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To the California Air Resources Board:

This letter is in response to the June 2008 discussion draft of the ARB Climate Change Scoping Plan. This scoping plan addresses a very complex and cross-cutting issue of grave importance to the state and makes strong inroads on tackling some of the largest sources of greenhouse gases (GHG). The UC Davis Agricultural Sustainability Institute would like to offer some suggestions for additional avenues for substantial emissions reductions, focusing on the food and agriculture system.

Our suggestions are based on insights gained from our study of the literature over the past one and a half years and from an experts symposium on this topic held at UC Davis in October, 2007. By approaching the topic from a life cycle assessment perspective, which considers GHG emissions accruing at all stages of the supply chain, we have identified the following emissions "hotspots" which do not receive adequate attention in the draft scoping plan:

1. Production and use of synthetic nitrogen fertilizer
2. Air freighting of foods
3. Consumers driving to shopping
4. Waste along the entire supply chain, including at the consumer level

The scoping plan already includes some technical means for addressing these hotspots, such as the low carbon fuel standard, vehicle efficiency standard, and increased efficiency of systems for moving goods. ***We would like to suggest that these technical means be complemented by more policy incentives for behavioral changes within industry, government, and the consumer public.*** Below, we address each of these issues and provide examples of how behavioral changes could lead to better emissions reductions.

1. Production and use of synthetic nitrogen fertilizer

We applaud the ARB for recognizing synthetic nitrogen as a large source of GHG emissions in agriculture and for beginning a research program on this topic (as noted on p 35). However, GHGs are not only emitted in the field, they are also generated during the manufacture of ammonia for fertilizers, due to the high fuel energy demand of this manufacturing process. According to some estimates, every kg of manufactured ammonium nitrate produces as much as 2.89 kg CO_2 (ecoinvent V.2). Referring to the ARB's Documentation of California's Greenhouse Gas Inventory, an estimated 833,622 metric tons of synthetic nitrogen fertilizer were applied statewide in 2004. We therefore estimate that synthetic fertilizer use in California may result in as much as 2 million tons or more of CO_2 generated every year, depending on specific fertilizer composition. These emissions are due solely to manufacture of the fertilizer, and are therefore in addition to the substantial N_2O emissions generated in the field. Moreover, these emissions are not accounted for in ARB's estimates of industrial emissions, since nitrogen fertilizer applied in California is imported. Measures that increase the efficiency of fertilizer application on the farm and/or encourage farmers to transition to production systems with lower synthetic fertilizer inputs can therefore reduce the associated GHG emissions by much more than only the amount of N_20 emissions spared in the field. For example, a

recent study estimated that transitioning all of Canadian wheat, canola, soy, and corn production to organic production methods could reduce GHG emissions from Canadian agriculture by 8.7%, with most of this reduction attributed to substituting other soil fertility sources (such as cover crops) for synthetic fertilizer use.[1]

2. Air freighting of foods

Due to higher rates of fuel use, air freight produces approximately 50 times the global warming potential as sea freight, a difference not easily amenable to a purely technical solution. Reducing demand for air freighted food through consumer education (including possible food labeling schemes) is therefore essential for reducing this source of GHGs. Using government food procurement policies to reduce or eliminate air freighted food from government functions and food service can also play an important role by setting an example for a "low-carbon diet".

3. Consumers driving to shopping

Research has shown that use of personal vehicles for consumer shopping trips can overshadow the impacts of transportation in all previous stages of a food's supply chain. While the scoping plan outlines actions for local governments to take regarding community design, we urge the ARB to consider strengthening these items to provide for more concrete measures that will reduce vehicle miles traveled by consumers for daily necessities such as groceries.

4. Waste along the entire supply chain, including at the consumer level

A University of Arizona researcher has estimated that households waste 14% of the food they purchase, and that some retail establishments, such as convenience stores, waste up to 26%.[2] The scoping plan addresses waste in landfills as a source of methane that can be captured for energy, and also considers possibilities for diverting the waste stream away from landfills. While these strategies are important, it is also crucial to consider reducing the amount of waste generated in the first place. All waste materials, including food waste, embody substantial GHG emissions that were generated all along their supply chains. For example, a discarded sandwich represents emissions generated during crop and livestock production, processing, transport, packaging, and retail. Composting of that sandwich alone will not recapture those GHGs once produced. Public education campaigns and other policy incentives to address the high rate of food waste generation will be necessary to substantially reduce emissions in this area.

We are finalizing a white paper summarizing current knowledge and perspectives on these topics, and are enclosing a draft of this paper. The final version will be posted on our website in upcoming months.

Thank you very much for your attention to this urgent issue.

Sincerely,
Sonja Brodt
Gail Feenstra
Thomas Tomich, Director

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[1] Pelletier et al. 2008. Scenario modeling potential eco-efficiency gains from a transition to organic agriculture... *Environmental Management* DOI 10.1007/s00267-008-9155-x

[2] 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.

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

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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.[3] 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% reduction in GHG emissions across all sectors by 2020 and an 80% 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 inform actions to reduce greenhouse gas (GHG) emissions in the food system by policy makers, consumers and other players in the food system. This paper summarizes the discussions of researchers, industry representatives, and government representatives at a symposium convened by the UC Davis Agricultural Sustainability Institute on October 8-10, 2007.

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?*

[3] 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 following:

- The high energy requirement, and therefore GHG emissions, to produce synthetic nitrogen fertilizer, which is used on conventional crops 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 50-100% 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.[4]

Factors Needing Further Research:

Clarifying trade-offs between production system efficiencies and transportation mode efficiencies will help buyers to 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 systems, including larger trucks, rail, and ships, with the exception of air freight (see Item A, above).

[4] 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.

- 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 (such as fresh and frozen produce), require substantially more energy for transportation than counterpart foods with opposite characteristics (such as 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 (for example, 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 the use of air freight in larger-scale systems being a particular "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:

- Off-season production of produce in 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 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 must be shipped before transportation-related emissions break even with processing-related emissions (similar to A).

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

Sample questions: *How much GHG emissions can be saved when choosing legumes and other plant foods, or eggs and dairy, over meat? Is it better to buy meat from free-range animals or from conventionally-raised animals?*

Key Factors:

- As a whole, the global livestock population is one of the largest anthropogenic sources of GHGs, producing an estimated 18% of global emissions,[5] most of this in the form of 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 cattle, goats, and sheep, produce significantly more methane than other livestock, and especially so for range-fed cattle.
- Increasing feed efficiency among ruminants can also reduce overall methane production.
- Depending on intensity of rearing methods, chickens are generally among the most energy and GHG efficient, due to their physiological efficiency of feed conversion.

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 animal rearing 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 coming from excess nitrogen in manure.

Bottom Line:

Given that animal-based foods are responsible for a disproportionate amount of GHG emissions, reducing relative 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.

[5] 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 1/3, according to one study[6]) of total life cycle emissions.
- Energy efficiency of consumer appliances varies greatly, with newer, Energy Star-rated appliances up to 10-50% more efficient than older appliances still commonly in use.
- A University of Arizona researcher has estimated that households waste 14% of the food they purchase, and that some retail establishments, such as convenience stores, waste up to 26%.[7]

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 at once. Furthermore, policy will have to 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 need to 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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[6] 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.)

[7] 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.