.
- c. *Transport:* Processing methods that reduce weight (drying or paste production) and/or eliminate refrigeration requirements (canning) may substantially decrease fuel consumption during transport compared with fresh foods.
- d. *Transport:* Caribbean and Central American production areas are closer to eastern US markets than is California.

4. ***Livestock Production Systems:***

Under what conditions are animal-derived foods relatively more energy- and GHG-efficient, and how does this efficiency compare to plant-derived protein foods?

*Specific issues:*

- a. Ruminant species (cattle, sheep) produce more methane than other species (chickens, pigs), but can better utilize less concentrated feed with lower embodied energy.
- b. Extensive production systems (range-fed) may contribute to more methane production but lower fossil fuel-related GHG emissions than intensive, confinement-based production systems.

- c. Animal products, such as milk and eggs, may be more energy- and GHG-efficient than meat and than some forms of plant-derived protein foods.

5. ***Pre-Retail and Post-Retail Sectors:***

Under what conditions do post-retail decisions made at the consumer- and institutional food services-level overshadow efforts to increase energy- and GHG-efficiencies within any pre-retail sectors of the food system?

*Specific issues:*

- a. ***Transport:*** Relatively small purchases to centralized supermarkets and use of fuel-inefficient vehicles can subtract substantially from the energy- and GHG-efficiency of food on a per unit basis.
- b. ***Cooking and Storage:*** A large range of energy-efficiencies in home and institutional appliances affects the overall energy- and GHG-efficiency of food preparation.

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**\*Extract of Action Plan for Achieving Objective 2b:** Perform the strategically-chosen LCA studies to test specific hypotheses and identify principles for choosing low-carbon foods.

A preliminary list of suggested suites of LCA studies to perform in order to address specific guiding questions includes the following (this list will be refined and amended during preliminary research and with input from participants in the symposium):

- 1) Production system and transport:
  - i) Organic vegetable or fruit commodity (tomato, lettuce, grapes) produced in Mexico or eastern US and consumed in CA
  - ii) The same commodities produced conventionally in CA and consumed in CA
  - iii) The same or similar commodities produced organically in CA and consumed in an eastern US city
  - iv) The same commodities as in (iii) produced conventionally in eastern US and consumed in eastern US city
- 2) Scale of Production, processing, and transport systems:
  - i) Lettuce grown on a small farm in CA and purchased directly by local consumers at a farmers market
  - ii) Lettuce grown on a large Salinas Valley farm and sold to a large packer and distributor, ultimately purchased by consumers in a large supermarket
- 3) Seasonality of production, processing and transport:
  - i) Tomato paste from tomatoes produced and processed in northern CA and consumed as pasta sauce in winter in US location(s)
  - ii) Fresh tomatoes sourced from Florida, Caribbean, or Latin America and consumed as pasta sauce in winter in same US location(s)

- iii) Fresh tomatoes from US-based greenhouse production consumed as pasta sauce in winter in same US location(s)
  - iv) Fresh New Zealand apples consumed in winter in CA
  - v) Dried or stored CA or WA apples consumed in winter in CA
- 4) Livestock production systems:
- i) Range-fed beef produced and consumed in CA and other US locations
  - ii) Feedlot-finished beef produced and consumed in CA and other US locations
  - iii) Free-range eggs produced in CA (functional unit = grams of protein)
  - iv) Conventional, confinement-produced eggs in CA (functional unit = grams of protein)
  - v) Beans or lentils produced in CA (functional unit = grams of protein)
- 5) Pre-retail and post-retail sectors:
- i) Select a sample of commodities being studied in any of the LCA studies above, and investigate range of portion sizes purchased by consumers, range of transport options, and range of home appliances used to store and prepare them, as well as magnitude of waste, in order to assess magnitude of energy use and GHG emissions relative to those for pre-consumer sectors.

All comparisons will be based on providing the same range and quality of produce items now available to typical consumers. Given that an increase in the consumption of fruits and vegetables is a national goal in order to curb negative health impacts of the average American diet, we will presume that it is essential to maintain (or even improve) consumer access to a wide range of high quality fruits and vegetables.