

*The Low Carbon Diet:
Reducing Energy Intensity and Greenhouse
Gas Emissions in the Food System Using a
Life Cycle Assessment Approach*

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The industrialized food system...

- Consumes close to 16 % of total national energy use in the US (Hendrickson 1996)
- Is responsible for 29% of the global warming resulting from all sectors of the consumer economy in the EU (EIPRO Report, European Commission 2006)

Uncertainties in the Food System

Unpack the food supply chain



Uncertainties due to complex tradeoffs



DAVIS
FARMER
MARKET

PURE APPLE
JUICE
1.50 PINT

McDonald Orchards
Open Valley
HONEY STICKS
ORANGE BLOSSOM
HONEY

McDonald Orchards
20179 County Road 704
Cupertino CA 95027
Cupertino Valley
Solo C...

Trade-offs in Local Food Systems

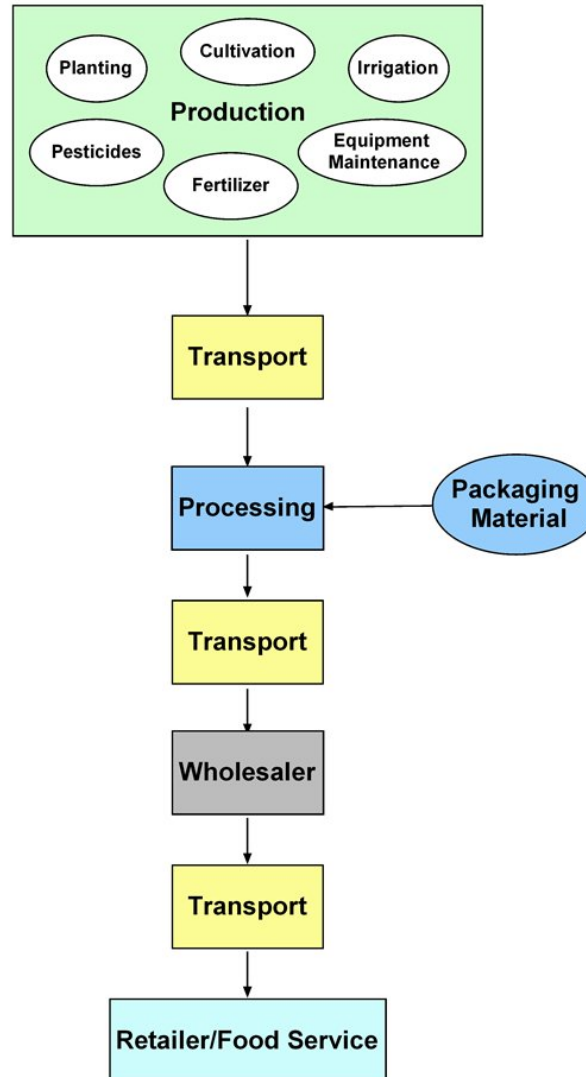
National Public Radio, “The Challenge of Eating Local: Distribution” (Jan 4, 2008)

Michigan entrepreneur trucks products from local farms to restaurants, stores, schools, resorts.

The success of this local distribution business is spurring one farmer to put in more *greenhouses* for lettuce.

Life Cycle Assessment

Sample Life Cycle Inventory for Tomato Paste



Agricultural Sustainability Institute, UC Davis

- Founded 2006
- 24 full and part-time staff in various programs
- 150+ faculty primarily interested in sustainable agriculture
- 150+ members of Students for Sustainable Agriculture
- UC Cooperative Extension



ASI Research and Outreach Initiative

Ultimate Goal:

Steer consumers and other members of the food supply chain towards a “low-carbon diet”.

Program Objectives:

- Research – using a life cycle assessment framework
- Outreach
- Industry implementation

Research Framework: Five Key Questions

- Embody typical dilemmas and tradeoffs facing consumers concerning energy use and GHG emissions in the food system
- Distill key issues that span across multiple stages of the food supply chain
- Identify “hotspots” in the supply chain and assess potential to mitigate them

Key Question #1

Tradeoffs Between Type of Production System and Transport Distance

How do fresh foods grown locally under conventional production systems compare* to fresh foods grown in alternative production systems (e.g. organic, conservation tillage, etc.) but imported from distant locations?

*in terms of energy use and greenhouse gas emissions

Sample question from a consumer's perspective:

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

Key Question #1: Production System vs Transport

Organic systems often have lower energy inputs than conventional systems, primarily due to **fertilizers**.

Corn production experiments in Canada:

(McLaughlin et al. 2000)

- Energy embodied in fertilizer: 33-54% of total energy input of conventional system.
- Substitution of manure → saved 31-34% of total energy inputs.*

*did not include transport of manure from storage to field, assumed it has to be disposed of anyway

But how does yield compare?

Key Questions #2

Scale of the Food System

How do:

small-scale local food systems, involving small farms,
short distribution distances, direct marketing

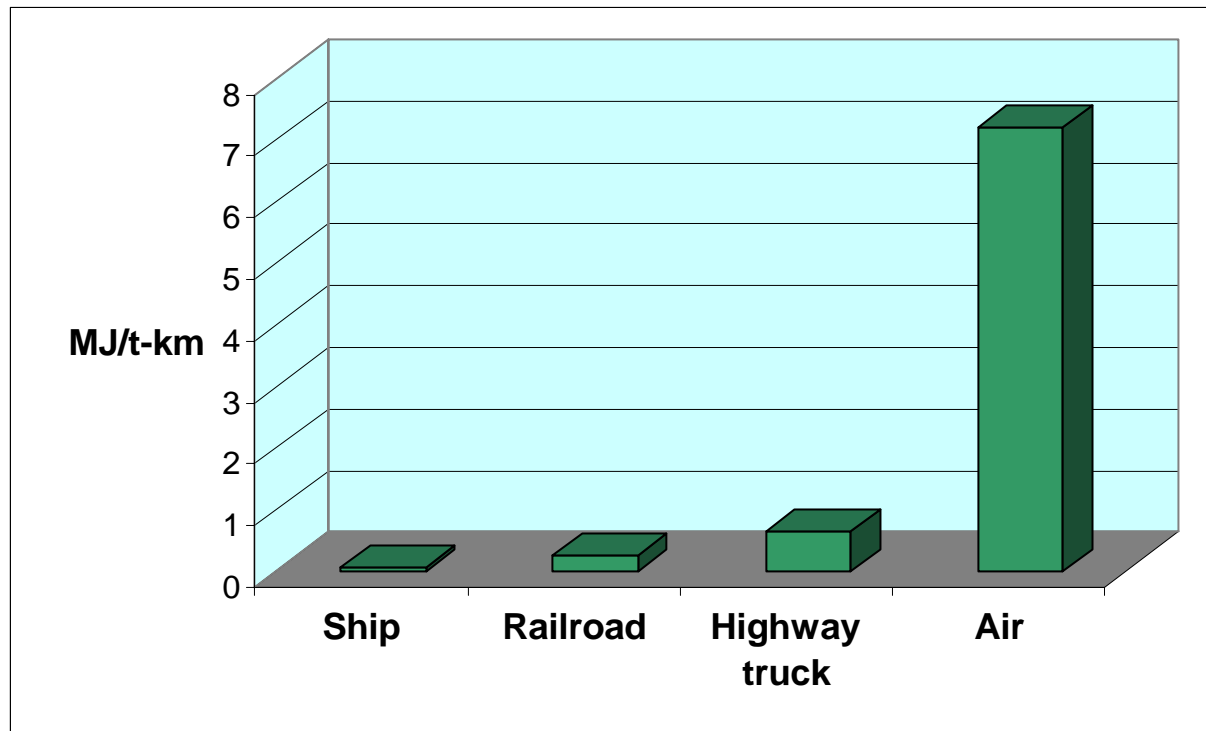
compare to

regional-scale food systems, involving regional
distribution networks

compare to

global-scale food systems involving global distribution
networks?

Key Question #2: Scale of the Food System



Network for Transport and Energy

Key Question #3

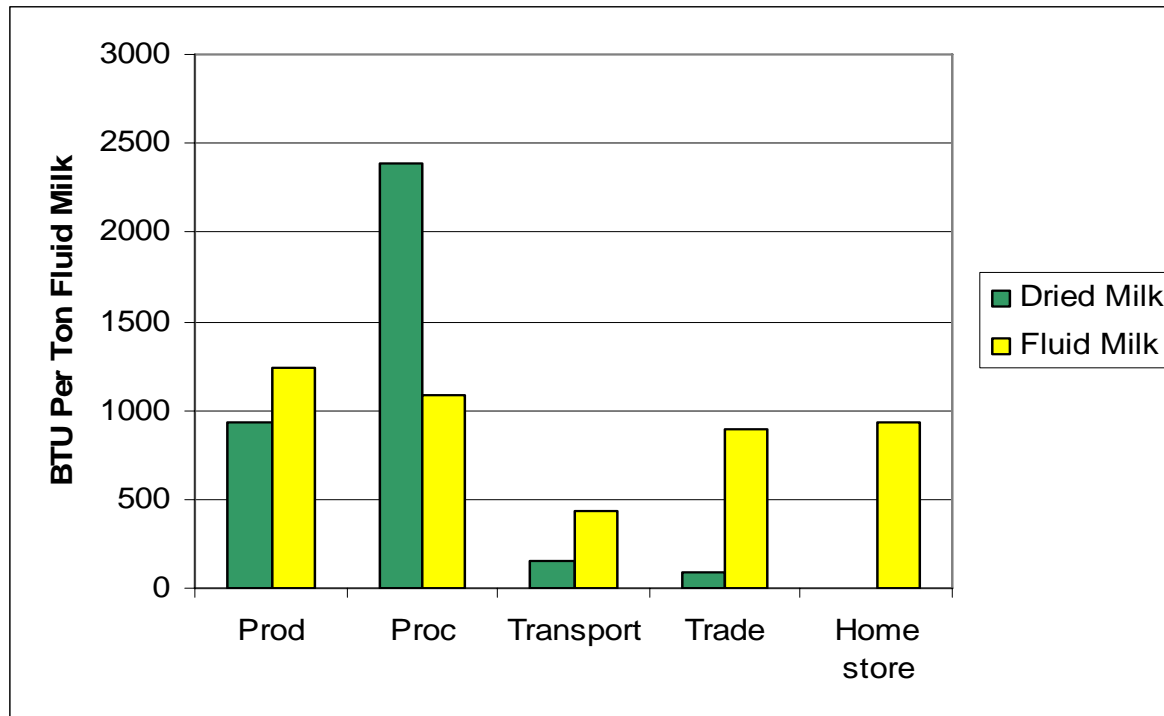
Seasonality of Production, Processing, and Transport

Under what conditions and for which commodities are processed foods more energy- and GHG-efficient than fresh foods?

Sample question from a consumer's perspective:

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

Key Question #3: Seasonality, Processing and Transport



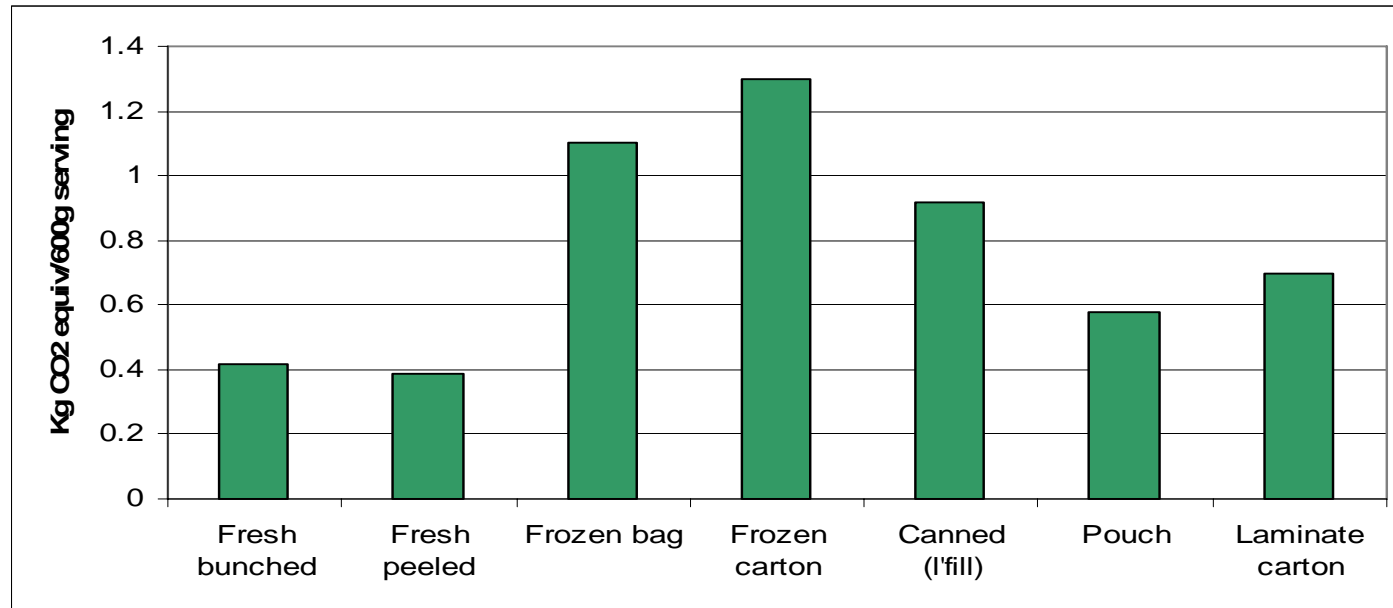
Total Life Cycle Energy Use

Fluid Milk: 4,574.35 BTU

Dried Milk: 3,862.40 BTU

Key Question #3: Seasonality, Processing and Transport

Example of Dutch carrots:



For **frozen carrots**: storage in distribution, retail, home are main contributors.

For **canned carrots**: recycling the steel can make a big impact.

For **fresh carrots**: higher waste levels may result in 15% higher impacts, compared to 5% for preserved forms.

Key Question #3: Seasonality, Processing and Transport

- **Heated greenhouses:** use 9 to 21 times more energy than open air production (Van Hauwermeiren et al. 2007)
- **Tomatoes consumed in Sweden:**
 - Fresh, from S Europe: 5.4 MJ/kg
 - Canned, from S Europe: 14 MJ/kg
 - Greenhouse, Sweden: 66 MJ/kg
(Carlsson-Kanyama et al. 2003)



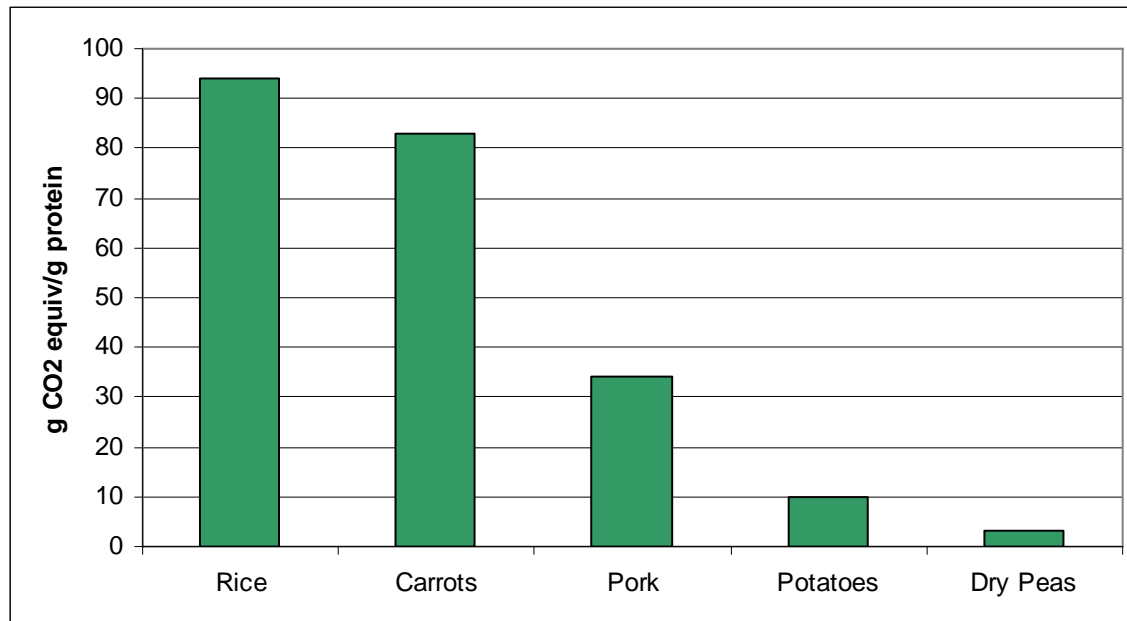
Key Question #4

Livestock Production Systems

How do different livestock products compare to one another (eggs versus chicken, milk versus beef, etc.) and how do livestock products compare to plant-derived protein foods?

Key Question #4: Livestock

- Meat and dairy products: **half** of all food-related emissions in EU study (Environmental Impact of Products Report 2006)
- Animal-based protein foods are 2-100 times more energy-intensive than plant-based protein foods.



Source: Swedish Nat'l Food Admin 1996, cited by Carlsson-Kanyama 1998

Key Question #4: Livestock

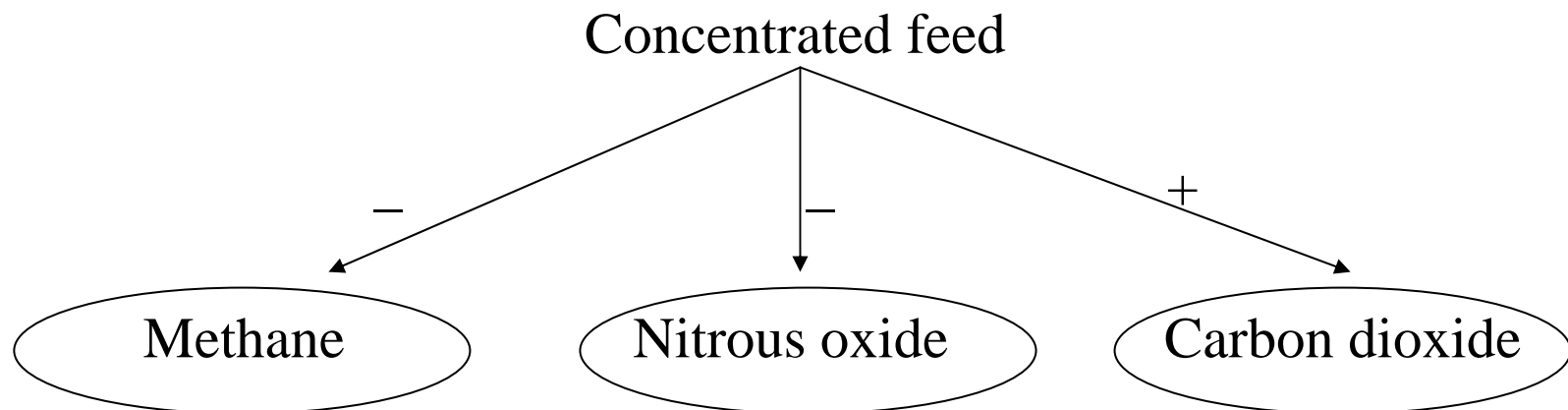
- Methane: 100-yr GWP = 25
- Nitrous oxide: 100-yr GWP = 298
- CH₄ and N₂O from manure: 5% of global GHG
(FAO 2006)
- 2.4 bil tons CO₂/yr due to global livestock-related
land use change (7% of global GHG emission)
(FAO 2006)

Key Question #4: Livestock



Trade-offs?

- Manure management
- Range-fed versus feedlot



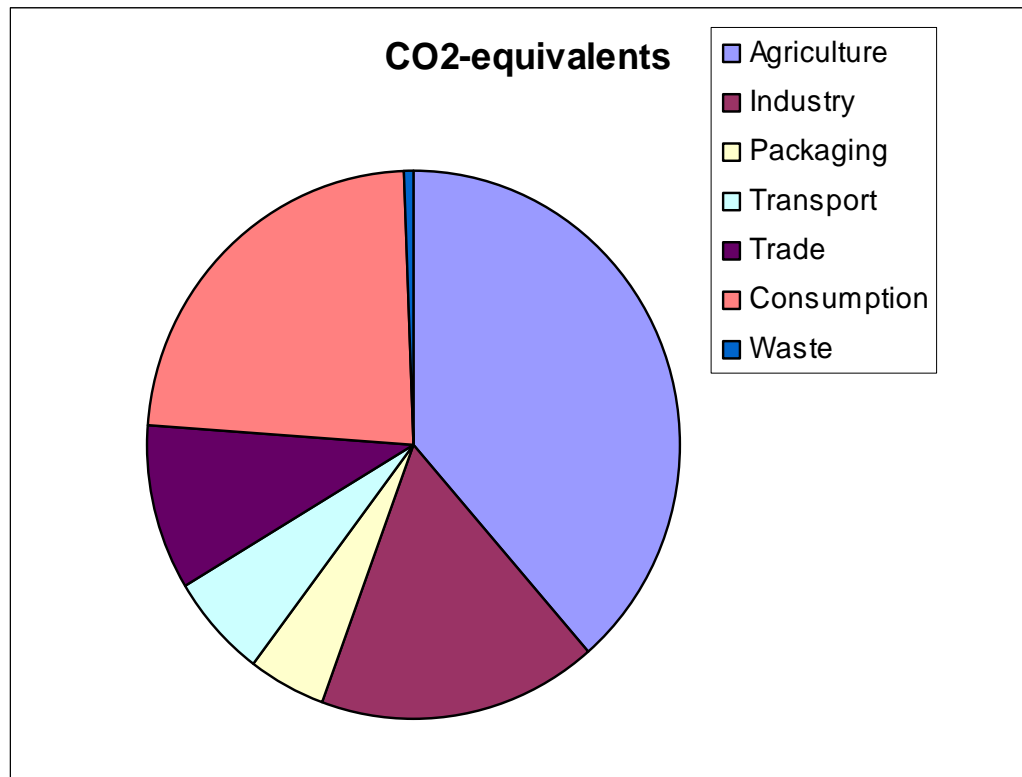
Key Question #5

Pre-Retail versus Post-Retail Life Stages

How large are consumer-level energy and climate impacts compared to all the pre-retail sectors of the food system?

Key Question #5: Post-Retail

Netherlands study: Consumption accounts for $\frac{1}{4}$ of GHG emissions of the Dutch food supply chain (Kramer 2000)



Kitchen Appliances:

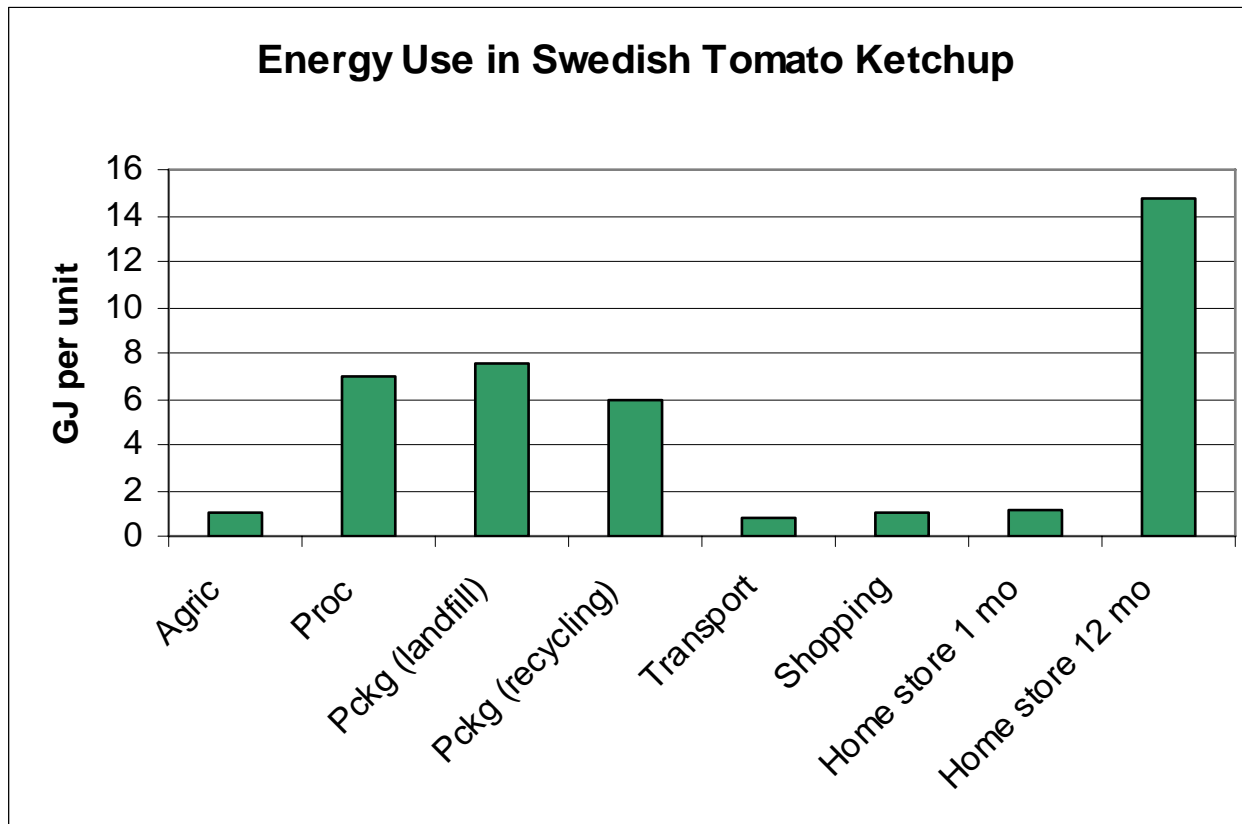
Changing from electricity to gas and using more efficient appliances could reduce energy and GHG by 6% in total system.

**Consumer
Transportation**

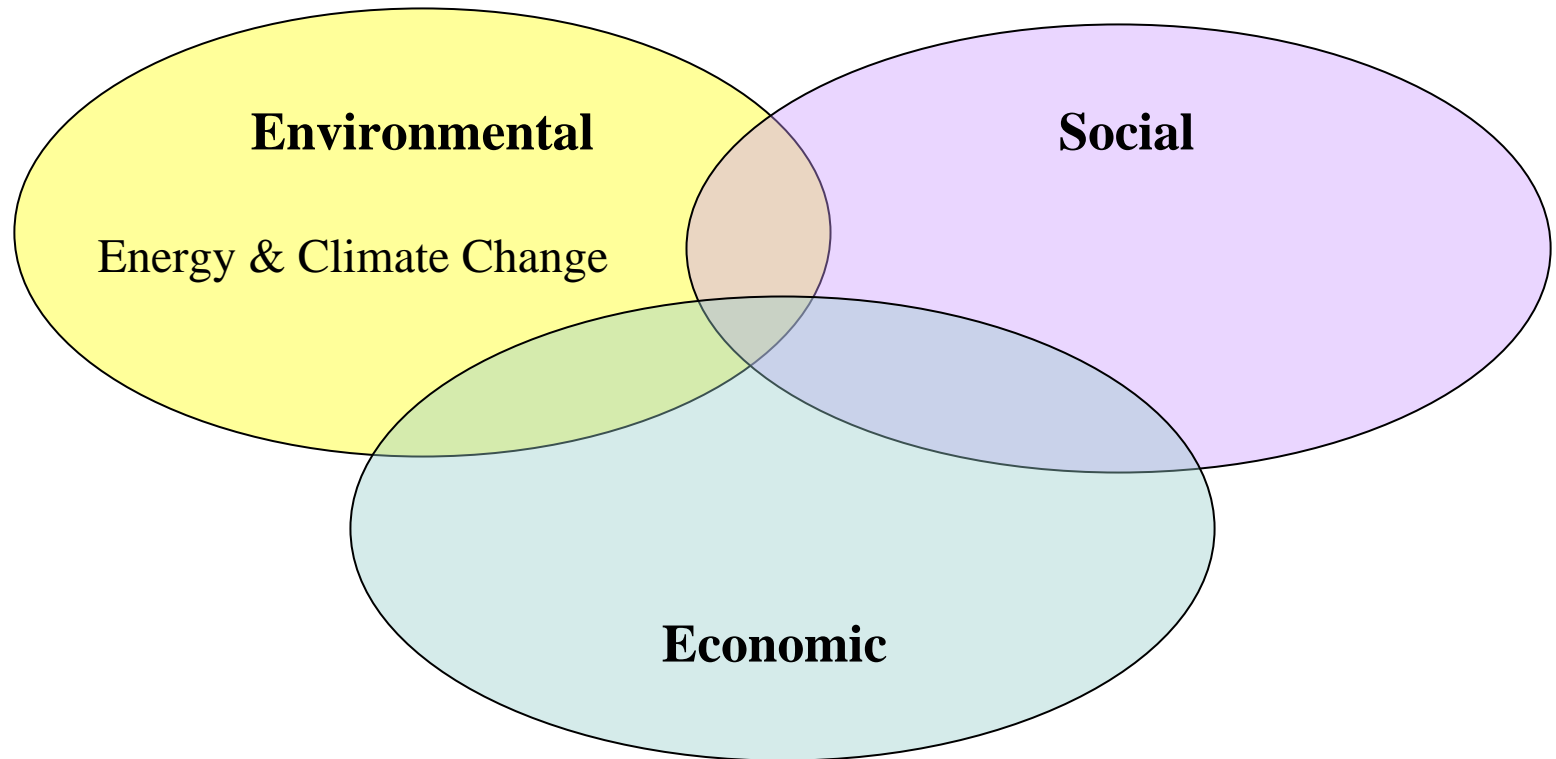
Cooking Method

Key Question #5: Post-Retail

Transportation, Storage, Cooking



Integrate with Other Aspects of Food Systems Sustainability



References

- Anderson, 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.
- Carlsson-Kanyama, A. 1998. "Climate change and dietary choices- how can emissions of greenhouse gases from food consumption be reduced?" *Food Policy* 23: 277-293.
- Carlsson-Kanyama, M.P. Ekstrom, and H. Shanahan. 2003. "Food and life cycle energy inputs: consequences of diet and ways to increase efficiency." *Ecological Economics* 00: 1-15.
- 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 Commission, Joint Research Centre, Institute of Prospective Technological Studies.
- Hendrickson, J. 1996. *Energy Use in the U.S. Food System: A Summary of Existing Research and Analysis*. Madison, WI: Univ. of Wisconsin, Center for Integrated Agricultural Systems.
- Kramer, K.J. 2000. *Food Matters: On Reducing Energy Use and Greenhouse Gas Emissions from Household Food Consumption*. PhD Dissertation, University of Groningen, The Netherlands: Universal Press.
- Ligthart, T.N., A.M.M. Ansems, and J. Jetten. 2005. "Eco-efficiency and nutritional aspects of different product-packaging systems: an integrated approach towards sustainability." TNO Report B&O – A R 2005/232.
<http://www.resol.com.br/textos/Ecoefficient%20and%20nutritional%20aspects%20of%20different%20product%20packaging%20systems.pdf>.
- McLaughlin, N.B., A. Hiba, G.J. Wall, and D.J. King. 2000. "Comparison of energy inputs for inorganic fertilizer and manure based corn production." *Canadian Agricultural Engineering* 42: 2.1-2.13.
- Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, C. De Haan. 2006. *Livestock's Long Shadow: Environmental Issues and Options*. Food and Agriculture Organization of the United Nations.
- Van Hauwermeiren, A., H. Coene, G. Engelen, and E. Mathijs. 2007. "Energy life cycle inputs in food systems: a comparison of local versus mainstream cases." *Journal of Environmental Policy & Planning* 9(1): 31-51.
- Whittlesey, N. and C. Lee. 1976. *Impacts of Energy Price Changes on Food Costs*. Pullman, WA: Washington State University College of Agriculture Research Center.