

Financial Asset Model of Energy

By Pat Westphal

- I. Introduction: I begin with a statement something like: “Defining energy is difficult and so I would like to begin by talking instead about something else from your everyday experience that forms some pretty good parallels. Suppose I ask you to describe ‘your family’s financial assets’. What would you include?”

Typical Student Responses Will Begin With:

- *Cash*
- *Checking account*
- *Savings accounts*
- *IRAs*
- *Stocks and bonds*

Let them continue to list items as you write them on the board. Be alert to the useful questions below when they arise.

- II. A Need to Describe the System: Who is included in “your family’s assets”? My answer is “Let’s limit it to those who live at your postal address. Not those who are in college or the service or married brothers and sisters or...”
- III. A Need to Define what an Asset is: Are children or pets an asset? A liability? Interesting thoughts will come from your group. Some say a child is an asset because he or she provides a tax deduction. Others will argue that the cost of raising a child depletes assets. The same question arises for jewelry, pieces of art, furs, I direct the conversation with “Let’s define an asset as something that can potentially be changed into cash or one of the other asset categories. Is this a reasonable definition of a financial asset?” Most will say yes; others will protest. At this point, I point out that sometimes we need to start with a definition. This will be our *definition* of a financial asset for the time being. If it is useful to re-define it later, we can visit this definition again.
- IV. A Need to Distinguish between Methods of *Storing Assets* and Methods of *Transferring Assets*: At some point, a job or “working” will come up in the discussion. At this time, I ask the question: “Is working a financial asset or is working a way of transferring assets into your family’s portfolio or system?” Students readily agree that working is a transfer process that results in increasing your cash or your bank account’s balance. “Working” is also a way to transfer assets *out* of your system. If you hire someone to do an electrical or plumbing job for you, you must use some of your assets to pay her for working for you. AN

IMPORTANT NOTE: I stress here that working is a verb (or more correctly, a gerund)! I really try hard to avoid using work as a noun throughout this entire unit. We do not calculate “work” as in traditional physics classes. I try to say “the energy transferred by working”. When “working” comes up, I ask if there are other transfer processes that may increase or decrease the size of your system’s assets.

Transfer processes that may arise:

- *Working*
- *Theft*
- *The lottery*
- *Interest*
- *Insurance*
- *Taxes*
- *Inheritance*
- *Many others*

Point out that most of these processes can transfer assets *into* or *out of* your system: Besides the obvious meanings of the terms

- if you are a robber, “theft” increases your assets.
- if you take out a loan, “interest” decreases your assets.
- stocks can lose money.
- you must pay for insurance; but you may also receive an insurance payment.

- V. Watch for an opportune time to introduce “pie charts” to represent your asset distribution. Point out that some assets are “fluid” and can be easily converted from one form to another without changing your overall wealth. You can transfer money from checking to savings and it changes pie piece portions but does not increase or decrease your overall wealth. *Transfers into or out of the system*, however, can make your pie larger or smaller.

By about this time, you are ready to transition from the financial discussion to a similar discussion for energy. Point out that during the beginning of the earlier exercise, you did not define a financial asset, yet your students had some notion of what it was. Soon it was necessary to narrow the idea down: “a financial asset is something that can be readily changed into another asset form like cash”.

- I. Begin with the question: “What sorts of things come to mind when you think of the energy assets of a system?” (By the way, when my classes do energy problems, I use the term “energy assets” all the time when soliciting information from them. And how *perfect* that energy is measured in ~~jewels~~ joules.)

Following the MOP activity you will be able to elicit some responses to the question:

- II. What are some energy assets a system might have? This is a list of some of the assets students will provide. I reword names like “kinetic energy”. Allowing such names convinces students that there are different KINDS of energy. I want them, as Jeff Elmer says, to think of “a joule is a joule is joule”. These are all the same thing. Just as all financial assets are “money” even if we choose to give them different names. If “working” and “heating” come up, refer to the comments later in this narrative.

Depending upon the background level of your students you may get answers like:

- *Energy of motion*
- *Energy of an electrical source*
- *Energy of position relative to the earth*
- *Energy of the nucleus*
- *Energy of chemicals, foods or fuels*
- *Energy of the sun*
- *Energy of compression/stretch of springs*
- *Energy of sound*

Questions/comments to bring in at opportune times:

Do all systems have all energies? No... and how you describe the system affects which energy assets you will find. Group A1 or A2 (MOP) provides good examples to consider here.

Do we need to define an energy asset like we did with our financial system? Usually, the answer is yes. “When we defined our financial assets notice that we said an asset must be something we can convert to another asset form like cash or a bank account balance. Let’s arbitrarily define an energy asset as something that we can use to produce a *change*. This *change* might be a change in motion or a change in position or a change in condition.” We have invented “money” as a method to keep track of the personal assets we store or exchange with other people. Similarly, we have invented “energy” as an accounting device that is useful to describe exchanges or storage of assets to produce a change. Several examples will usually lead to, at least, preliminary acceptance of this definition. If the system is a ball resting on a compressed spring, energy can be transferred to the ball because the spring’s compression *has the ability to* produce motion of the ball.

Working, as in the financial analogy, is not an asset but a process to transfer energy assets. Students will accept this quite readily. Don’t go into too much detail for all parts of the analogy at the beginning or it will become too cumbersome to handle.

Heating merits some comment. When “heating” comes up as an energy asset, you will need to elicit some clarification from the student proposing the idea. If they are talking about putting a pot on the stove, then *heating* should be added to the list of *transfer processes* instead of the list of (storage) assets. On the other hand, if student has heard that “hot substances have greater molecular speeds than cold ones”, (an over-simplified statement), then rename this asset type as “thermal energy or molecular energy”. Emphasize that thermal energy includes things like bond vibration energies, too. Again, it is good to avoid using heat as a noun. And be careful of writing problems that ask the student to “calculate the heat to ...”. A less confusing form asks students to “find the energy transferred by heating”. This wording reminds them that heating is a process, not an asset. Radiating is another process for transferring energy when a light crosses the system-surrounding boundary.

Any change in a system's energy assets equals the energy transferred into or out of the system by working and heating and radiating, $\Delta E = W + Q (+R)$.

