Feeding a Hungry World:

The Role of the Global Cold Chain

World Cold Chain Summit to Reduce Food Waste
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Prepared by United Technologies Building & Industrial Systems

Food loss and the cold chain

Of the more than 7 billion people living on Earth, some 842 million are chronically undernourished. That means a population nearly equivalent to the European Union and United States *combined* goes hungry each day. What is more, estimates are that nearly one-third of the edible food produced never reaches the human stomach.

By 2050 the world's population is expected to swell to 9.6 billion inhabitants. Proactive, concerted steps are required to address the problems of hunger and poverty.

The global community is responding in a wide variety of ways. Government, not-for-profit and commercial entities, often in collaboration, have launched initiatives ranging from improved farming and harvest practices to programs emphasizing retail and consumer education.

One of the most powerful tools available to government and industry in addressing the problem of hunger is the *cold chain*—a seamless and interconnected global network that includes marine container refrigeration, truck and trailer refrigeration, cold storage and food retail refrigeration designed to preserve and extend food supplies.

For a century the cold chain has improved the *world's standard of living by preserving and* protecting perishable food during its journey from farm to store. Technologies exist today that can expand the reach, effectiveness and sustainability of the cold chain in ways that will dramatically improve food safety and reduce global food loss. One industry observer has concluded that "the greatest potential for food loss reduction involves market-led, large-scale investment in agricultural infrastructure, technological skills, storage transport and distribution."

Where the cold chain exists today it can be improved; where it is still nascent it can be expanded; where it does not exist it can be built to extend food to people that need it. In all cases, investment in an integrated network of temperature-controlled space can have a profound impact on reducing food loss and feeding a hungry world.

Where Does All the Good Food Go?

Today the world produces about 4 billion metric tons of food per year. Due to inefficiencies in harvesting, inadequate resources for storage and cooling, and wasteful retail and consumer practices, estimates are that approximately 1.3 billion metric tons of the edible part of food is never consumed.

A common set of terms has been developed that help define this problem more precisely. *Food waste* refers to product that is lost to behavioral issues, including food that is over-bought, overcooked, over-served, mislabeled or expired. Anyone who has eaten only a portion of a restaurant meal or discovered blackened vegetables in the bottom of a refrigerated vegetable drawer understands the concept of food waste. Consumer, food service, retailer and government behavior also influences food waste

when harvesting practices dictate that nutritionally sound but cosmetically imperfect produce is left in the fields and warehouses or on the grocery shelves to be discarded.

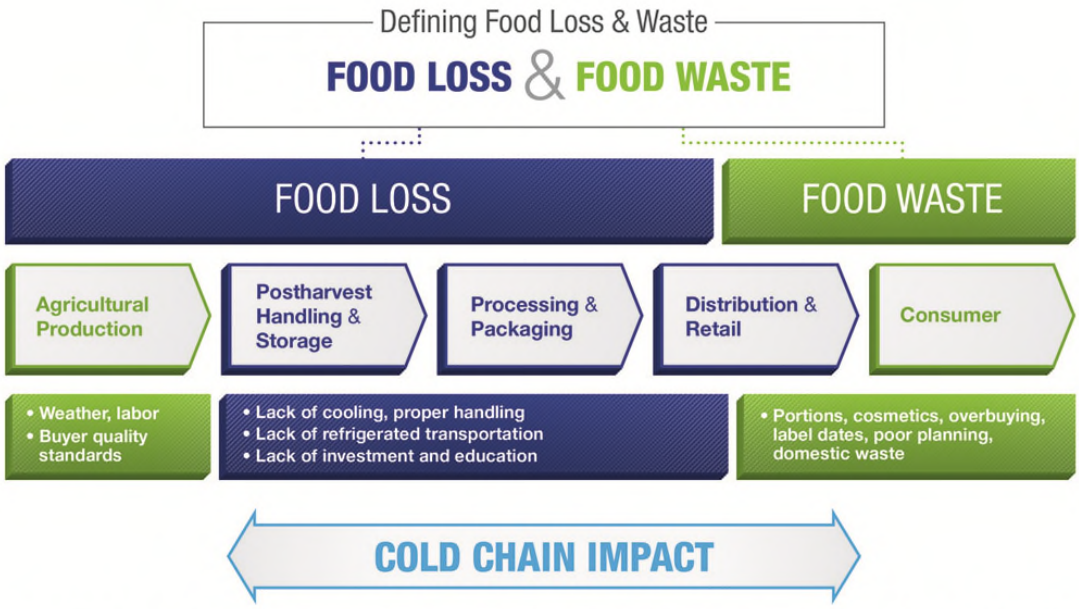
By contrast, *food loss* refers to a decrease in food available for human consumption due to food quantity or quality. Food loss is caused by inefficiencies in food supply chains—often a function of inadequate investment in cooling technology and infrastructure (including power grids and roads), lack of expertise, failure to follow best practices, and poor coordination among players along the supply chain.

Food loss can be reduced substantially by the global cold chain.

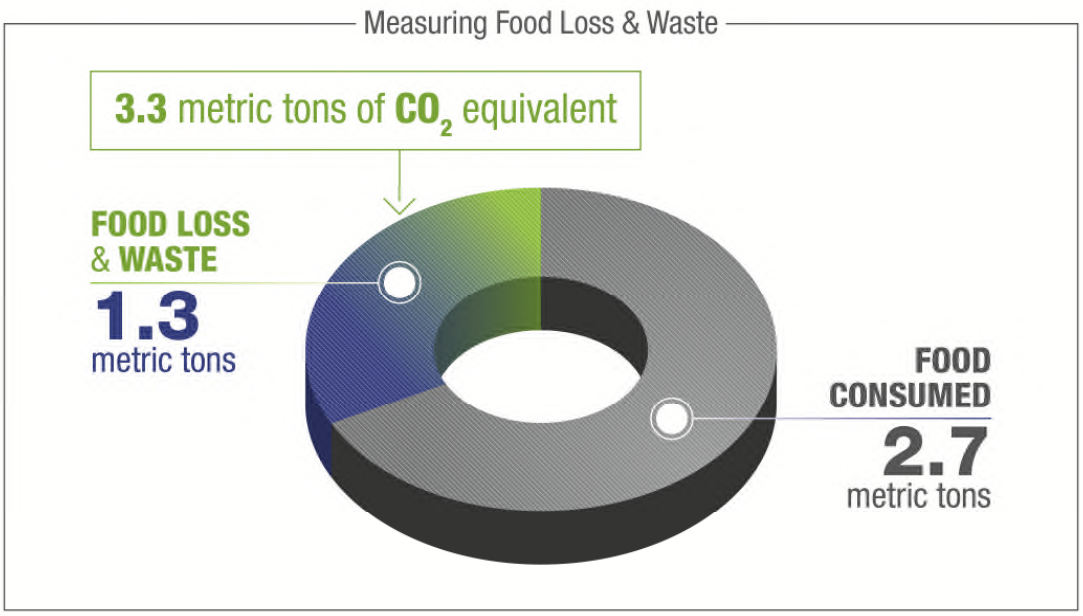
In addition to the social cost, food loss and waste have considerable environmental impact, particularly with regard to climate change.

The carbon footprint of food loss and waste – which includes the energy used in production, processing, packaging and more – is estimated to be 3.3 billion metric tons of CO_2 equivalent, making it the third largest emitter of carbon dioxide (CO_2) after China and the United States.

The pressure on natural resources dedicated to producing food that nobody will ever eat is immense, occupying 30 percent of the world's agriculture area and costing $750 billion (USD) annually. The United Nation's Food and



Sources: NRDC, *Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill*, 2012; Joint Food Wastage Declaration, *Every Crumb Counts*, 2013; FAO, *Food Wastage Footprint: Impacts on Natural Resources*, 2013.



Sources: FAO, *Food Wastage Footprint: Impacts on Natural Resources*, 2013; The High Level Panel of Experts on Food Security and Nutrition, *Food Losses and Waste in the Context of Sustainable Food Systems*, 2014.

Agriculture Organization states that "Food wastage [the sum of food loss and waste] reduction would not only avoid pressure on scarce natural resources but also decrease the need to raise food production by 60 percent in order to meet the 2050 population demand."

Rapidly growing economies are often hardest hit by food loss. India, for example, loses as much as 50 percent of all its perishable food due to inadequate cooling and handling. Of all fresh fruits and vegetables produced globally, as much as one-third are lost before reaching consumers. "The way we farm, harvest, store, transport, process, distribute and consume food," the Institution of Mechanical Engineers has concluded, "will be a major determinant in the outcome of our well-being in the 21st century."

The Modern Global Cold Chain

A robust global cold chain is pivotal in meeting this challenge.

In fact, in much of the developed world the cold chain has been so effective for so long that it is taken for granted. It was not until the early 20th century that the first mechanically-refrigerated vessels designed to maintain the shelf-life of bananas from the tropics to northern ports were introduced. Today, bananas account for the contents of 20 percent of all seaborne refrigerated containers.

By 2000, some 550,000 marine containers transported food throughout the world to approximately 1.2 million refrigerated road vehicles. Today, the modern cold chain protects everything from vaccines to industrial composites, while still transporting the average piece of American produce 1,500 miles from field to point of sale.

In parts of the world where the cold chain is established and effectively run, perishable food loss can be maintained as low as two percent.

The cold chain preserves not just food, but particularly nutritious food. One study suggests that after its widespread adoption in the United States in the 20th century, refrigeration increased people's food intake by 5,500 calories and 400 grams of protein per capita per year. We now understand that as income in a country grows, the consumption of starchy foods declines in favor of produce, meat, fish and dairy. These foods are dependent on a smoothly functioning cold chain. "No other processing technology combines the ability to extend product shelf life and in parallel maintain the initial physical, chemical, nutritional and sensory properties desired by consumers to the same extent as refrigeration," a report by the International Institute of Refrigeration (IIR) concluded in 2009. "Greater use of refrigeration technologies would ensure better worldwide nutrition, in terms of both quantity and quality."

Consequently, the modern cold chain is not just a collection of cooling technologies that preserve perishable products, but an intensive, value-added process that seeks to extend shelf life, protect the safety and integrity of products, reduce food loss, and enhance global *food security*—the promise of access to sufficient, safe and nutritious food to maintain an active and healthy life.

As the cold chain grows, so too have technologies to reduce the environmental footprint. Advancements have been made in non-ozone depleting/low global warming refrigerants, fuel reduction savings for road transportation systems, energy savings measures, and more recyclable materials.

The reach and impact of the modern cold chain is extraordinary but uneven. In the United States, 70 percent of all the food consumed each year passes through the cold chain. In a rapidly developing nation like China, the equivalent number is 25 percent for beef and 5 percent for produce. In places like Latin America, supermarkets have grown segment share from as low as 10 percent to a current 60 percent, requiring massive and rapid improvements in the cold chain. In parts of the world like sub-Saharan Africa, the installation of basic cold chain practices is hindered by poor roads or lack of electricity. The uneven implementation of cold chain technologies has a pronounced impact on food loss.

The IIR estimates that around 360 million metric tons of perishable foods are lost each year through insufficient use of refrigeration alone. "Thus, in theory," the report states, "if developing countries could acquire the same level of refrigerated equipment as that in industrialized countries, over 200 million metric tons of perishable food would be preserved," or about 14 percent of the current consumption in these countries.

A complicating factor is the rapid growth of urban areas around the world. Where just 17 percent of the world's population lived in cities in 1950, more than half do today. By 2050, the global urban population is expected to grow to 75 percent, one of the great social transformations in human history. This will have the unintended consequence of stretching the distance between urban consumers and areas of food growth and processing. Reliance on an effective cold chain will become ever greater.

Food safety standards have been driving development of the global cold chain and have a greater role to play in emerging economies. A committee of the UN has suggested that "clear linkages among food safety authorities is required at the international level" as a way of promoting the integrity of the global food supply chain. The European Union has in place legislation that requires cold chain transport vehicles "where necessary. . . to be capable of maintaining foodstuffs at appropriate temperatures and allow those temperatures to be monitored." In 2011, the European Commission set a target to reduce food wastage by 50 percent in 2020, including improved logistics. Regulatory pressure on the cold chain is being driven in the United States by the Food Safety Modernization Act (FSMA), signed into law in January 2011. The language on contamination and cold chain, while still under review, envisions the upgrade of transportation equipment used in the distribution of perishable foods to halt the rapid growth of undesirable microorganisms (e.g. salmonella, listeria).

A senior advisor in the Food and Drug Administration's Center for Food Safety and Nutrition remarked, the FSMA "reflects our understanding that we have one highly integrated food safety system. So we don't have a separate system for domestic and foreign foods. We don't have a separate system for human food and animal food, and, instead, we have this single system."

Regulations are advancing around the world. A new amendment to China's Food Safety Law has been proposed to include "stronger regulation of their internal operations and supply chains" and stronger monitoring by government agencies. One analyst believes that this could "bring a rigor to China's food regulatory system that has traditionally been associated with regulation of drugs and medical devices." In October 2013, India's Supreme Court took the remarkable stand of declaring a constitutional right to unadulterated food, directing the Food and Safety Standards Authority in India to "gear up their resources" and "conduct periodical inspections and monitoring of major fruits and vegetable markets." This emphasis on food safety followed the 2012 establishment of the National Centre for Cold Chain Development by India's government. The Centre works in close collaboration with industry and other stakeholders to promote and develop an integrated cold chain in India for perishable fruits, vegetables and other agricultural commodities to reduce wastages and improve the gains to farmers and consumers.

It is clear that cold chain technologies exist to address the complex problems of inadequate food safety. These technologies are now more critical than ever, as the world's population grows to 9 billion by mid-century.

The Role of United Technologies

United Technologies (UTC) is one of the primary builders and caretakers of the modern cold chain through its UTC Building & Industrial Systems brands Carrier Transicold, Carrier Commercial Refrigeration, and Sensitech.

Today, 52 percent of world seaborne trade is delivered by container vessel, and 65 percent of refrigerated products are transported in containers, the majority of which are supplied by Carrier Transicold. On any given day, Carrier-refrigerated marine containers carry goods valued at $6 billion. In 2014 Carrier Transicold celebrated the sale of its 1 millionth container refrigeration unit, forty-six years after pioneering the first front-wall, or "picture-frame," refrigeration unit.

Transicold also helps improve global transport and shipping of temperature-controlled cargoes with a complete line of equipment for refrigerated trucks and trailers. Recent innovations include Thin-Film Flexible Solar Panels using solar energy to charge transport refrigeration unit batteries, and the Vector™ 8100 all-electric trailer refrigeration unit for stationary cold storage, which provides quiet electric operation without the noise, emissions and fuel consumption associated with diesel-powered units.

Reducing the environmental footprint of the cold chain is a priority of UTC Building & Industrial Systems. Recently, Carrier Transicold introduced NaturaLINE™, the world's first refrigeration unit for marine container applications that uses carbon dioxide as its refrigerant, enabling it to reduce climate impact by 35 percent, compared with previous systems. Carrier has also pioneered carbon dioxide as a refrigerant for supermarket refrigeration with its CO_2OLtec® system operating in nearly 1,100 supermarkets across Europe. UTC is exploring how it can use this technology in truck and trailer refrigeration applications. Carrier Transicold's PrimeLINE unit achieved a new distinction in sustainability, becoming the first container refrigeration system with a UL Environment validation for recyclability of 93 percent. Other potential future innovations being explored by the transport and cold chain industry include hydrogen-powered refrigeration units and greater use of electric delivery trucks.

With a footprint in more than 20 countries throughout Europe and a significant presence in the Middle East and Asia, Carrier Commercial Refrigeration is a leading supplier of high-efficiency turnkey refrigeration systems and services in the food retail industry. By focusing on the latest merchandising trends and customer needs, Carrier is able to offer a comprehensive portfolio of next-generation refrigerated cabinets, freezers, counters, systems and controls that maximize

merchandising opportunities while reducing energy consumption and operating costs. A 2014 survey by shecco among food retailers located in western and northern Europe indicated a doubling of uptake of natural refrigerant technology in the last two years alone. This, along with the introduction of European regulations forcing the phase-out of traditional, high global warming refrigerants by 2022, could indicate a “tipping point” for the mainstream adoption of sustainable refrigeration solutions.

For more than 20 years, Sensitech has focused exclusively on the cold chain, supporting global temperature monitoring programs for more than 7,500 food suppliers, including 150 of the world’s largest food service and supermarket establishments. Its Cold Chain Logistical Services combine electronic temperature monitoring, data management, analysis and reporting to ensure the quality and shelf-life of perishable products throughout the global cold chain.

UTC Building & Industrial Systems’ mission is to play a leading role in achieving reductions in global food waste by developing new technology, convening experts in the discussion, and supporting research to transform the way food is safely transported, preserved and distributed. Its vision is to extend the food supply by improving cold chain practices to help to feed a growing global population. “With renewed discipline, proper education and cooperation from key players at all levels,” says David Appel, president of Carrier Transicold & Refrigeration Systems, “food loss in the cold chain can largely be eliminated to the point of having little or no impact on feeding a growing global population.”

In November 2014 Carrier convened its inaugural “World Cold Chain Summit to Reduce Food Waste” in London, bringing together global leaders in academia, government and business to discuss food waste in emerging and developed economies. Participants helped identify actions needed to accelerate progress in cold chain technology and policy development.

Focus and investment by the public sector, and investment and innovation by the private will not only extend the cold chain around the globe, but ensure its sustainability for future generations.

For a century the cold chain has preserved and protected food. Now, a wide variety of existing, new and customized applications are available to extend its reach in both developed and developing economies around the globe.

John Mandyck, Chief Sustainability Officer, United Technologies Building & Industrial Systems, has concluded, “The cold chain is an essential strategy to extend food supplies, feed a growing planet and tackle climate emissions associated with food waste. We can meet the food needs of a 9 billion person planet with a simple equation—waste less, feed more—with substantial benefits to the natural environment.”