Energy Flows and Materials Circulate

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The axiom contained in the title of this article may not be a true physical law, but it helps to explain how the universe operates. The first law of thermodynamics is often paraphrased: Energy is neither created nor destroyed, and energy flows downhill. The analogy of energy flowing like a river helps explain the idea of material circulation. The kinetic energy of the flowing river turns a waterwheel. The waterwheel represents circulating materials. Take the terrestrial carbon cycle illustrated in Figure 1 as an example. Think of an invisible string pulling down on the left hand side of the picture, causing the cycle to spin counter clockwise. This string is energy flowing through the system. Solar energy strikes the earth. Some energy (and today most believe too much energy) is temporarily stored as heat in the earth's crust and atmosphere. Most passes back out into space as long wave radiation.

Nature also stores energy in Carbon. Plants take carbon dioxide from the air, water from the soil, and use solar energy to create plant organic matter. Of course, photosynthesis also releases oxygen into the atmosphere, but what is important for the carbon cycle is that energy is stored in organic matter. A second thing to remember is the carbon cycle wheel has been turning for a long time. Fossil fuels such as coal, oil, and natural gas are organic matter that was once sunlight millions of years ago.

Living creatures unlock the energy in organic matter for their own use. When a cow eats grass, she is harvesting the same energy released in a prairie fire. The process is the same for hogs -- just replace grass with grain and soybeans. Animals put carbon dioxide back into the atmosphere for plants to use. Burning fossil fuels also releases carbon dioxide, and it is being emitted to the

atmosphere faster than plants can absorb. The more carbon dioxide in the air, the more heat is trapped.

Animals release most of their digested organic matter as manure. Soil microorganisms emit carbon as they use the energy in manure to build soil organic matter -- and the wheel keeps spinning. Microbes also release plant nutrients from manure keeping the cycle lubricated.

Aerobic organisms (Many soil microbes, as well as people and pigs, which require oxygen to live) release water and carbon dioxide when they tap into the energy stored in organic matter. Anaerobic organisms (those that don't need oxygen to live) release a mixture of water, carbon dioxide, and methane. Anaerobic digestion is the industrial process of converting manure (or any kind of organic matter) to energy, water, and carbon dioxide and methane.

The down side of methane is it is really good at trapping heat in the atmosphere – somewhere between 20 and 70 times better than carbon dioxide at trapping heat. In other words, the heat trapping ability of methane is 20 to 70 carbon dioxide equivalents (CO_2eq). If methane is allowed to escape into the atmosphere, it can accelerate the rate at which planet Earth warms. But, methane is also highly flammable. We can convert methane's energy to heat and release lower heating trapping carbon dioxide in its place.

You undoubtedly have heard that swine production has a smaller "carbon footprint" than most commercial operations. Even though mass of CO_2eq released in swine production is relatively small, most is released in two processes – growing crops and handling manure. More than 50% of the CO_2eq emitted while finishing hogs for market comes from methane released during manure storage (Figure 2). If we could capture the methane and convert it to carbon dioxide, we would reduce swine production's already small carbon footprint by about one half. Using the energy released by

anaerobic digestion – to run ventilation fans, heat and light barns – would further reduce the carbon footprint by replacing the energy that might have otherwise been produced from fossil fuel.

The idea of a "cap and trade" policy to reduce green house gas emissions is a dirty word with many pork producers. Yes, capping fossil fuel emissions could raise the energy costs for everyone. But, if you have carbon to trade, it could put you into a good negotiating position to lower your costs. The idea is a power company who has its CO_2 equivalents capped could pay the pork producer to install an anaerobic digester to reduce methane emissions from his lagoon. The trade would reduce overall CO_2eqs emitted.

Maybe renaming the policy "cap and pay the farmer" would get the wheels turning.

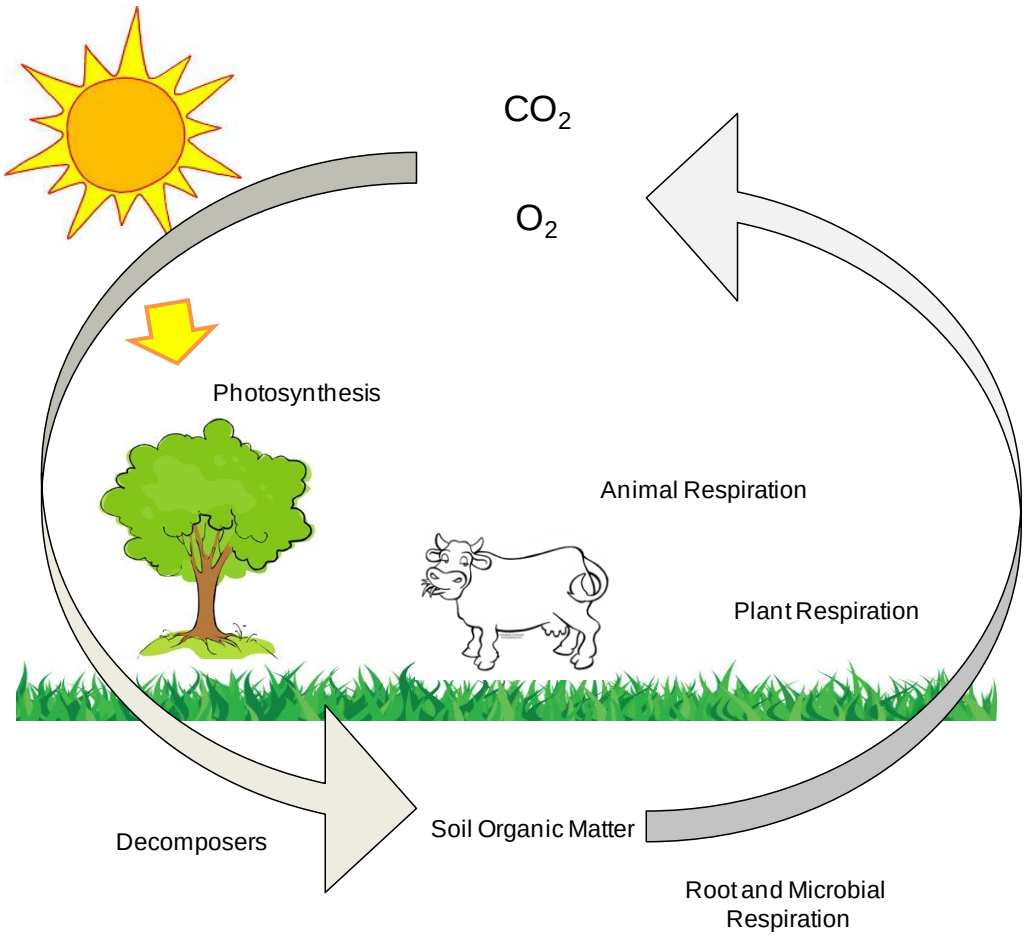

Figure 1. Terrestrial Carbon Cycle (from D. Hamilton. 2012. Organic Matter Content of Wastewater and Manure, BAE-1760. Oklahoma Cooperative Extension Service.)

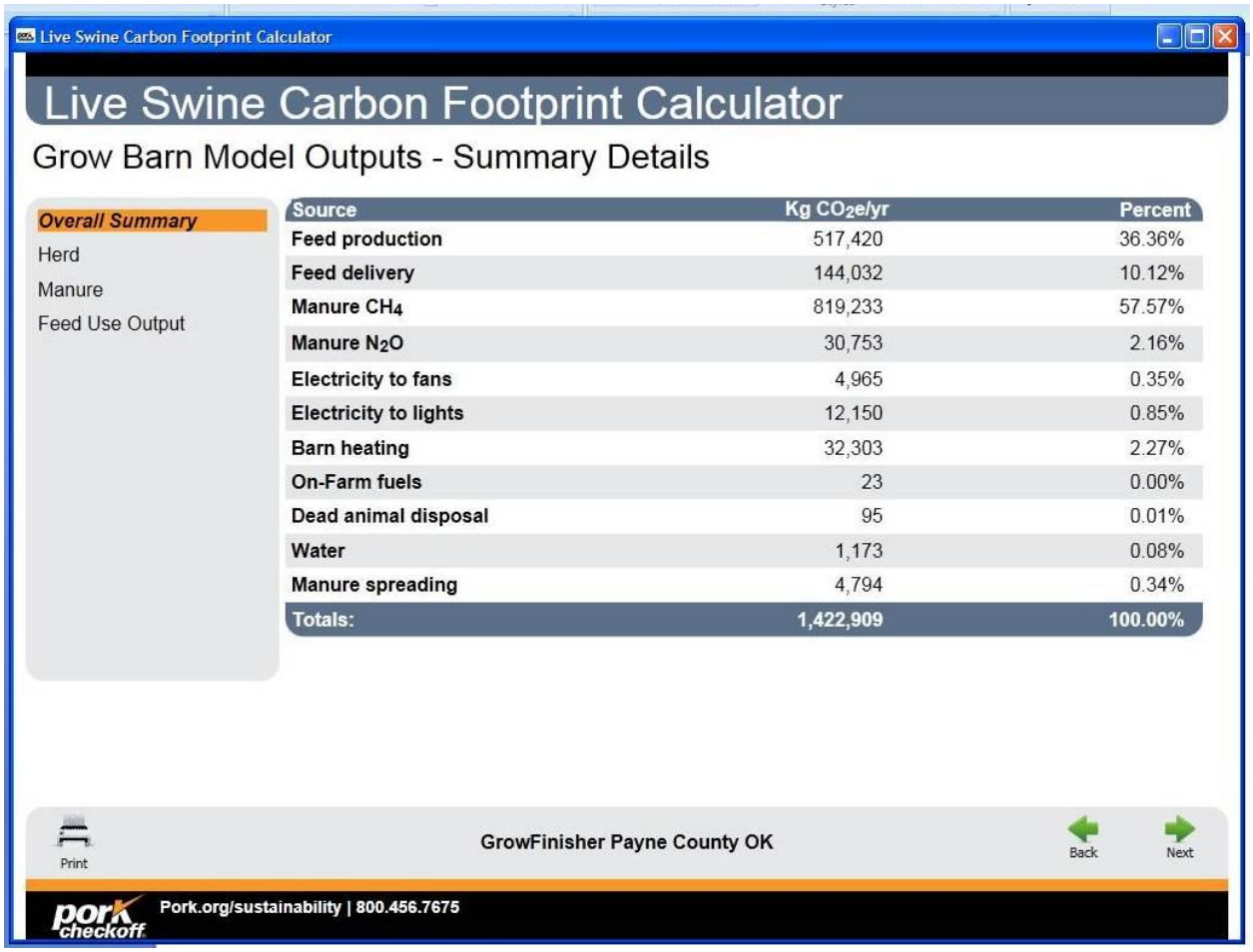

Figure 2. Carbon dioxide equivalents emitted by a pull-plug, 1,000 head capacity, finisher barn using an anaerobic lagoon for treatment and storage. Calculated using the National Pork Board Live Swine Carbon Footprint Calculator.