

Restaurant and food service life cycle assessment and development of a sustainability standard

Cheryl Baldwin · Nana Wilberforce · Amit Kapur

Received: 4 January 2010 / Accepted: 3 September 2010 / Published online: 23 September 2010
© Springer-Verlag 2010

Abstract

Purpose There is no clear guidance for responsible food service operations to reduce their environmental footprint, so the efforts put forth by a restaurant may not have the environmental impact intended. As a result, Green Seal conducted life cycle assessment research on restaurants and food service operations to define priorities for environmental improvement. This information was then used to develop a sustainability standard and certification (i.e., ecolabel) program.

Methods The life cycle assessment study focused on the day-to-day activities of running a restaurant, including direct and indirect contributions. To do this, a restaurant and food service operations model was developed by grouping the operational activities into four subsystems: food procurement, food storage, food preparation and cooking, and service/support. Data was collected from a range of restaurants in the United States. The impact categories examined included respiratory inorganics, acidification/eutrophication, fossil fuels, ecotoxicity, carcinogens, land use, and climate change.

Results and discussion Of all the subsystems, food procurement contributed hotspots in all impact categories examined. On the contrary, the food storage subsystem contributed no hotspot in any of the impact categories examined. Normalization of the results confirmed that food procurement was the largest source of environmental impacts. In addition, it was found that the impacts of food

services were dominated by land use, respiratory inorganics, and fossil fuels. The impacts could be reduced with various preferable practices. As a result, a sustainability standard for restaurants and food services was developed to include these preferable practices, the Green Seal Standard for Food Services, GS-46.

Conclusions This study presents an overview of the main environmental impacts from the operation of a restaurant or food service. The results provided direction in the development of a sustainability standard and ecolabel program. This standard, the Green Seal Standard for Restaurants and Food Services, GS-46, is a comprehensive framework for operations to make meaningful reductions in their environmental impact. Further, operations that meet the requirements in the GS-46 standard have demonstrated significant reduction in their environmental impact. Finally, it was found that this environmental impact reduction can be done without added cost (e.g., cost neutral, with potential for financial gains).

Keywords Ecolabel · Food service · Food · Green Seal standard, GS-46 · Life cycle · Restaurant · Standard

1 Introduction

The food service industry in the USA was projected to have sales of \$558 billion in 2008 and is the largest private-sector employer, according to the National Restaurant Association. Further, 42% of US consumer spending on food is at food service establishments (BLS–United States Bureau of Labor Statistics 2010). In this significant industry, environmentally preferable practices are growing. This has been done as means for cost savings (e.g., energy conservation) and growing consumer

Responsible editor: Niels Jungbluth

C. Baldwin (✉) · N. Wilberforce · A. Kapur
Green Seal,
1001 Connecticut Ave, NW, Suite 827,
Washington, DC 20036, USA
e-mail: cbaldwin@greenseal.org

interest in sustainability. According to the National Restaurant Association's 2009 Restaurant Industry Forecast, more than six out of ten consumers say they are likely to choose a restaurant based on its environmental efforts. In addition, 44% of consumers say they are likely to make a restaurant choice based on a restaurant's efforts to conserve energy and water (National Restaurant Association NRA 2008). Further, when consumers were asked the likelihood of visiting the "green" store or restaurant, participants responded (SCA 2009):

- 49%, equally as likely regardless of distance/effort required
- 26%, more likely if no extra distance/effort required
- 8%, more likely even if extra distance/effort required

However, clear guidance on best practices for "green"/responsible food service operations is not available because the environmental impacts are not yet defined. Therefore, the efforts put forth by a restaurant may not have the environmental impact they and their customers hope for. As a result, Green Seal conducted a life cycle assessment (LCA) study with the goals to:

1. Determine the sources and priorities of environmental impacts from operations of restaurants and food services
2. Determine the opportunities for reducing the identified environmental impacts
3. Provide a scientific basis for the development of a sustainability standard for restaurant and food services, developed by Green Seal, that can serve as a comprehensive framework for food service operations to inform and focus their efforts in achieving environmental improvement and provide a basis for an ecolabel program (e.g., certification)

2 Methods

A cross section of restaurants was studied. This included six operations with different service styles, including catering, quick service, and full service operations that are open for one meal a day or up to three meals a day. The operations were located in the Chicago, IL metropolitan area and the Washington, DC metropolitan area in the USA. ISO 14044 was the key guide for methodology development. SimaPro LCA software was used to implement ISO 14044.

Scope The study scope covered the day-to-day activities of a restaurant or food service in the USA for a period throughout 2008, including direct and indirect aspects and excluding seasonal variation, the construction of the

building, packaging of purchased materials, and transportation (of staff and purchased materials). To apply LCA to food service operations, a model was developed to categorize the numerous operational activities of the food service into four subsystems in a farm-to-fork study, see Fig. 1:

1. Food procurement—the purchase of food and beverages (and related waste)
2. Food storage—energy used in storing food, beverages, and other products in the restaurant or food service (it did not include food)
3. Food preparation and cooking—energy used in preparing food, beverages, and other products at the restaurant or food service and water use (it did not include food)
4. Food service and operational support—energy used for lighting, heating, ventilation, and air conditioning, water use, supplies (restroom, cleaning, disposable products), and administrative support (paper)

These operational aspects were computed monthly, and the functional unit of the study was the operation of a restaurant or food service per month. This provided a common measure for the range of operations in the food service. An alternative functional unit that looked at per-customer or per-meal was not used since it is highly dependent on the type of operation (e.g., catering, quick service, cafeteria, and full service all have different customer and meal models).

Inventory Foreground data was collected with questionnaire data sheets completed by the food service operation

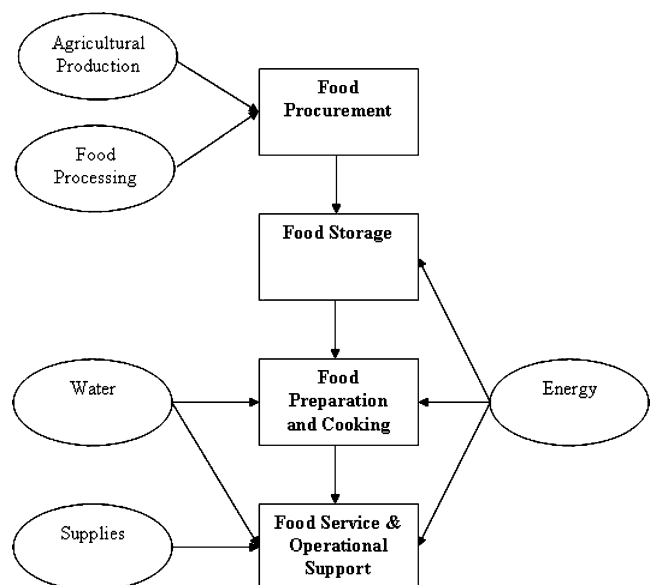


Fig. 1 System boundaries for the farm-to-fork LCA study of restaurants

representatives with supporting documentation (e.g., invoices). Telephone discussions and face-to-face interviews were held with operation representatives to supplement the questionnaire. Site visits of a few facilities were included for quality assurance purposes to check for data quality and consistency. The food and resource consumption data was averaged over 12 months to estimate the monthly profile of the food service inventory. For example, electricity use was 27,000 kWh, heat use (derived from natural gas) 400 GJ, and water use was 16.5 m³ per month. Food purchasing averaged \$60,000 per month for the operations studied. On a weight basis, the purchases typically comprised 45% fruits and vegetables, 10% meat, 4% beverages (on a solids basis), and the rest, processed or prepared foods. The supplies included disposable service products (e.g., utensils, plates, cups), preparation products (e.g., foil, gloves), cleaning products, restroom products, and office supplies.

For the background data, the life cycle inventory (LCI) data for food products was taken from the Dutch Food LCA database and Dutch and European Union Input Output data available in the SimaPro LCA software. The LCI data for energy use (US grid mix and heat from natural gas) and other ancillary materials was sourced from Ecoinvent. Utility audits were not part of this study and as a result, energy was allocated to the subsystems according to industry averages: 35% from cooking (included in the food preparation and cooking subsystem), 28% heating, ventilation, and air conditioning (included in the food service and operational support subsystem), 18% dishwashing (included in the food service and operational support subsystem), 13% lighting (included in the food preparation and cooking subsystem), and 6% refrigeration (included in the food storage subsystem; EPA—United States Environmental Protection Agency 2009a,b).

The data quality for the foreground data can be considered to range from good to very good. The energy and water use data was readily available through the utility bills and can be considered of very good quality. However, food purchase data was mostly reported in monetary units. Therefore, suitable conversion factors were applied to determine the equivalent weight of each food item. The conversion factors were estimated based upon consultation with relevant expert in the food service supply and distribution industry. The supporting background data from various databases is considered to be of excellent quality. In case suitable LCI data was not available for a particular material, then the 1% cutoff criterion on the basis of mass was applied. If the cutoff criterion was applicable, then the

particular material was excluded from the food service inventory. Otherwise, a suitable proxy was selected to represent the “cradle-to-gate” environmental burdens of the material.

Impact assessment The Eco-indicator 99 (Hierarchist perspective) methodology was used for the LCA impact assessment. This methodology includes impact categories such as respiratory inorganics, land use, fossil fuels, acidification and eutrophication, ecotoxicity, and climate change. The rationale for the selection of the impact assessment methodology and the included impact categories was the ability to communicate the life cycle impact assessment results to both technical and non-technical audience (Monte et al. 2005).

Normalization was conducted, as allowed according to ISO 14044, to help provide additional information about prioritizing sources of environmental impact and help understand the relative contribution of each impact category to the overall impacts and studying corresponding ways to reduce the impacts. The normalization was done as per the Eco-indicator 99(H) v 2.07 method included in the SimaPro LCA software and represents the damage caused by an average European citizen per year. The Eco-indicator 99 impact assessment methodology is a damage-oriented approach with human health, ecosystem quality, and resources as the three endpoint damage categories. The human health and ecosystem quality are given equal weighting (40% each) whereas resources are given 20% weighting in the normalization process.

Interpretation The model developed to establish the boundaries of the study was also used to analyze the data (see Fig. 1). In addition, several aspects within the model were studied to determine the significance of the findings (e.g., theoretical scenarios). For example, one of the scenarios tested included elements included in the Green Seal Standard for Restaurants and Food Services, GS-46, to understand potential impact reductions. Finally, the data quality was validated and sensitivity analysis was conducted on several elements throughout the study.

3 Results

The relative contribution of the subsystems in the restaurant and food service model to the total environmental impacts are presented in Table 1. The

food procurement subsystem was the leading source of four of the impact categories including land use (97.2%), respiratory inorganics (84%), acidification/eutrophication (65.1%), and climate change (52.6%). Service and operational support led the remaining three impact categories including carcinogens (69.9%), fossil fuels (60.1%), and ecotoxicity (79%). Table 1 also maps the environmental hotspots in the food procurement, food storage, food preparations, and operational support process subsystems. A life cycle stage is considered a hot spot in a given impact category if it contributes more than 10% to the total impact in the respective category. The procurement subsystem was a hot spot for all impact categories in this study. The food storage and food preparation and cooking subsystems did not contribute significantly to any of the impact categories examined.

Figure 2 demonstrates this predominance of the food procurement subsystem contributing to the total environmental impact. This is further noted upon normalization of the data, shown in Fig. 3. The distribution of total impacts in each of the four subsystems is shown in Fig. 4. With this analysis, food procurement was responsible for close to 95% of the total impacts. Figure 3 also highlights that the dominating impacts of restaurants were land use, respiratory inorganics, and fossil fuels.

Land use impacts were primarily from the production of food. Agriculture contributes to land use impacts through conversion of land for arable production and intensive farming. Significant effects of agriculture on the land use impacts include soil erosion, soil degradation, salinization, and desertification. In an LCA context, land use relates to the exclusive use of land for certain purposes and adapting the properties of land areas in view of these purposes. Several methods have been developed for the assessment of environmental impacts generated by land use and land use change (e.g., monitoring procedures, standards with principles, criteria, and indicators, environmental impact assessment, and LCA). These methods and tools face specific and shared problems regarding land use impact assessment. Among these, the selection and definition of relevant and measurable indicators seem to be one of the most persistent problems, as well as a lack of consensus on what exactly has to be assessed. As a result, there is uncertainty about the extent this impact may contribute overall to the total impacts.

Respiratory inorganic impacts primarily came from food production. The result was high amounts of particulates and, to a lesser extent, sulfur oxides, nitrogen oxides, ammonia, and nitrogen dioxide. Particulates are released into the atmosphere during

farming. Inorganic dust comes primarily from soil components and is dominated by silicates but may include significant concentrations of crystalline silica (Nieuwenhuijsen and Schenker 1999). Recent research has identified adverse respiratory effects of inorganic dust exposure in the agricultural workplace (Schenker 2000). Ammonia and nitrous oxide emissions are mainly associated with animal manure and nitrogen fertilizers (Bellarby et al. 2008). These emissions also contribute to climate change and acidification. Fertilizer use can be decreased with careful land management techniques such as organic farming, cover crops, and use of appropriate amount of fertilizer. Fossil fuel impacts were driven by energy use and plastic products in the operational support subsystem and food production in the procurement subsystem.

The trends identified in this aggregate study generally applied to all the individual operations studied. When each operation was studied, only one variance from the trend was noted despite the wide range of styles, size, and location of operations included in the study. The noted variance was in operations that purchased significant amounts of plastic products, namely disposable utensils and service items. In that situation, fossil fuel impacts were predominantly from plastic products rather than energy use. This also resulted in the total impacts being higher for plastic than energy, though still significantly lower than the impact from food. In this situation, the impact ranking was slightly different with land use, fossil fuels, and then respiratory inorganics (vs. land use, respiratory inorganics, followed by fossil fuels). This increase in fossil fuels also shifted the total impact from food procurement down to about 80% of the total impacts.

A sensitivity analysis of the land use impact showed that despite common variances/uncertainties with this impact category (noted above); reducing the impact category by 50% had no change in overall results—priority and source of impacts. A fossil fuel impact analysis, however, revealed that energy use and plastic product purchases/use could switch their ranking as a leading source of the impact. This result was also noted, as described above, in the individual operation assessments.

4 Discussion

When considering global environmental impact sources, the food supply plays a significant role. It is consistently ranked with buildings and transportation as the top three sources of global environmental impact (EC—European Commission 2006; EPA—United States Environmental Protection Agency 2009b). This is because the food supply is responsible for about 30% of the global greenhouse gases

Table 1 Environmental hot-spots in the food supplies, food storage, food preparations, and operational support process subsystems

	Procurement	Storage	Food preparation	Operational support
Carcinogens	23.9%	5.6%	0.6%	69.9%
Respiratory inorganics	84%	0.8%	1.4%	13.8%
Climate change	52.6%	2.5%	3.4%	41.6%
Ecotoxicity	13.6%	7.1%	0.2%	79%
Land use	97.2%	0.05%	0.8%	2.0%
Fossil fuels	32.5%	3.43%	4%	60.1%
Acidification/eutrophication	65.1%	3.4%	3.02%	30.1%

(Bellarby et al. 2008). The food supply also is the largest user of water worldwide with only 45% of the irrigation water effectively used (FAO—United Nations Food and Agriculture Organization 1995). The US Environmental Protection Agency estimates that 70% of river and stream pollution is caused by agriculture from chemicals, silt, and animal waste (EPA—United States Environmental Protection Agency 1998). Further, those chemicals polluting waterways include pesticides, herbicides, and fertilizers. Many pesticides have been linked to causing cancer and having endocrine disruptor activity and the two most commonly applied herbicides in the US are suspected endocrine disruptors (Horrihan et al. 2002). The Worldwatch Institute (Worldwatch 2004) estimates that 70% of the antibiotics used in the USA are used for livestock. The practice of feeding antibiotics to healthy animals promotes antibiotic resistance in bacteria that cause human infections (GGHC—Green Guide for Health Care 2007). As a result, the agricultural production stage of the food supply's life cycle typically drives food's environmental impact (Baldwin 2009; Roy et al. 2009). Given these significant impacts and the volumes of food purchased by restaurants

and food services, the results of this study are not surprising—food purchased by the operation is the predominate source of environmental impact of restaurants and food services. However, the industry commonly focuses on kitchen energy use when trying to green their operation. This may be a result of the potential cost savings that result from such measures and may be because there has not been a life cycle-based study like this one to clearly identify the impact sources.

With the impact sources identified as food purchases, energy use, and disposable plastic product purchases, practices to reduce such impacts were studied. These practices were included in a framework of a sustainability standard, the Green Seal Standard for Restaurants and Food Services, GS-46 (Green Seal 2009).

First, it is understood that food must be purchased/produced for the food service operation; however, there are ways to ensure that the impact is minimized by reducing wasted food and making more responsible food choices. Typically, 4–10% of food purchased at a food service operation is wasted before it reaches the customer (LeanPath 2008). In this study, it was found that food waste was on the lower end of that range, with one facility only wasting 3% of the food purchased before it reached the consumer. In addition, diners leave about 17% of their

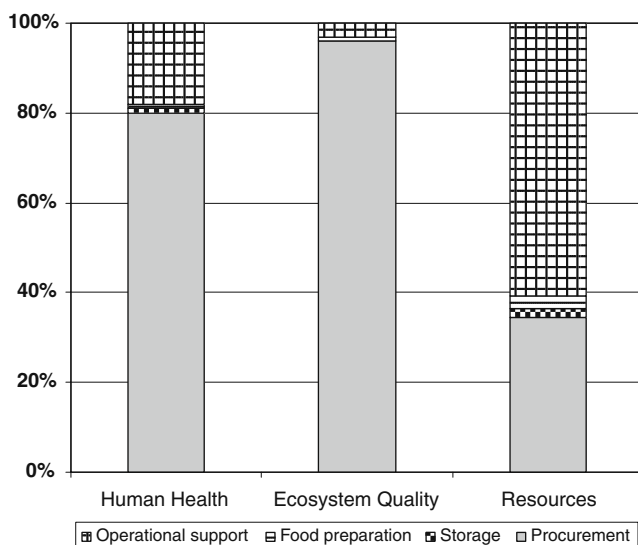


Fig. 2 Impacts of the operations of the food service model to human health, ecosystem quality, and resources

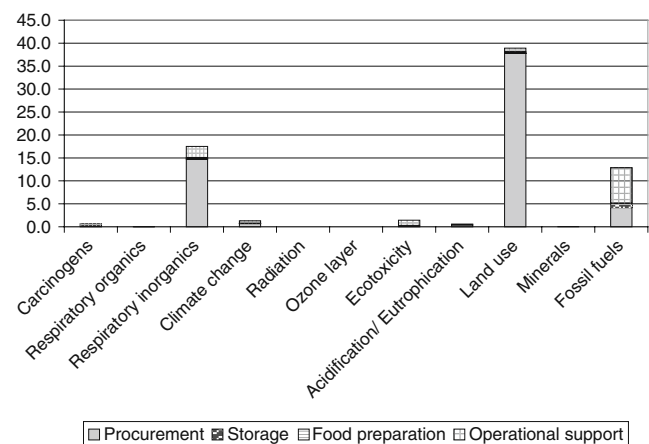


Fig. 3 Graphical demonstration of the relative percentage of environmental impacts of baseline scenario and 7% reduction in energy use scenario

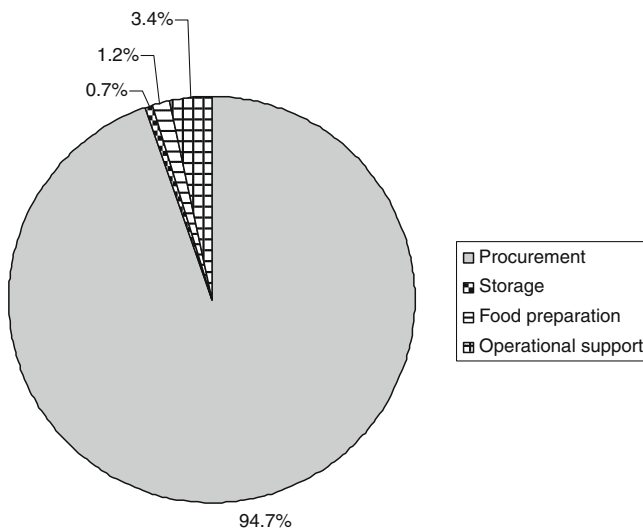


Fig. 4 Pie chart of relative contribution of the impact categories to the total environmental impacts (normalized results)

meals uneaten (Bloom 2010). While waste audits were not conducted as part of this study to identify specific sources of waste, if they were conducted, specific opportunities to reduce waste may be found such as through better forecasting, reducing trim waste (yield testing can help manage this), better portioning, improved ordering practices, and specification optimization (Green Seal 2008, Gossling et al. 2010). When an operation implements an effective waste tracking system and taking actions to reduce such waste, it can reduce the amount of food purchased by 7% (LeanPath, personal communication on 6 August 2010 with Andrew Shakman, President of LeanPath Inc). Figure 5 demonstrates how this management technique can reduce the total environmental impacts. As a result, the GS-46 standard requires waste auditing and waste management plans to enable this reduction of environmental impact. Further, this requirement can save an operation significant money. In the operations included in this study, there was a potential to save about \$50,000 per year, each (based on the average of food procurement in the study). In addition to reducing wasted food, making different choices on food purchased can reduce the environmental impact. This can be achieved by purchasing responsibly grown options, such as those with reduced fertilizer and other inputs (e.g., organic), less tillage, and well-managed grazing (Bellarby et al. 2008; Cederberg 2003). Figure 6 shows the reduction in environmental impacts made by replacing 25% of total food purchased with organic options. This type of change does not require changes in the menu, but it will likely add to the cost of the food. For example, in this study the operations may see an increase of up to \$50,000 per year (assuming an upcharge of, on average, 30% for the 25% of food replaced (IBIS World 2009)). Cost may be lower with seasonal and local options. Also, typically such a cost increase is added to the price of

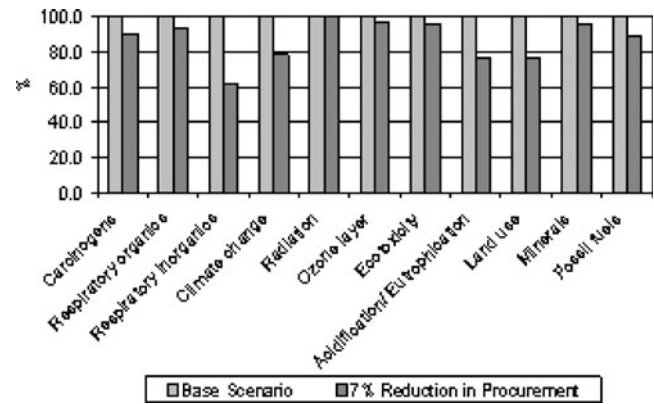


Fig. 5 Graphical demonstration of the relative percentage of environmental impacts of baseline scenario and 7% reduction in procurement scenario

the food items the customer pays. This, however, may not need to be done since an equivalent amount can be saved with reduction in wasted food. As a result, the GS-46 standard includes a requirement for a minimum of 25% of food purchased to be from responsibly grown sources. Another approach to reduce the environmental impact from food choices is to reduce meat purchases. Meat production is the leading source of environmental impact compared to other foods (Mogensen et al. 2009, Gossling et al. 2010). Table 2 shows the greenhouse gas intensities of different food items and how meat typically ranks much higher than other food items (Gossling et al. 2010). Meals with less meat (regardless of field or greenhouse grown) have been found to have less environmental impact (Mogensen et al. 2009). However, meals with field-grown vegetables have lower impacts than those grown in heated greenhouses (Mogensen et al. 2009). Figure 7 shows how a reduction in total meat purchased can decrease environmental impacts. Such a reduction can be achieved with portion size adjustments or a replacement of an entrée. Of meat sources, red meat has been shown to have the largest environmental impacts (Mogensen et al. 2009).

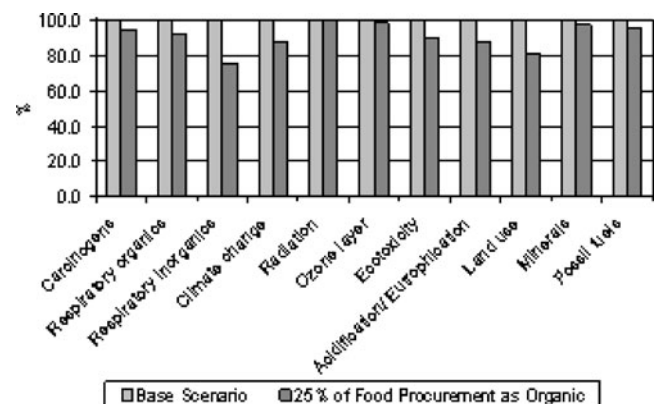


Fig. 6 Graphical demonstration of the relative percentage of environmental impacts of baseline scenario and 25% of food procurement as organic

Table 2 Greenhouse gas intensity of various foods on farm (adapted from Gossling et al. 2010)

	kg CO ₂ -e/kg ^a	kg CO ₂ -e/1,000 kcal ^a
Carrots	0.036–0.234	0.112–0.730
Onions	0.060–0.382	0.201–1.28
Potatoes	0.073–0.274	0.114–0.464
Tomatoes	0.082	0.456
Tomatoes, heated greenhouse	1.30–28.5	7.20–158
Wheat	0.180–0.710	0.0157–0.225
Rice	4.55	1.25
Chicken	1.35–8.17	1.25–7.6
Pork	3.75–8.80	1.10–3.50
Beef	11.6–29.0	7.40–16.1

^a Expressed as ranges published by Gossling et al. (2010)

As a result, the GS-46 standard includes encouragement for a progressive reduction of red meat purchased. Other studies have shown that additional considerations for responsible food choices are the distance and mode of distribution of the food, as well as the production yield and seasonality (Gossling et al. 2010). For example, boat and train distribution is generally more efficient than trucks. Air transit of food is the least efficient option, and thus, should not be used. Further, the number of trips or delivery vehicles makes a difference: there is efficiency in scale (Gossling et al. 2010). These considerations were not included in the study due to the limited availability of such information to the operations. Further, they were not mandatory requirements in the GS-46 standard, but credit is provided for those working to improve these attributes.

Energy use within a food service operation ranges. It has been estimated that 35% of energy use is from cooking, 28% heating, ventilation and air conditioning, 18% dishwashing, 13% lighting, and 6% from refrigeration (EPA—United States Environmental Protection Agency 2009a, b). Food service operations comprise 7% of all commercial building energy use in the USA (DOE—United States Department of Transporta-

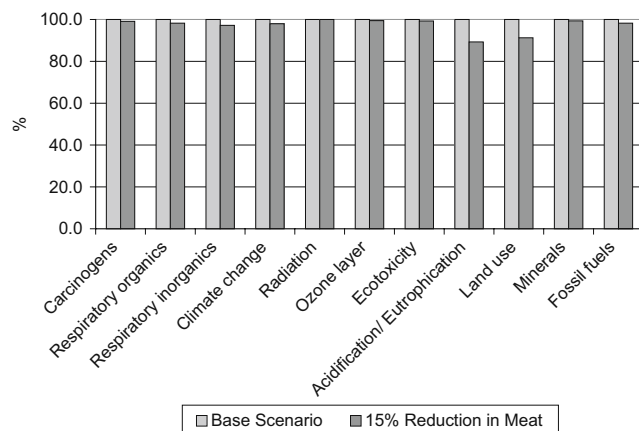


Fig. 7 Graphical demonstration of the relative percentage of environmental impacts of baseline scenario and 15% reduction in meat purchased scenario

tion 2003). While this is less than 1% of total energy used in the USA (and typically a small component of total operational costs), food service operations are the most intensive energy users in the commercial sector in terms of BTUs per square foot (DOE—United States Department of Energy 2003). Further, electricity costs have been steadily increasing for the last 10 years (EIA—United States Energy Information Administration 2007, DOE—United States Department of Energy 2001). As a result, careful energy management is an important practice and all areas of energy use have potential for conservation. Energy management begins with tracking of energy use and includes energy use planning (only having equipment on when in use), proper maintenance of energy using devices and equipment, and use of energy-efficient devices and equipment. Such measures can result in significant energy conservation results. For example, proper maintenance of the heating, ventilation, and air condition system can reduce that energy demand by 15–20% (equating to about 4–6% total energy savings in a food service operation; Piper 2009). Additional simple actions like reducing idle times for equipment can further reduce energy needs (EPA—United States Environmental Protection Agency 2009a, b). Figure 8 shows how a 7% reduction in energy use decreases the

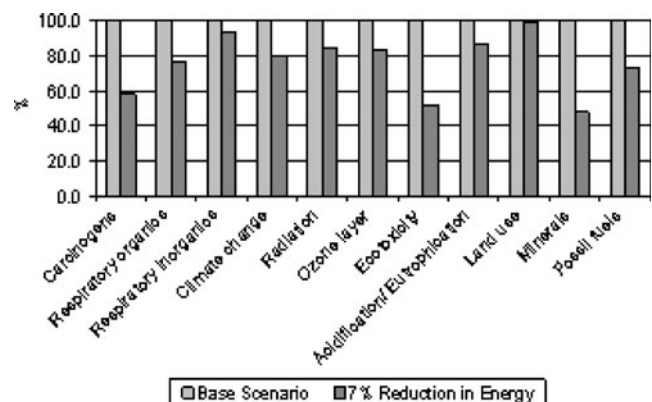


Fig. 8 Graphical demonstration of the relative percentage of environmental impacts of baseline scenario and 7% reduction in energy use scenario

Table 3 Highlights of the green seal standard for restaurants and food services, GS-46

Responsible food purchases	Minimum requirements for food purchases from environmentally responsible sources
Energy and water conservation and management	Energy and water auditing and management practices, minimum amount of energy conservation performance
Waste reduction and management	Waste auditing and management practices to reduce waste, composting, recycling, environmentally responsible disposable product practices
Supplies and operational support	Environmentally responsible cleaning and paper products
Management	Management plan, operating procedures, training

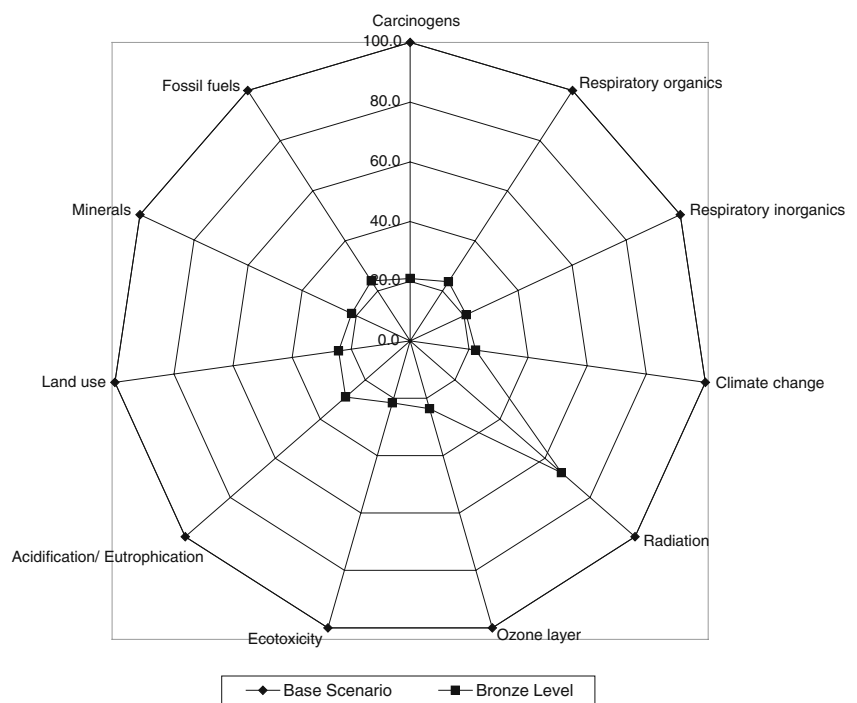
environmental impact of an operation. Since energy use costs the operation money, it was found that energy conservation could result in a saving of at least \$5,000 in the operations in this study. As a result, the GS-46 standard includes requirements for energy management and conservation.

Plastic disposal products are used for sanitary and convenience in food services. As a result, complete replacement with reusable options is neither necessarily feasible nor preferable. There are options to reduce the impact of such products, however. This can be done by controlling the dispensing of the products to reduce wasted products or by using more preferable options (e.g., lightweighted, recycled content, recyclable, or compostable). The GS-46 standard includes these approaches to reducing such impacts.

In addition to including the leading sources of environmental impacts of food, energy, and waste described above in the GS-46 standard, other means to reduce and support such reduction are included. These include organizational plans and goals for environmental improvement, socially

and environmentally responsible purchasing, employee training, and continuous improvement. Such efforts make sure the focus on environmental improvement sustains over time and institutionalizes the commitment. Table 3 includes an overview of the GS-46 standard. The GS-46 standard is organized to provide three levels of recognition for restaurants and food services: bronze (entry), silver, and gold (the highest). Bronze recognition includes the requirements discussed above (e.g., 25% of food purchased from responsible sources, 7% food waste reduction, and 7% energy savings). However, achieving the full 15% reduction of red meat is not required at the bronze, entry level (it is required for silver and gold certification), in order to provide time for the adjustment in the menu. Since all operations may not have high impacts from plastics, the possible reductions may vary for each facility; neither of these two requirements was included in the summary analysis of bronze certification, as shown in Fig. 9. The bronze certification resulted in a 76.8% reduction in total impacts (determined by comparing normalized results).

Fig. 9 Spider plot of base scenario and reduced impacts included in GS-46 bronze level of certification



This same level of reduced impacts was noted for greenhouse gases (78%) calculated using CO₂, CH₄, and N₂O equivalences. For the restaurants in this study, the GHG reduction was 80.9 t of CO₂ eq. annually, the amount of GHG from 13.4 passenger vehicles (EPA—United States Environmental Protection Agency 2010). The GS-46 standard includes additional requirements not included in the discussion above that may further decrease a food service operation's environmental impact without adding to operating costs.

5 Conclusions

This study presents an overview of the main environmental impacts from the operation of a restaurant or food service in the USA. Normalized results showed that the most dominating impact categories were land use, respiratory inorganics, and fossil fuels. The results further indicated that the food purchases of a restaurant or food service are the largest source of environmental impact. These impacts can be reduced, despite them coming from indirect sources/upstream of the food service operation. The environmental impacts also came from, though to a much lesser extent, energy use and plastic disposable product use. With the sources of the impacts identified, ways to reduce these impacts were outlined and confirmed with additional LCA study. With this information, a sustainability standard was developed to provide guidance to restaurants and food services on effective ways to reduce environmental impacts and be able to recognize those with such achievements. The Green Seal Standard for Restaurants and Food Services, GS-46, includes requirements that reduce each of the major environmental impacts. In addition, this proven environmental impact reduction can be done without added cost (e.g., cost neutral, with potential for financial gains).

References

- Baldwin C (2009) Sustainability in the food industry. Wiley-Blackwell, Ames
- Bellarby J et al. (2008) Cool farming: climate impacts of agriculture and mitigating potential: published by Greenpeace
- Bloom J (2010). American wasteland: how America throws away nearly half of its food (and what we can do about it). Da Capo Lifelong Books. Cambridge
- BLS—United States Bureau of Labor Statistics (2010). Consumer expenditures in 2008. Accessed 4 August 2010. <http://www.bls.gov/cex/csxann08.pdf>
- Cederberg C (2003) In: Mattsson B, Sonesson U (eds) Life cycle assessment of animal products in environmentally friendly food processing. Woodhead Publishing Limited, Cambridge
- DOE—United States Department of Energy (2001) A look at commercial buildings in 1995: characteristics, energy consumption, and energy expenditures
- DOE—United States Department of Energy (2003) Commercial building energy consumption survey. Accessed 4 August 2010. <http://www.eia.doe.gov/emeu/cbeecs/>
- EC—European Commission (2006). Environmental Impact of Products (EIPRO): analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Accessed 4 August 2010. http://ec.europa.eu/environment/ipp/pdf/eipro_report.pdf
- EIA—United States Energy Information Administration (2007). Average retail price of electricity to ultimate customers by end-use sector. Last accessed 4 October 2008. <http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html>
- EPA—United States Environmental Protection Agency (1998). Reducing water pollution from animal feeding operations. Testimony before subcommittee on Forestry, Resource Conservation, and Research of the Committee on Agriculture, U.S. House of Representatives, 13 May 1998. Accessed 30 September 2008. http://www.epa.gov/ocirpage/hearings/testimony/105_1997_1998/051398.htm
- EPA—United States Environmental Protection Agency (2009a). Energy star guide for restaurants. Accessed 4 August 2010. http://www.energystar.gov/ia/business/small_business/restaurants_guide.pdf
- EPA—United States Environmental Protection Agency (2009b). Sustainable materials management: the road ahead appendix relative ranking technical support document. Accessed 4 August 2010. <http://www.epa.gov/waste/inforesources/pubs/vision2-app.pdf>
- EPA—United States Environmental Protection Agency (2010) Greenhouse gas equivalencies calculator. Accessed 4 August 2010. <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>
- FAO—United Nations Food and Agriculture Organization (1995) Water: a finite resource in dimensions of need: an Atlas of food and agriculture. Rome. Accessed 3 October 2008 <http://www.fao.org/docrep/u8480e/U8480E0c.htm#Irrigation>
- GGHC—Green Guide for Health Care (2007). Technical brief environmentally preferable purchasing: food. Accessed 30 September 2008. http://www.gghc.org/PilotDocsPub//GGHC%20Tech%20Briefs/GGHC_TechBrief_Food_080627.pdf
- Gossling S et al. (2010). Food management in tourism: reducing tourism's carbon footprint. Tourism Management. doi:10.1016/j.tourman.2010.04.006
- Green Seal (2008). Green Seal Proposed Environmental Standard for Restaurants and Food Services, GS-46, Background Document. Accessed 6 August 2010. http://www.greenseal.org/certification/gs-46_restaurants_and_food_service_proposed_standard_back_ground_document.pdf
- Green Seal (2009) Environmental leadership standard for restaurants and food services, GS-46.
- Horrihan L, Lawrence R, Walker P (2002) How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environ Health Perspect 110 (5):445–456
- LeanPath (2008) A short guide to food waste management best practices
- Mogensen L et al (2009) Life cycle assessment across the food supply chain: chapter 5. In: Baldwin C (ed) Sustainability in the food industry. Wiley-Blackwell, Ames
- Monte MD, Padoano E, Pozzetto D (2005) Alternative coffee packaging: an analysis from a life cycle point of view. J Food Eng 66:405–411

- National Restaurant Association (NRA) (2008) 2009 Restaurant Industry Forecast.
- Nieuwenhuijsen M, Schenker M (1999) Personal exposure to dust, endotoxin and crystalline silica in California agriculture. *Ann Occup Hyg* 43:35–42
- Piper J (2009) HVAC Maintenance and Energy Savings. *Facilitiesnet*. Accessed 4 August 2010. <http://www.facilitiesnet.com/hvac/article/HVAC-Maintenance-and-Energy-Savings—10680>
- Roy P et al (2009) A review of life cycle assessment (LCA) on some food products. *J Food Eng* 90:1–10
- SCA (2009) Green buying remains strong during down economy.
- Schenker M (2000) Exposures and health effects from inorganic agricultural dusts. *Occupational and Environmental Lung Diseases Env Hlth Persp* 108(Suppl 4):661–664
- Schenker M (2008) Respiratory health hazards in agriculture. *Am J Respir Crit Care Med* 158:S1–S76
- IBIS World (2009) The cost of America's groceries press release.
- Worldwatch Institute (2004). Good stuff: a behind-the-scenes guide to the things we buy. Accessed 3 October 2008. <http://www.worldwatch.org/system/files/GS0000.pdf>