Meridian Institute
Connecting People to Solve Problems

Potential Post-Production Opportunities

Major transformations are required to create sustainable food systems, but near-term immediate actions can support longer-term, more fundamental transition to sustainability. For incremental steps to contribute to long-term changes, stakeholders should define sustainability, measure unsustainability, and understand what interests, ideas and institutions contributed to the current structures, ideas, institutions, policies, and practices. Such understanding will enable stakeholders to choose near-term actions that can lead towards sustainability.

The tables, below, are intended to provide a starting point for stakeholders who are working to build sustainable food systems and are considering a range of near-term interventions. Much additional experience and knowledge by farmers, peasants, indigenous groups, communities and practitioners should be consulted for a full understanding of these and additional potential interventions.

The following tables summarize mitigation opportunities, adaptation potential, and food system implications based on global literature of post-production impacts. We recognize that much of the peer-reviewed literature has focused on post-production impacts in high-income countries. Therefore, the opportunities may not be relevant or appropriate for low- and middle-income countries.

Based on a systematic literature review, the Authors identified mitigation opportunities in food processing, packaging, transportation, and refrigeration.

Food Processing. Mitigation options include energy savings within the food processing industry (van der Goot et al., 2016). Other cultural or dietary shifts can directly affect the amount and intensity of necessary food processing. For example, a change in rice processing and consumption patterns (e.g. from parboiled rice to untreated rice and from well milled to partially milled rice or brown rice) would conserve about 43–54 million tons of rice, and reduce CO2 emissions from rice processing by 2–16% (Roy et al., 2013).

Packaging. Mitigation options include recycling of packaging materials, which can lead to significant reductions in energy use (Ahmed and Alam, 2013) and other efforts to “green” food packaging. Light weighting of packaging affects not only the impacts due to producing the packaging materials but also the cost (environmental and economic) of shipping. The indirect effects of packaging – through impacts on food waste – can be significant (Wikstrom et al., 2014; Williams et al., 2012; Williams and Wikström, 2011).

Transportation. Mitigation options should consider that “food miles” – the distance food travels from producer to consumer – is of limited value in predicting the carbon footprint or environmental impact of a food. The mode of transport – whether truck or train, ship or plane – matters much more than the distance alone. Rail shipments can go two to ten times farther than truck shipments (depending on truck size) and result in the same emissions, whereas transoceanic shipping freight can go 5 times farther than rail with the same carbon footprint. Air freight is 100 times more emission intensive than ocean shipping, and 2 to 12 times more intensive than trucking (James and James, 2013). A study comparing the advantages of local production against production in suitable regions (Kreidenweis et al., 2016) showed that transportation impacts were minimal compared to the benefits of growing staple crops where they grow best.

Refrigeration. Mitigation options include reducing energy use in the existing cold chain. Estimates indicated that energy use can be reduced 20%–50% through correct specification and use of equipment, and emissions related to CFCs by 80%–90% using existing and emerging technologies. There is potential to reduce energy usage and CO2 emissions by raising the temperature control set point of cold stores and also by raising the associated evaporating temperatures (James and James, 2013). Shifts to less refrigeration dependent foods could also help. For instance, meat products tend to be most refrigeration dependent.

Refrigerants. Efforts to phase out HFCs are extremely important as the impact of these refrigerants is significant. Refrigerant leakage can be up to 15% per year in commercial refrigeration plants and an estimated 20% of the global-warming impact of refrigeration is due to these leakages (James and James, 2013). Numerous alternative refrigerants are feasible, but often there is a balance between cost, efficiency, environmental impacts and flammability.

Opportunity Table: Processing

Opportunity	Mitigation Potential	Adaptation Potential	Co-benefits	Food System Implications
	Qualitative description plus quantitative if available (range of possible emission reductions?)	Qualitative description plus quantitative if available		Briefly characterize the implications of each intervention for other food system activities or drivers
Reduce waste during food processing by valorizing (developing markets for) byproducts	Increases efficiency of food system by utilizing more of primary production	Reduces demand for raw materials/food production	Potential to generate new markets, innovative products	Reduces demand for raw material production by utilizing more of the total production output; could introduce novel agricultural inputs (fertilizers, biocides, etc) derived from processing by-products
Promote transition in food processing from pure, standard quality ingredients to functional fractions (see van der Goot et al, 2016)	Offers potential to reduce energy use in food processing	Likely will require more diversified and dispersed processing (rather than highly centralized and standardized)	Potential nutritional advantages	May encourage crop and varietal diversification in ag. production as meeting rigorous standards becomes less important and opportunities to introduce novel functions (colors, flavors, nutritional composition, etc) increase
Promote or support development of non-thermal processing techniques	Non-thermal techniques for enhancing shelf-life and altering material properties - such as high pressure processing, pulsed electric field, cool plasma, UV irradiation, ultrasound - typically have reduced energy requirements and could lead to improved energy efficiency in food industry (Pereira & Vicente, 2010; Augustin et al 2016)			May introduce opportunities for unrefrigerated distribution and storage; could have implications on packaging needs (either increasing or decreasing); implications for food safety would need to be carefully researched, regulated and monitored.
Promote recycling of packaging materials and packaging with high recycled rate	For most materials, recycling and utilizing recyled material in new products reduces overall system energy use and environmental impacts. This can not be universally assumed, however.	Recycling reduces demand on dwindling natural resources	Diverts materials from landfill	
Promote light weighting and minimal packaging, but not at the expense of packaging performance				Could have implications for handling and distribution logistics as minimal packaging may require additional tertiary packaging and special handling procedures
Consider the indirect role that packaging plays in reducing food waste when implementing packaging related mitegation strategy or policy	Indirect influence of packaging on system GHG emissions can be greater than the direct impacts of packaging material production or disposal; this must be considered on a case-by-case basis			Reducing food waste reduces production demand; packaging changes may have consumer acceptance implications.

Opportunity Table: Transportation

Opportunity	Mitigation Potential	Adaptation Potential	Co-benefits	Food System Implications
	Qualitative description plus quantitative if available (range of possible emission reductions?)	Qualitative description plus quantitative if available		Briefly characterize the implications of each intervention for other food system activities or drivers
Focus on transport mode over transport distance; increase access/availability of low emission modes (rail, water)	"Food miles" have received a great deal of attenion, but research has demonstrated repeatedly that distance alone is not a good indicator of GHGE associated with food transport.		May lead to reduced costs, but there can be tradeoffs with storage costs/impacts	Could influence temporal supply/demand logistics and market access;
Increase backhauling opportunities	Improves efficiency of transportation network		Should improve cost efficiency. Introduces logistical challenges	
Avoid air freighted foods	"Scholz et al. (2009) report that fresh salmon air freighted from overseas has about twice the environmental impact as frozen salmon transported by container ships over the same distance. The difference owing to transport modes is far more signifi cant in this case than production choices suc as wild versus farmed or organic versus conventional." (Wakeland et al 2012)			May be detrimental to some commodity markets as well as year-round access to complete diversity of foods (e.g., berries may not be available everywhere year round)
Investment in more efficient vehicles	Improving fleet energy efficiency directly reduceds GHGE per unit of food transported			Could influence food cost, presenting access/affordability implications
Use of information and communications technologies for optimal route planning	Avoiding unnecessary or inefficient logistics improves energy efficiency of food system. Studies suggest that in most cases, short-term storage in intermediary refrigerated wharehouses for the purpose of increasing load efficiency results in net reductions in energy use and emissions.Lean supply chains do not always equate with "green" supply chains. (Venkat & Wakeland, 2006; Wakeland et al 2012)			

Opportunity Table: Refrigeration

Opportunity	Mitigation Potential	Adaptation Potential	Co-benefits	Food System Implications
	Qualitative description plus quantitative if available (range of possible emission reductions?)	Qualitative description plus quantitative if available		briefly characterize the implications of each intervention for other food system activities or drivers
Promote energy efficiency in equipment and grid electricity generation	Electricity is the primary energy carrier for stationary refrigeration. Using the best available technology can greatly reduce energy demand of refrigeration.			Carries implications throughout food system, wherever electricity is utilized
Promote/ assure correct specification of new equipment through proper technician training; make energy efficiency goals a priority of these training curricula	Emissions related to energy use can be reduced 20%–50% through correct specification and use of equipment (Garnett, 2007)			
Polygeneration (trigeneration)	Significant technical polygeneration potential exists in the European Food industry. If exploited can give about 34 TWhel/ year and can result in 13 million tones of CO_2 savings (0.3% of EU-28+Iceland 2014 GHG emissions) (https://ec.europa.eu/energy/intelligent/projects/en/projects/optipolygen)			Integrates refrigeration needs within food processing with other energy needs such as heating/thermal processes, electricity. May offer valorization of bio-based waste materials/low-value co-products
Eliminate (minimize) refrigerant leakage	Not only do HFC refrigerants act as GHG, if a refrigeration system loses 15% of its refrigerant then its energy requirement can double for a given amount of cooling (Garnett, 2007)			
Use alternative (non GHG) refrigerants)	Emissions related to CFCs can be reduced by 80%–90% using existing and emerging technologies (Garnett, 2007)			
Improve efficiency of mobile refrigeration units through adoption of new technologies	(Tassou et al., 2009)			Could improve food safety and food shelf life by minimizing thermal shocks during transport
Retail "choice editing" of domestic appliances to improve/increase energy efficiency	Retailers can influence energy efficiency of appliances by preferencially stocking higher efficiency units			Could have rebound effects as home energy savings translate into financial savings that are spent elsewhere on potentially more impactful activities
Maintain food refrigeration systems; repair door seals and door curtains, clean condensers	Improves energy efficiency			Could improve food safety and food shelf life by minimizing thermal shocks during storage
Inform and encourage retailers to replace energy inefficient frozen and chilled food display cabinets by the best currently available technology	5-6 fold differences in energy consumption between efficient and inefficient operating refrigeration units			
Promote home refrigeration upgrade "trade-in" programs	Avoid situations where old refrigerator is maintained in home as second unit, thus negating the benefits of efficiency upgrades			Potential rebound effects
Promote small capacity refrigeration in homes where routine access to markets via walking biking or public transit is feasible	Owning household refrigerators has been linked to the overbuying of food; Ligon, V. K. Shop More, Buy Less: A Qualitative Investigation into Consumer Decisions that Lead to Food Waste in U.S. Households; The University of Arizona, 2014.		Promotes/encourages mixed use urban development, community building, healthy behaviors	Dependance on local/neighborhood shopping may also influence purchase choice, with nutrition/health as well as diet related environmental impact implications; if walking/biking/public transport is not used, could encourage more frequent shopping trips, meaning more emissions
Consider indirect rebound effects - such as shifts in diet, purchasing patterns, food waste rates - of introduction of cold chain; address these effects along with cold chain development	It is currently unclear how the many direct and indirect forces involved in the introduction of a developed cold chain into the food system will balance when it comes to net system environmental impact. (Heard & Miller, 2016)	Certainly developing a cold chain with attention to such factors can/will improve resilience	Likely economic and social benefits	Intervention based on broad system-wide implications

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Establish guidelines and regulation for insulation value of stationary and mobile refrigeration	Common foam-based insulation degrades at a rate of 3-5% per year. Alterantive insulation technologies (vaccum based) have great potential to offer prolonged insulative benefit. (Tassou et al., 2009)	Resilient insulation in refrigeration infrastructure will only become more important as average temperatures rise	Economic benefits (reduced energy use)	Could improve food safety and food shelf life by minimizing thermal shocks during storage