NEW ADMINISTRATION READINESS CHECK-UP: FINDING BALANCE

Author's Note: This is the third in a series of articles that address the practical impacts of the results of the recent elections on the regulated community's environmental compliance activities.

Among the many changes expected to come from the Biden Administration are significant changes in climate change and sustainability policy. Manufacturers will likely experience the effects of such changes directly in the form of legislative or regulatory initiatives that restrict operations or that require disclosure of a business's environmental impacts. Indirect effects are also likely to come in the form of demands by shareholders, lenders, and other stakeholders for transparency regarding a business's impact on the environment, commitments to reduce such impacts, and accountability for meeting such commitments.

To respond to these increasing demands, senior executive leaders and managers need a solid understanding of the environmental impacts of their respective businesses. A business's operations and supply chain can be quite complex, so this can be a daunting task. However, one can get a handle on such impacts by developing an understanding of the mass and energy balances of the systems related to the business's operations. To do so, it helps to begin by asking the following questions:

1.) What is the "system" being analyzed?
2.) Is the system "steady state" (parameters remain constant over time) – or "transient" (parameters change over time)?
3.) Using the general balance equations for mass and energy, how much mass or energy is entering, exiting, or accumulating within the system?

A system can be just about any size. Scientists who study the earth's climate consider the earth itself as the system, and analyze the energy entering, exiting, and accumulating within the system. On the other hand, a business considering its impacts on the environment may consider a single facility, a business unit, or even the entire business plus the extended supply chain (suppliers, transporters, customers, etc.) as a system.

Once the system has been defined, the mass and energy balances around this system can be considered. Mass balances rely on the fundamental principle that mass can neither be created nor destroyed.[1] So, the amount of mass that accumulates within a system must be the difference between the amount that enters and the amount that exits the system:

Mass Input – Mass Output = Mass Accumulation

This is an expression of the general mass balance equation. It can be used to analyze the total mass balance, or the mass balance of a single element such as carbon.

Where one is using mass balance principles to conceptualize broad systems, it is easier to think of the processes acting on these systems as steady state processes where the amount of mass accumulating within the system over time is zero. If there is no accumulation within the system, then one is left with "what goes in must come out," or:

Mass Input = Mass Output

As with mass, energy can neither be created nor destroyed, so:[2]

Energy Input – Energy Output = Energy Accumulation

Also, as with mass balances, the simplest way to conceptualize broad systems is to think of the processes acting on these systems as steady state processes where the accumulation of energy within the system is zero:

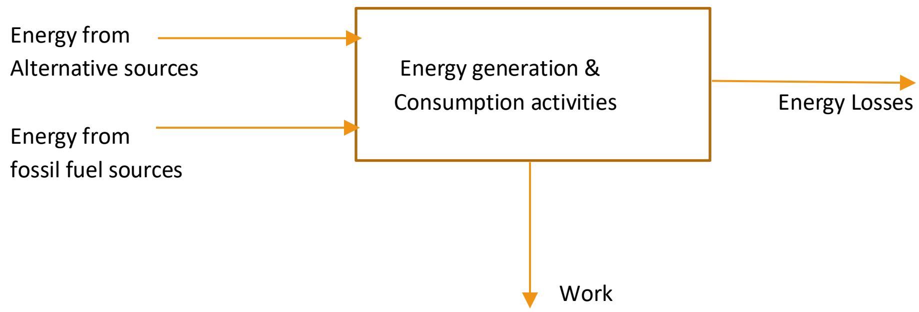
Energy Input = Energy Output

To understand how these principles might be applied, we can consider the example of a business trying to achieve carbon neutrality, or net zero CO_2 emissions. Since CO_2 emissions are largely a function of a business's energy usage, one can begin to conceptualize this goal by starting with an energy balance. As discussed above, the first step is to define the system under consideration. One could start with an energy balance of the entire business. However, such a system would be large and complex with too many inputs and outputs to consider. Instead, it may be easier to conceptualize the problem by starting with a smaller system such as the energy generation and consumption activities of a single facility. This system would have two energy input "streams" and two energy output streams. The input streams would consist of energy generated from fossil fuel sources and energy generated from alternative sources such as wind

[1] This principle does not apply in the world of quantum mechanics where mass can be converted to energy.

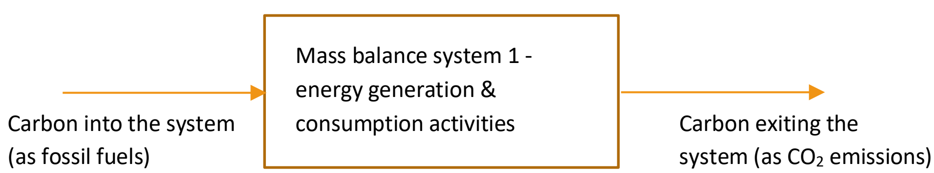
[2] Although it is common to refer to the energy "generation" and "consumption" activities of businesses and economies, it is important to remember that such activities really involve the conversion of energy from one form to another (i.e., the conversion of chemical energy to heat energy and kinetic energy or work).

or power. The output streams would consist of energy applied to work in powering the facility's unit operations and total energy losses. Pictorially, it might look like this:



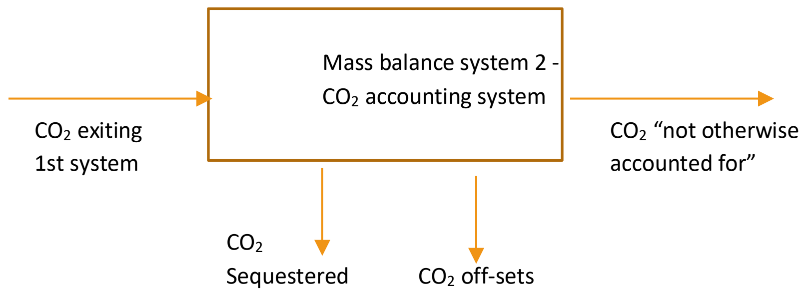
Under the general energy balance equation, the sum of the energy inputs equals the sum of the energy outputs. So, when considering the general energy balance for such a simple system, one can see how energy inputs can be reduced by: increasing the energy efficiency of the facility (i.e., reducing energy losses), reducing the energy requirements of the unit operations of the facility (i.e., reducing the amount of "work"), or increasing energy usage from alternative sources.

After this simple energy balance has been utilized to develop a sense of how the fossil fuel inputs might be minimized, one can develop a simple carbon mass balance for the same system. For the purposes of conceptualizing the problem, one can again consider the facility's energy generation & consumption activities as a single system. One can further assume that all carbon entering the system will exit as CO_2 emissions:[3]



With this assumption in place, a second system can be constructed which would be a hypothetical CO_2 "accounting system." Since this is a hypothetical system where no physical activities are taking place, the mass balance can be expressed in terms of CO_2 rather than just carbon. The input to this system would be total CO_2 exiting the first system (i.e., the facility). The output would consist of three streams: (i) CO_2 captured or sequestered; (ii) carbon credits or off-sets; and (iii) CO_2 emissions "not otherwise accounted for." Such a balance might be pictorially represented as follows:

[3] In reality, some amount of carbon would exit the system with uncombusted fuel or products of incomplete combustion. However, this assumption is a close enough approximation for the purposes of this exercise.



The CO_2 emissions "not otherwise accounted for" would be the difference between the CO_2 entering the system and the sum of the other two output streams. This represents the total mass of CO_2 emissions that must still be reduced to achieve the goal of carbon neutrality. Potential solutions for achieving such a goal may involve investigating the possibility of obtaining additional off-set credits, or perhaps even going back to the energy balance to investigate any potential options for reducing the energy input from fossil fuel sources to the system.

Remember, the initial statement of the problem in this example – achieving carbon neutrality – focused on an entire business. Nonetheless, considering the problem at the single facility level made it easier to understand the flows of mass and energy into and out of the system. From there, it becomes easier to consider and analyze such problems on a larger scale, even if only in a qualitative or narrative sense.

Ultimately, this example illustrates that the key to applying these principles is to properly identify the system to be considered. The fundamental principles underlying mass and energy balances are not very complicated, and in fact are probably intuitive even if people don't really think in these terms very often. Once one has defined a relatively simple system that is easy to conceptualize, the mass and energy balances are usually fairly easy to identify. And, once one is accustomed to thinking about a business's environmental and sustainability problems in this manner, that individual will be in a better position to provide more robust and meaningful input on issues ranging from ensuring accurate reporting of data regarding certain sustainability metrics to identifying the ways in which the business can reduce its carbon footprint to meet government-mandated renewable energy requirements.

The next topic in this series will be about how and when a business might be able to amplify its participation in regulatory and policy development by leveraging the benefits of existing memberships in national, regional, and local trade organizations.