

How agricultural rendering supports sustainability and assists livestock's ability to contribute more than just food

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Implications

- Consumers are widely unaware of how agriculture and livestock produce more than just food and rendering prevents waste in animal production systems by utilizing nearly all by-products from the production of meat.
- Rendering is highly sustainable; “*Rendering is Recycling/Upcycling*” and supports the three pillars of sustainability (Environmental, Social, Economic).
- Rendering is essential in producing sustainable animal feed ingredients and pet food as well as many nonfood products consumers use every day.
- Extending the utilization of rendered products in animal food would improve sustainability across the board.
- Rendering directly supports environmental sustainability by utilizing by-products that would otherwise be treated as food waste, thus diverting it from landfills and even less desirable disposal options.

Key words: animal feed ingredients, biofuels, pet food, rendering, sustainability, upcycling

What Is (Agricultural) Rendering?

For clarity, agricultural rendering will be referred to as “rendering” throughout this article.

Render, from the French verb *rendre*, meaning “to give back,” is the act of processing and cooking undesired, or uneaten livestock and poultry meat (and used cooking oil [UCO]) that remains after a meat animal has been slaughtered and the

meat used for consumption has been harvested. Rendering then safely and hygienically processes it to create new products so nothing is wasted. Renderers upcycle that unused material (fat, protein, feathers, bone, etc.) for new, secondary uses (Meeker and Hamilton, 2006; Figure 1).

Rendering has existed for centuries and is one of the oldest “recycling” practices. That is why it is often said rendering is “recycling” as the rendering process “gives back” in the form of new, high value, rendered goods (Meeker, 2020), while additionally returning resources to the environment in the form of water recovery and reclamation, saved landfill space and reduced greenhouse gas (GHG) emissions.

At its start, rendering was used primarily for soap and candle making, mostly done in a kettle over an open fire. Further developments to the rendering process came in the 19th century enabling family owned, small renderers and packers to produce both edible and inedible products (Meeker, 2020).

Many meat eaters in North America consider roughly 50% of a meat animal to be “inedible,” leaving a large amount of material left over (NARA, 2020). Rendering reclaims this otherwise wasted food (protein, bone, fat, etc.), as well as UCO from restaurants, and transforms it into ingredients for countless new goods-upcycling most of this unwanted meat from slaughter and processing into things like animal feed ingredients, safe and nutritious pet food, beauty, household and industrial products, biofuels, and many more useful and common goods.

Instead of wasting these leftovers through other disposal methods, renderers in the United States and Canada recycle the materials into 15.7 million tons of fat, oil, and protein products annually (NARA, 2020). Doing this not only creates alternative, sustainable fuels to power trucks, trains, water vessels, and other vehicles but also nutritiously feeds cattle, hogs, turkeys, chickens, household pets, and other animals.

As a result, huge volumes of meat leftovers and UCO are kept out of landfills, resulting in a net reduction of carbon emissions, a substantial GHG reduction, reduced food waste and saved landfill space. Renderers and those in the rendering industry play an important role in reducing food waste, sustainably recycling valuable agricultural resources, and positively

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Figure 1. Offal.

contributing to local, state, national, and international economies (NARA, 2020).

Safety and Regulation

Safety practices in the processing of rendered material are of utmost importance. Renderers have quality and safety control systems in place with voluntary programs such as the Rendering Industry Code of Practice (NARA, 2017) designed to foresee hazards that could occur, and prevent them. Each rendering plant develops its own feed safety plan based on the raw materials processed and the end products manufactured. These control systems assure that cooking temperatures are high enough to kill bacteria and control pathogenic microbial contamination.

Additional programs also address plant and transport cleaning, and other biosecurity measures such as traffic control. Stringent testing protocols are used to verify that rendering processes are accurately managed and operated. Testing programs include training and strict record keeping, as well as spot checks and follow-up by independent third-party audits to ensure plants are following all plan instruction and protocol to the letter to ensure product safety. These voluntary programs have been followed for years and prepared the industry well for compliance, the programs were implemented long before Food Safety Modernization Act (FSMA) regulations even became mandatory.

FSMA legislation and regulations are the most comprehensive overhaul of the FDA food safety regulations in over 70 years. Legislation was passed by Congress on December 21, 2010 and signed into law by President Obama on January 4, 2011. FDA finalized, and published regulations in consultation with industry over several years, and effective dates began in 2015. FSMA is broken into seven different rules, with the intent to protect the U.S. food supply at all points.

The intent is to transform the nation's food safety system by shifting the focus from responding to foodborne illness to preventing it. FSMA does not cover meat and poultry slaughter

already covered by USDA inspection, but does regulate all animal food and ingredients with few exceptions (FDA, 2020).

FSMA requires hazard analyses by all feed and ingredient manufacturers and preventive controls such as validated and monitored cooking operations must be implemented for all significant hazards. Current good manufacturing practices are required throughout plants for training, sanitation, operations, equipment, and other areas to ensure safe production. Rendering plants are among the most scrutinized and most inspected animal food ingredient producers in the world, and the rendering industry is highly compliant with FSMA regulations.

More Than Just Food—Rendered Products Surround Us Every Day

Renderers often discuss the “Big 4” rendered product markets: pet food/animal feed, fuel, oleochemical products, and fertilizer. However, other rendered products not mentioned as often include gel bone (rendered bone chips) used to create gel caps used for vitamins, supplements, and drugs, cosmetics (like lotions and soaps made from rendered fats), and even tires.

Rendered fat *alone* is utilized for production of many nonfood and nonanimal feed applications such as candles, detergents, fabric softener, deodorant, shaving cream, perfume, cosmetics, lotions, crayons, paint, lubricant, biodiesel, plastic, waterproofing materials, cement, ceramics, chalk, matches, antifreeze, insulation, linoleum, rubber, textiles, medicines, soap, and crayons (Iowa State University Extension, 2020; Figures 2–4).

Most rendered fats are derived from beef animals for tallow, swine for lard, and poultry as poultry grease or poultry fat. Minor percentages of total fats are derived from other species, such as sheep for mutton tallow and fish. Rendered fats specifically have many additional industrial uses with over 70% of those requiring processes like refining, filtration, bleaching, hydrogenation, *trans*-esterification, and drying before they can be made into new products. All these processes for fats fall under the category called *oleochemistry*.

Soap can be used as a historical example of a product made from rendered fat: harder fats produce firm soaps, whereas softer fats produce soft soaps with harder fats resisting oxidation so firmer soaps do not go rancid as fast (as softer soaps). Free fatty acids provide a measure of the amount of hydrolysis that has taken place within the fat molecule. Time, temperature, and the presence of moisture all favor the hydrolysis of fat into free fatty acids and glycerol needed for the final product. Refined and bleached (R&B) color is a factor that is determined by the degree of damage done to the fat. As the soap-making industry grew and became more refined, the quality standards and specifications for animal fat became more precise to meet the soap industry's needs. The specifications and terminology from the soap industry formed the basis for the quality standards and characteristics used today.

Industrial uses of different fats depend on their characteristics as determined by analyses such as titer, fatty acid profile, free fatty acid content (or sometimes acid value), saponification



Figure 2. Crayons.



Figure 3. Chalk.

value, R&B color, peroxide value, and the absence of impurities, like moisture and unsaponifiable matter. Rendered fats may be further processed by refining, bleaching, and deodorizing, and used as raw materials in hydrogenation, hydrolysis to fatty acids, and *trans*-esterification to fatty esters. Many factors affect the suitability of rendered fats for such use including the types and blends of animal byproducts to be rendered, storage conditions of the animal raw material byproducts before processing, storage conditions of the rendered fats after processing, and the methods and procedures of the rendering process used.

Whiteness, or lack of color indicates the fat was rendered from high-quality raw materials and good rendering techniques which is important for finished soap quality. Moisture, impurities (such as soil or metals), and unsaponifiables (plant sterols and pigments from plant sterols originating from the gut contents [forages, grains] of rendered offal) are important determinants of fat quality and indicated by the abbreviation MIU. Excess MIU will cause deterioration of the fat during storage (Meeker, 2020).

Biodiesel fuel is an important subcategory made possible by using rendered materials including fats and proteins. A considerable percentage of America's biodiesel and renewable diesel is



Figure 4. Perfume bottles (perfume).

made from recycled cooking oil, also known as UCO, such as that used in fryers, with a large amount also coming from animal fats. According to the U.S. Energy Information Administration (EIA, 2018) 1.86 billion gallons of biodiesel were produced in 2018. Of that total, 9.2% of the feedstock (644,000 tons) were classified as animal fats and 13.2% of the feedstocks (918,000 tons) were classified as recycled yellow grease or other, with UCO included in the recycling category. Because of their chemical composition, fats release concentrated amounts of energy when burned which can be used as a biofuel (Panwar et al., 2011).

Materials such as organs, hair, hooves, and blood also contribute to other products in addition to foodstuffs. Examples can be found below.

- Blood components are used for dyes and inks, adhesives, medicines, and laboratory materials.
- Hides are utilized in the production of gelatin, sheetrock, adhesives, and medicines.
- Hooves and horns are also used for adhesives, as well as plastics, plant food, photo film, shampoo, lamination, wall-paper, and plywood.
- Hair can be used for air filters, brushes, felt, insulation, plaster, and textiles.

- The brain and internal organs are utilized to produce antiaging creams, medicines, musical instrument strings, tennis racquet strings, hormones, enzymes, and vitamins.
- Bone is used for charcoal, fertilizer, and glass.
- All rendered proteins including meat and bone meal and blood meal are rich in nitrogen and phosphorus and can be used to produce natural fertilizers (Jatana et al., 2020).

Many items made with rendered products, including biodiesel, may be a surprise to consumers and the general public, whereas other processed goods from proteins and fats (like protein meals used in animal feed) are more widely known and come in a variety of different forms with unique attributes. Descriptions of each material are in the definitions below.

Protein Meals

Protein meals manufactured from animal products provide essential protein for the dietary needs of livestock and other animals. The meals are used for pet food, poultry, livestock, fish, and crustaceans. The Association of American Feed Control Officials (AAFCO) defines the identity and composition of these feed ingredients (AAFCO, 2020), those definitions are paraphrased here:

- *Blood meal*: Produced from clean, fresh animal blood free from all extraneous materials including hair, stomach contents, and urine.
- *Hydrolyzed poultry feathers*: The product resulting from the treatment, under pressure, of clean, undecomposed feathers from slaughtered poultry, free of additives or accelerators.
- *Meat and bone meal*: Rendered product from mammalian tissues, including bone. Not to contain added blood, hair, hoof, horn, hide trimmings, manure, stomach, and rumen contents.
- *Meat meal*: Similar to meat and bone meal, meat meal is the rendered product produced from mammalian tissues, exclusive of any added blood, hair, hoof, horn, hide trimmings, manure, stomach, and rumen contents.
- *Poultry byproduct meal*: Rendered and clean parts of poultry carcasses, such as necks, feet, and whole carcasses, exclusive of added feathers.
- *Poultry meal*: Dry rendered product derived from the parts of whole carcasses of poultry or a combination of clean flesh and skin with or without accompanying bone, free of feathers, heads, feet, and entrails. Suitable for use in animal food.
- *Fish meal*: Clean, dried, ground tissue of either or both whole fish or fish cuttings, with or without the extraction of portions of the oil.

Fats

The AAFCO defines a number of animal fats suitable for animal food, including the ones paraphrased below.

- *Animal fat*: Fat obtained from mammals or poultry tissues in the commercial processes of rendering or extraction. It consists predominantly of glyceride esters of fatty acids and

contains no additions of free fatty acids or other materials obtained from fats.

- *Hydrolyzed fat or oil, feed grade*: Obtained through the fat processing procedures commonly used in edible fat processing or soap making.
- *Yellow grease, feed grade*: The rendered product from the tissues of mammals and/or poultry blended with used cooking or frying oil from human food preparation, consisting of animal and/or vegetable fats or oils.
- *Used cooking oil, feed grade*: The product of used cooking or frying oil from human food preparation, consisting of animal and/or vegetable fats or oils, collected from commercial human food facilities, then heated (Figure 5).

A Sustainable Contribution

The sustainability benefits of rendering can be accurately tracked and are more highly valued as our environment faces threats of climate change and reduced landfill space. Additionally, consumers seem ever more aware of their sustainability practices when making purchases due to this information and education on sustainability being widely available across media platforms. Specific areas of rendering's sustainable contributions include reduced food waste, water reclamation, and sustainable pet food; each detailed below.

Rendering reduces the environmental impacts of animal agriculture by sequestering five times more GHGs than are produced (Gooding and Meeker, 2016). By reclaiming otherwise discarded meat leftovers, renderers make our food production footprint smaller (Figure 6).

Reduced food waste

Sixty-two billion pounds of raw materials are cooked and rendered to result in approximately 31.4 billion pounds of

The Processing Steps of Rendering

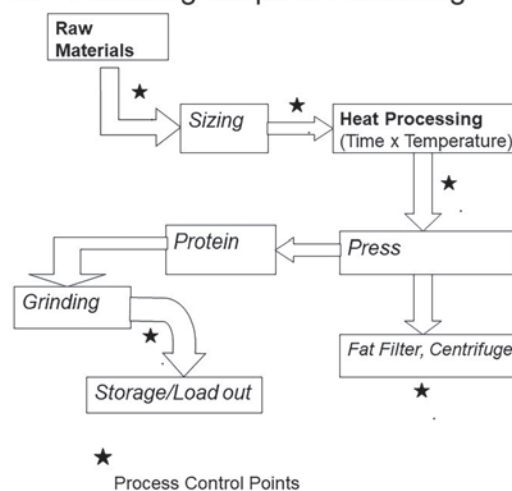


Figure 5. Rendering process infographic—visually represents the processing steps of rendering.

RENDERING: The Facts

Render: "To reduce, convert, or melt down (fat) by heating" from the French word "rendre", meaning "to give back"

RENDERING IS RECYCLING!

FROM SCRAPS TO VALUABLE COMMODITIES

Rendering reclaims the meat and bone scraps from animal agriculture and grocery store leftovers and transforms them into ingredients for new products. This recycles these raw materials into 29 billion pounds of fat, oil and protein.



FROM FRIES TO FUEL Renderers recycle billions of pounds of used cooking oil each year into biodiesel and renewable diesel. Rendered protein and fats are also used to produce hundreds of industrial and personal care products.

FEEDING THE FUTURE

Rendering helps grow the next generation of food by "recycling" unwanted meat into new and clean ingredients for animal food and fertilizer.



RENDERING RECLAIMS AND PROTECTS

3.7 billion gallons of water that would otherwise be wasted are reclaimed during rendering, cleaned, and returned to rivers and streams. Rendering also improves water quality by reducing grease and oil that clog sewer and wastewater systems.



RENDERING COMBATS CLIMATE CHANGE

Rendering protects the environment from high greenhouse gas emissions of other disposal methods. It reduces the environmental impacts of animal agriculture by sequestering 5 times more greenhouse gases than are produced.

This is equal to removing **18.5 million** cars off the road each year.

If all renderable products were sent to landfills, all available space would be gone in **4 years.**



SUSTAINING THE ECONOMY

The rendering industry is sustainable and financially stable with an annual economic contribution of

\$10 billion



QUALITY JOBS

Rendering employs skilled workers with full-time jobs and benefits. Employee retention rates are high, contributing to more stability in local communities, many in rural America.

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Figure 6. "Rendering—the facts" infographic.

rendered products produced annually from in the United States and Canada. As a result, these huge volumes of meat leftovers and UCO are kept out of landfills, resulting in a net reduction

of carbon emissions (NARA, 2020). In fact, if all renderable products were sent to landfills, all available landfills would be full in approximately *four years*.

Preventing food waste in the first place is an important first step in saving landfill space, and one that comes before rendering (as expressed in the food recovery hierarchy shown here) (Figure 7; EPA, 2020). Although all livestock food animals generate byproducts as they are transformed for human diets, reduced restaurant and personal food waste can be eliminated before it becomes a problem by following the levels of the hierarchy starting with “source reduction.” Renderers pick up UCO from restaurants which helps reduce food waste from that sector, but plate waste is not well utilized because of lack of infrastructure and the high cost of logistics to collect and cook waste food for animal feed; additionally no system exists to collect either UCO or other food waste from households.

Grocery store leftovers would also be a contributor to food waste, but because renderers pick up those meat leftovers (in the form of trimmings, fat and bone) from butcher shops, grocers, and small slaughtering operations, grocery store waste has a much smaller footprint. Renderers also recycle billions of pounds of UCO from restaurants used to cook fried food items like French fries, and transforms that oil and fat into biodiesel, renewable diesel, and ingredients for pet food and animal feed (Figure 8).

Water reclamation

Rendering reclaims and cleans valuable water that would otherwise contribute to the decay of byproducts and cause contamination in the environment. The rendering process evaporates the moisture from the raw materials and processes all runoff and wash water through water treatment that meets regulatory standards. Annually, 3.7 billion gallons of water are reclaimed during the rendering process and naturally released back into the environment through evaporation or returned as clean water to streams and rivers (NARA, 2020)—that is enough water to fill 5,604 Olympic swimming pools. All this

water meets federal, state, and local safety standards when returned to rivers and streams.

Additionally, renderer pickup of used cooking grease and oil from restaurants saves municipal sewer and wastewater systems from becoming clogged. This helps prevent millions of dollars in damage, repairs and contaminated water quality from broken sewer lines and sewage back up.

Sustainable pet food

Protein and fat ingredients obtained from rendering are used to manufacture pet foods. These rendered ingredients are not only sustainable, but also safe due to the enforcement of strict safety guidelines including the use of high heat in the rendering process to destroy bacteria and harmful pathogens. The resulting products are also handled, stored, and distributed under controlled conditions to minimize contamination. All rendering plants are required to be in compliance with FDA’s animal food regulations under FSMA, which ensures safe processing occurs. In addition, renderers have voluntary quality and safety control systems in place via formal programs such as the Rendering Industry Code of Practice (Meeker and Meisinger, 2015).

The rendering industry adds value to animal parts not normally used for human consumption (organs, bones, cartilage, and fat) by processing this material for pet food ingredients. These rendered end products provide essential fat, protein, vitamins, and minerals to enhance pet health and nutrition (Meeker and Meisinger, 2015). Use of rendered products in pet food also significantly reduces the carbon footprint of the food we feed our dogs, cats, and other pets by repurposing byproducts that might otherwise be wasted (Meeker and Meisinger, 2015). With many pet parents’ growing interest in the sustainability and carbon footprint of their pets’ food, renderers highlight the rendered protein ingredients in their pets’ food is not only nutritious but is also helping to reduce food waste.

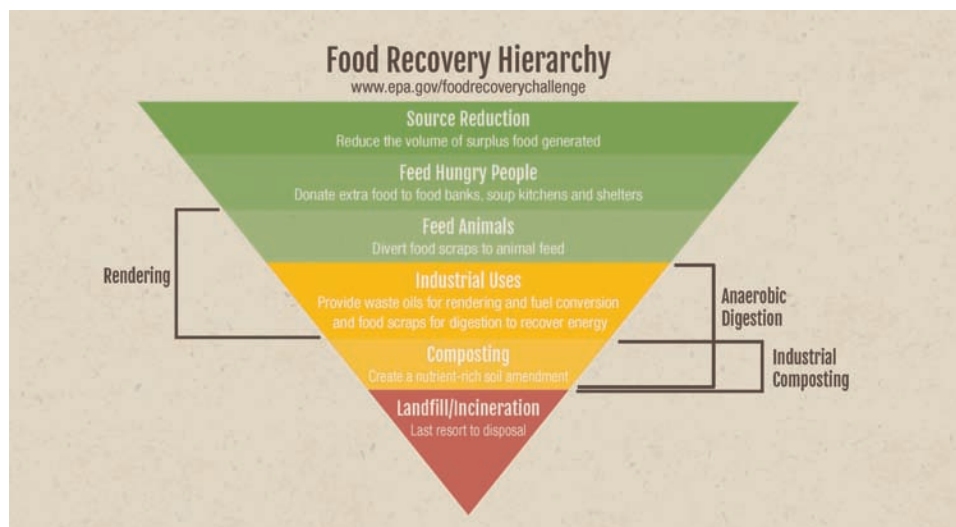


Figure 7. Food recovery hierarchy chart.

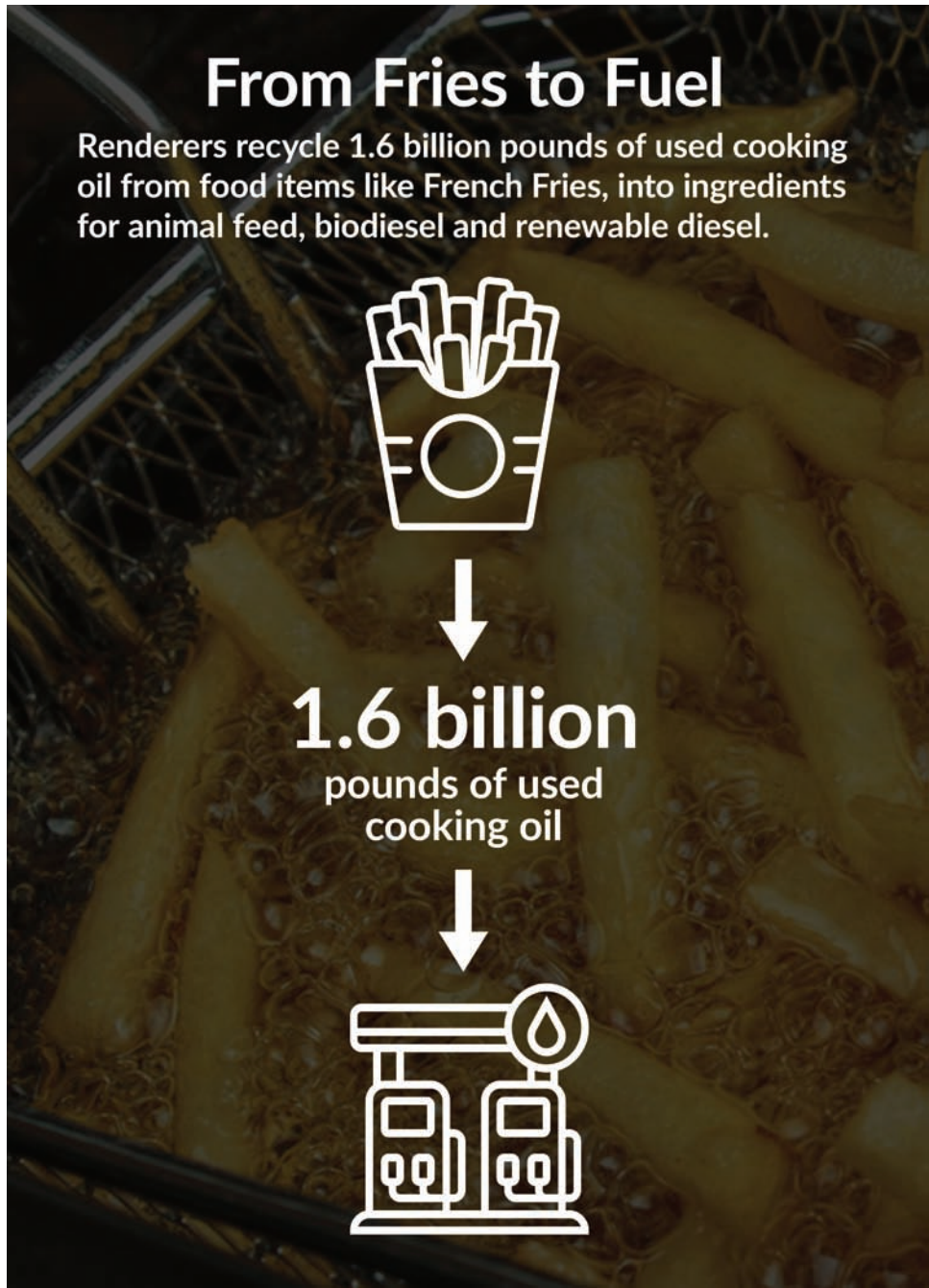


Figure 8. “From fries to fuel” infographic.

Supporting the Three Pillars of Sustainability

Rendering also represents all three pillars of sustainability—Environmental, Economic, and Social. These three pillars are sometimes depicted visually as architectural pillars and other times as a three circle Venn diagram. The concept of sustainability has been discussed publicly as early as the 1980s and the three pillars have been presented as a “common view” of sustainable development in media since as early as 2001 (Purvis et al., 2019; Figure 9).

Pillar 1—Environmental

- Rendering’s environmental support pillar is a strong one. More than 62 billion pounds of renderable materials are produced in the United States and Canada each year. By reclaiming otherwise discarded meat leftovers, renderers make our food production footprint smaller, save landfill space, and help minimize the environmental impacts of animal agriculture such as climate change, as rendering assists greatly in the reduction of food waste, reduced GHG and water consumption.

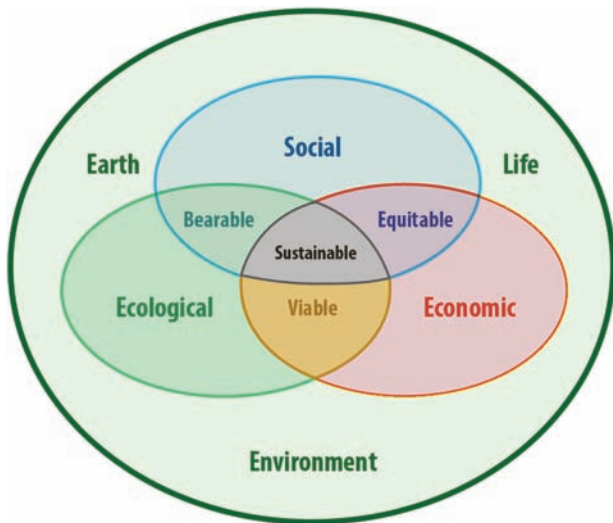


Figure 9. The 3 pillars (of sustainability)—Venn diagram representation.

- Rendering reclaims and protects valuable water that would otherwise be wasted or contaminated. Billions of gallons of water are reclaimed during the rendering process, then naturally released back into the environment as clean water that meets all federal, state, and local safety standards.
- Renderers feed and grow the next generation of food by “recycling” unwanted meat into animal food and fertilizer, reduce waste by rendering grocery store leftovers and UCO—both which would be a substantial contributor to food waste were it not for rendering.
- Renderers recycle 1.6 billion pounds of UCO from food items like fries, into biodiesel, renewable diesel, and ingredients for safe and nutritious pet food and animal feed. Without rendering’s reclamation of this otherwise wasted material, and it was instead thrown away, all available landfill space would be used up in approximately four short years.
- Vital to the environmental pillar is rendering’s reduction of GHG emissions. Biofuel from rendered animal fat generates 20.7 g CO₂e/MJ of GHG when produced and used compared with the GHG emissions of conventional diesel of 94.4 g CO₂e/MJ (Rui et al., 2017). An average rendering plant sequesters five times more GHG emissions from the environment (such as carbon dioxide and methane) than it emits (Gooding, 2012) and rendering also avoids at least 90% of the potential GHG emissions compared with industrial composting, equal to removing 18.5 million cars off the road each year (Figure 10).

Pillar 2—Social

- Rendering is a financially sound and community focused industry. With employee retention rates high, renderers offer career stability and contributions to local communities.
- By reclaiming and converting animal leftovers and UCO into

new products, rendering helps customers and consumers to be more sustainable while providing thousands of full-time and stable jobs supporting families and local communities from coast to coast in America and Canada, many in rural areas. Adding to the stability of work in the rendering industry, these positions cannot be exported due to the raw and perishable nature of the material the rendering industry reclaims.

- Rendering workers are highly skilled and competitively compensated, and renderers contribute to their local communities and organizations.
- The average North American rendering plant employs 94 employees and does not run a swing shift. Paid time off starts after 2 weeks and 70% or more of the employees’ health insurance premium is covered by the company (NARA, 2020).
- Disability insurance, job-related certification, education and a 401(k) program with a company match is also provided. Renderers and plant owners also invest considerably in improvements and enhancements to sustainability efforts, in addition to supporting their local communities both financially and socially (NARA, 2020).

Pillar 3—Economic

There is some expected overlap in the Social and Economic pillars in reference to the rendering industry as the economic stability of the industry directly affects the stability of careers, therefore leading to rendering’s high job retention and financial ability to contribute to their communities.

- The rendering industry is sustainable and financially stable with an economic contribution of \$10 billion, annually.
- An average rendering plant provides nearly 100 stable jobs that offer competitive pay and benefits (NARA, 2020).

New Data

Renderers play an important role in reducing food waste, sustainably recycling valuable agricultural resources and positively contributing to local, state, national, and international economies. Quantification data were collected by the North American Renderers Association and published in 2020 (NARA, 2020).

This report is not available publicly, but the executive summary and all key takeaways are included here:

From powering passenger vehicles and trucks, trains and inland and ocean-going water vessels to feeding cattle, hogs, turkeys, chickens, and other animals, the nation’s renderers play an important role in positively contributing to local, state, and national economies, while also sustainably using these valuable resources. The findings from this research will allow the industry to better communicate its value, identify opportunities and plan for a strong future.

This research consisted of understanding the total supply of renderable products, estimates of total rendered products, conducting a three-part survey of rendering companies in

WHAT IF THERE WAS NO RENDERING?

WITH RENDERING

WITHOUT RENDERING

✓ Reduced food waste



✗ Roughly 50% of each meat animal wasted

✓ 62 billion pounds of food waste diverted from landfills



✗ All U.S. landfills full in 4 years

✓ 3.7 billion gallons of clean water reclaimed and returned to rivers and streams



✗ Wasted water: not cleaned or returned to waterways & contaminated water if animal leftovers sent to landfill

✓ Fewer greenhouse gas emissions (5 times more GHGs sequestered than produced)



✗ Lost environmental benefits for animal agriculture (less GHG reduction)

✓ Lower carbon emissions from biodiesel and renewable diesel (80% less than petroleum diesel)



✗ Increased carbon emissions from less environmentally friendly fuels

DID YOU KNOW THAT RENDERING...

- Is a financially stable and sustainable industry with a \$10 billion annual economic contribution.
- Helps contribute to food security through the production of livestock feed and fertilizer.
- Supports thousands of full-time jobs with benefits, many in rural America.

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Figure 10. "What if there was no rendering" infographic.

the United States and Canada, and studying consumer and industry-driven market trends. Highlights from the research are outlined below.

More than 62 billion pounds of renderable raw materials are produced in the United States and Canada each year from farms, feedlots, and slaughter facilities working with cattle, hogs, sheep, chickens, and turkey. These materials are highly perishable byproducts of meat and poultry produced for human consumption—offal, bones, blood, feathers, and animals that die on farms or in transit to slaughterhouses.

This figure includes organ meats and meat and poultry byproducts that move directly from slaughter to pet food processors. It does not include UCO. Although there are 213 companies classified as rendering and meat byproduct processing companies in the United States, there are 34 primary rendering companies in the United States and 3 primary rendering companies in Canada, making the total employment for the rendering industry in the United States estimated at 8,916 people and 1,803 in Canada (NAICS, 2019).

Approximately 15.7 million tons of rendered products are produced from beef, pork, turkey, and broiler processing plants annually. This is 57% protein meals, 40% fats, and 3% plasma meal. In 2018, the equivalent of 11.1 million acres of soybeans (protein equivalent) and 2.6 million acres of corn (energy equivalent) were averted (not planted). This is due to:

- 6.1 million tons of protein from 8.9 million tons of protein meals being recovered by rendering plants.
- 52 trillion kcal of energy from 6.3 million tons of fats being recovered by rendering plants.

Rendered products have a substantially positive environmental impact in that it keeps those products from ending up in landfills by redirecting them to higher valued, more sustainable markets such as feed, fuel, and fertilizer. An additional sustainability benefit of rendering is the reclamation and return of clean water to the environment. 3.7 billion gallons of water from the products that are rendered are either released as water vapor (evaporation) or through treated wastewater discharge.

Approximately, 289,037 tons of animal and poultry fats, and 501,413 tons of fresh and frozen meat and poultry byproducts and organ meats that come from a combination of direct slaughter and rendering plants are used by pet food manufacturers, and roughly 1,543,129 tons of rendered protein meal from byproducts of meat, poultry, and fish are included in pet food diets. In addition, 1,333,248 tons of meat and poultry are most likely sourced directly from slaughter plants for pet foods.

Survey respondents report they reclaimed and repurposed approximately 800,000 tons of UCO in the 1-year study period, which represents about half of all UCO. Repurposing a large amount of this material averts what would otherwise go to other less-sustainable destinations.

According to the U.S. Energy Information Administration (EIA) 1.86 billion gallons of biodiesel were produced in 2018. Of that total, 9.2% of the feedstock (644,000 tons) were classified as animal fats and 13.2% of the feedstocks (918,000 tons)

were classified as recycled yellow grease or other. UCO is included in the recycled category.

Renderers are substantial employers who offer competitive benefits to their employees, including paid time off, contributions to 401(k) (and other retirement funds that help ensure their employees are taken care in retirement), paid health insurance premiums, disability insurance, and education assistance for job-related skills and certificates.

In addition to upcycling materials that would otherwise end up in landfills, renderers are investing millions of dollars in environmental improvement efforts resulting in a total of \$165.5 million spent on all environmental improvement efforts over the last 5 years (2015 to 2019) and \$188 million planned to be spent on all environmental improvement efforts over the next 5 years (2020 to 2024).

Looking Forward

The rendering industry is dynamic and ever changing. New focus and initiatives continue to occur in the areas of environmental issues, governmental regulations, raw material, and market conditions.

Large amounts of energy are used during the rendering process, in the cooking process, and by the fleet of trucks needed to haul the raw and finished material to the plant or customers. Renderers continue to seek to solve these evolving issues by finding more efficient solutions and economical rendering equipment.

Updates in consumer preference of food will also continue to change. Reduced waste is a factor front-of-mind for many consumers, as is sustainability. The rendering industry continues to educate the public on the many sustainability benefits of upcycling rendered material into new goods.

Looking ahead the rendering industry has these large-scale issues to keep in mind, as well as more focused key items to consider as it prepares for the future. The rendering industry and markets for rendered products should expand to match the predicted growth of meat production and services needed by a growing U.S. and Canadian population. Continued investments in research such as that by the Fats and Proteins Research Foundation (FPRF) are also needed to fund research that can enhance product safety, improve rendering efficiency, support use in animal nutrition, and find new uses and markets for these byproducts.

African Swine Fever continues to spread across southeastern Asia, as such, the animal feeding and rendering industries need to remain cognizant and ready to combat nonscientific animal health and feed safety concerns regarding porcine-derived products with knowledge of existing research.

In simple terms, swine producers and veterinarians often think use of rendered products pose a risk of spreading virus. Scientific data does not support this assumption.

Trends continue to evolve in the pet food sector as well, the latest of which relates to the use of animal byproducts in dog and cat foods that are not rendered but rather purchased raw or frozen and then extruded as a complete pet food. Another trend emerging in the poultry industry is to eliminate animal

About the Authors



Anna D. Wilkinson manages all internal and public NARA communications, public relations, and marketing, and serves as Communications Director for the Fats and Proteins Research Foundation (FPRF). She maintains and advocates for the sustainability brand of the rendering industry. A seasoned communicator with a background in the waste, recycling, and sustainability industries, she has several published articles to her name. She has been interviewed on NPR and quoted in publications including The Huffington Post,

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byproducts in poultry rations. The rendering industry must continue to use new and existing research data to prove that animal byproducts can provide a nutrient rich diet for poultry. The rendering industry also continues to research new methods and processes to meet needs of evolving customers.

Conclusion

The rendering business is profitable and sustainable. It is also essential to making a meat animal more sustainable than it would be if byproducts were not rendered and used for the highest possible purpose.

By making numerous new products with the unused meat and byproducts derived from livestock, rendering and renderers provide local jobs, support their communities, and contribute to significantly reduced food waste, saved landfill space,

reduced GHG emissions, production of nutritious and sustainable animal food, and clean water reclamation.

Literature Cited

- AAFCO (American Association of Feed Control Officials). 2020. Association of American Feed Control Officials Official Publication [accessed February 3, 2021]. Available from <https://www.aafco.org/>
- EIA (The U.S. Energy Information Administration). 2018. Biodiesel and other renewable fuels overview [accessed February 3, 2021]. Available from <https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T10.04#?f=M&start=200905&end=202008&charted=5-20>
- EPA (The U.S. Environmental Protection Agency). 2020. Sustainable Management of Food: Food Recovery Hierarchy [accessed October 6, 2020]. <https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy>
- FDA (The U.S. Food and Drug Administration). 2020. Food Safety Modernization Act (FSMA) [accessed February 3, 2021]. Available from <https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma>
- Gooding, C.H. 2012. Data for the carbon footprinting of rendering operations. *J. Ind. Ecol.* 16(2):223–230. doi:10.1111/j.1530-9290.2011.00430.x
- Gooding, C.H., and D.L. Meeker. 2016. Comparison of 3 alternatives for large-scale processing of animal carcasses and meat by-products. *Prof. Anim. Sci.* 32:259–270. doi:10.15232/pas.2015-01487
- Iowa State University Extension. 2020. Cattle by-products [accessed October 12, 2020]. https://www.extension.iastate.edu/sites/www.extension.iastate.edu/files/allamakee/Lesson1Activity4Dairy_By_Products.pdf
- Jatana, B.S., Kitchens, C., Ray, C., Tharayil, N. 2020. Regulating the nutrient release rates from proteinaceous agricultural byproducts using organic amendments and its effect on soil chemical and microbiological properties. *Biol. Fertil. Soils* 56:747–758. doi:10.1007/s00374-020-01446-z
- Meeker, D.L. 2020. Rendering. In: Shahidi F., editor. *Bailey's industrial oil and fat products*. vol. 7, 7th ed. Hoboken (NJ): John Wiley & Sons, Ltd. Available from <https://onlinelibrary.wiley.com/doi/book/10.1002/047167849X>
- Meeker, D.L., and C.R. Hamilton. 2006. An overview of the rendering industry. In: Meeker, D.L., editor. *Essential rendering*. Alexandria (VA): National Renderers Association; p. 1–16.
- Meeker, D.L., and J.L. Meisinger. 2015. Rendered ingredients significantly influence sustainability, quality, and safety of pet food. *J. Anim. Sci.* 93:835–847. doi:10.2527/jas2014-8524
- NAICS (North American Industry Classification System). 2019. NAICS Code Description, Rendering and Meat Byproduct Processing [accessed February 3, 2021]. Available from <https://www.naics.com/naics-code-description/?code=311613>
- NARA (North American Renderers Association). 2017. Rendering code of practice [accessed February 3, 2021]. Available from <https://nara.org/biosecurity-and-appi/rendering-code-of-practice/>
- NARA (North American Renderers Association). 2020. Sustainability and economic analysis. Alexandria (VA): North American Renderers Association and Urbandale (IA): Decision Innovation Solutions.
- Panwar, N.L., S.C. Kaushik, and S. Kotharia. 2011. Role of renewable energy sources in environmental protection: a review. *Renew. Sustain. Energy Rev.* 15(3):1513–1524. doi:10.1016/j.rser.2010.11.037
- Purvis, B., Y. Mao, and D. Robinson. 2019. Three pillars of sustainability: in search of conceptual origins. *Sustain. Sci.* 14:681–695. doi:10.1007/s11625-018-0627-5
- Rui, C., Z. Qin, J. Han, M. Wang, F. Taheripour, W. Tyner, D. O'Connor, and J. Duffield. 2017. Life cycle energy and greenhouse gas emission effects of biodiesel in the United States with induced land use change impacts [accessed February 3, 2021]. Available from <https://www.sciencedirect.com/science/article/pii/S0960852417321648?via%3Dihub>