Steps to Sustainability
Part 34 of a Series:
Systems Thinking Basics

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A previous Steps to Sustainability piece of November 21 – 27, 2016, Vol. 11, No. 39, pages 6 and 11 focused on "tipping points" and on the historical background of systems thinking. A tipping point can be thought of as something that happens within or to a system to lead it towards destruction or collapse – as in the example of the wine glass that tips over, shatters and cannot be restored to its previous state. In our essay on the historical background to systems thinking -- Vol. 11, No. 49. January 30 – February 5, 2017, Page 7 – we saw how systems thinking grew out of the failures of Cartesian analysis to solve certain scientific problems in Western thought. In this edition of our essay mini-series, we consider the systems concept in more detail and introduce a few new terms and concepts. One way to begin to understand any set of ideas is to learn the vocabulary that goes with it.

In her widely used introductory book on *Thinking in Systems: A Primer*, Donella H. Meadows (2008:11) defines a system as "an interconnected set of elements that is coherently organized in a way that achieves something." A system has "elements," or components, but systems thinking emphasizes not only the descriptions of the components but also the ways in which those elements are organized – that is to say, the relationships among the elements. As physicist Fritjof Capra notes in his 1996 book, *The Web of Life* (1996:27), the word "system" derives from a Greek word, synhistanai – to place together. But Meadows (2008:11) goes beyond this by stating that a system must also have a function. It is not merely a collection of things placed together.

We can get a grasp of this by thinking of all the parts of a new Prius sitting in a neat pile on a field. All the components are there and have been manufactured to precisely the specifications of the engineers. But the car will only become a car when all the parts have been fastened together in a particular way – to create a system capable of transporting people and items from one place to another. In some cases the parts must be welded and in others they must be held together by bolts tightened to a particular degree for the automobile to ride safely.

Another important aspect of systems is that they process matter and energy as they carry out their function(s). In the example of the Prius, when the gasoline engine is engaged, the system is burning a fossil fuel to generate energy to move the car and/or to perform other functions such as charging the electrical system to run the heater, the air conditioner or the sound system. When on battery, the car is using a non combustion chemical reaction in the battery to generate electricity to move the car and perform other functions.

Throughput

The matter processed in any system and the energy used in that processing have been labeled as "throughput" by the economist Herman Daly. According to Daly (1974:17), the economy is a subsystem of the larger system of the Earth. Throughput is the total energy and matter flowing through an economy. The system begins with extraction (say, of raw materials), continues through production and distribution and ends with waste – waste often being pollution (Daly 1974:15). The throughput can be measured – or at least estimated – a fact that makes it possible to assess whether a system is tending to stay within or push beyond the limits set by the surrounding systems.

The concept of throughput thus makes it possible to connect the human economy with the larger systems of which it is a subsystem.

That larger system can be inorganic like the solar system or it can be an assemblage including both living and non living (inorganic) components. To bring additional conceptual order to the myriad elements of nature, the term *ecology* was coined in 1866 by the German biologist Ernst Haeckel. He defined it as "the science of relations between the organism and the surrounding outer world" (Capra 1996:33). In thinking about organisms and about Earth's life support system, it is sometimes useful to assign words to larger or smaller units. So – within the science of ecology –

- Ecosystems are made up of smaller systems called habitats.
    - Habitats (smaller ecosystems) are made up of reproducing populations called species.
        - Species are partially governed by genes – their structured reproductive molecules.

All of these larger or smaller units are systems. The smaller systems are nested inside the larger ones.

Drivers or Forcings

Processing matter and energy involves some components driving or forcing other components to act in certain ways. The explosion in the compression chamber of a car engine drives the piston down which forces the crankshaft to turn which pushes gears and eventually the wheels and the tires so the car goes forward or backward. We also sometimes say that the explosion *causes* the piston to move down, etc. The word "forcings" is used in climate research in place of drivers. Certain temperature changes force the movement of air in the atmosphere, for example.

So far, we see that systems are made up of components and relationships, that they process matter and energy for some (usually identifiable) purpose, and that some components and processes drive or force others to behave in certain ways. The next step in systems thinking is to examine how systems stabilize or perpetuate themselves or how they become disturbed or can collapse. In a future column we shall take up an overview of feedbacks.

923 words

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To access all of Franke's Steps to Sustainability essays, go to https://msuweb.montclair.edu/~franker/FrankeTompkinsWeekly.htm

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