<u>The Laws of Energy</u>

Fred J. Weber, P.E.

mail@wrenchtime.com

For the last two centuries the laws of energy and thermodynamics were defined by three distinguished men of science, Rudolf Clausius, Lord Kelvin and Max Planck. The first law of Thermodynamics is defined: “that energy can neither be created nor destroyed.” The second law of Thermodynamics can be summarized by “Simply no perpetual machines allowed” or “The work effect can’t be greater than the energy supplied.”

This paper explores a different approach to energy and thermodynamics based on the following statements:

1. All energy has two components: work energy and heat energy
2. Work and heat are byproducts of the transfer of energy.
3. Without the transfer of energy there is no transfer of work or heat. .
4. Work can create heat but heat can’t create work

One reason for using this approach is to eliminate the confusion of the term “heat” currently used in the discussions of thermodynamics and physics. In most thermodynamics books the term “heat” is used to describe the transfer of energy in two different ways. In half of the book “heat” can be converted to work and later in the book “heat” represents the energy wasted. To eliminate this confusion the terms “heat” and “work” will not be used to describe the transfer of energy but only act as the byproducts of the transfer of energy. One example of this approach is to change the simple statement from “the sun heated the water” to “the sun transferred energy to the water”.

The following is a step by step approach to this paradigm shift in energy and thermodynamics:

<u>Step 1</u>…Redefine the follow terms in science

Energy is the ability to do work and heat.

Work is the energy <u>available</u> to produce work.

Heat is the energy <u>unavailable</u> to produce work.

Thermodynamics is the science that deals with the interaction of heat energy and work energy between two mediums and the heat energy and work energy change within each medium.

Step 2…Define a system and display a graphic representation

System is the transfer of energy between two mediums. (a source transfers energy to the sink)
Analyzing a system requires that each medium has their own set of data and equations. A symbolic representation of this transfer of energy between two mediums is called a "System Diagram" as shown in the diagram below:

System Diagram

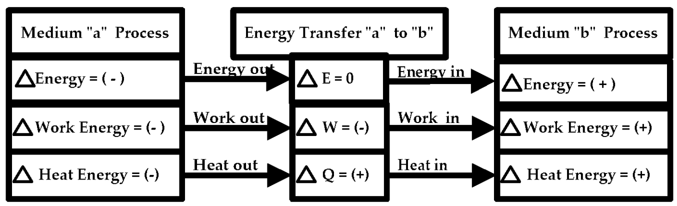

Fig. 1

The system diagram above shows three components;

Medium "a" Process
For this example medium "a" is the source.
ΔEnergy = (-)… shows energy released from medium "a" (Energy out)
ΔWork Energy = (-)…shows the work component of the energy released from medium "a" (Work out)
ΔHeat Energy = (-)…shows the heat component of the energy released from medium "a" (Heat out)

Medium "b" Process…
For this example medium "b" is the sink.
ΔEnergy = (+)… shows energy absorbed by medium "b" (Energy in)
ΔWork Energy = (+)…shows the work component of the energy absorbed by medium "b" (Work in)
ΔHeat Energy = (+)…shows the heat component of the energy absorbed by medium "b" (Heat in)

Energy Transfer "a" to "b"...
This is the net change in energy, work and heat between two mediums.
ΔE = (0)…shows no energy added or removed from the system
ΔW = (-)…shows a net loss in energy available to do work (System's Net Work)
ΔQ= (+)…shows a net gain in energy unavailable to do work (System's Net Heat)

If the medium's energy is changed during any process then something outside of the medium either added energy to the medium or removed energy from the medium. Therefore a system is required for each change in the medium's energy. For reference the ideal Rankine cycle which consists of two constant entropy processes and two constant pressure processes would require four interlocking systems.

Step 3… Grasp the definition of these words and their symbols:

Energy (E)= m(e) … capacity *available* and *unavailable* for performing work.

(e)= specific energy… energy per unit mass

Work Energy (Ew)= m(ew) … capacity of energy within the medium *available* for performing work

(ew)= specific work energy… work energy per unit mass

Heat energy (Eq)= m(eq) … capacity of energy within the medium *unavailable* for performing work

(eq)= specific heat energy… heat energy per unit mass

Work (W)= **(**ΔEw**) =** m **(**Δew**)**…change in work energy; change in energy available for performing work

Heat (Q) = **(**ΔEq**) =** m **(**Δeq**)**…change in heat energy; change in energy unavailable for performing work

Miscellaneous symbols:

(m)= mass

(Δ**) =** change…the final state of a medium minus the initial state of that medium

(1) = initial condition state of medium

(2) = final condition state of medium

Ex: (Δ E) = E2 –E1 = the change in energy is equal to final energy value minus the initial energy value

Step 4…Develop a common sense sign convention for transferring energy between two mediums:

(+) = added, absorbed or in….energy in, energy added, work in, work added, heat in, heat added

(-) = removed, released or out…energy out, energy removed, work out, work removed, heat removed

The following are examples of this common sense sign convention:

+ Δ **E = Ein =** the change in energy is positive (+)… energy is added to the medium

- Δ **E = Eout =** the change in energy is negative (-)… energy is removed from the medium

+ Δ **Ew** = **Win =** the change in work energy is positive (+)… work is added to the medium

- Δ **Ew = Wout =** the change in work energy is negative (-)… work is removed from the medium

+ Δ **Eq = Qin =** the change in heat energy is positive (+)…. heat is added to the medium

- Δ **Eq = Qout =** the change in heat energy is negative (-)…heat is removed from the medium

Step 5…Establish a set of general equations based on the following statement:

" all energy has two components: work energy and heat energy "

Energy (E) = Work Energy (Ew) + Heat Energy (Eq) ….E = Ew + Eq

Energy (E) = mass (m) times specific work energy (ew) + mass (m) times specific heat energy (eq)

E = m (ew) + m(eq) = m (ew + eq)

The change in Energy (ΔE) = change in Work Energy (Δ Ew) + change in Heat Energy (ΔEq)

(Δ E) = (Δ Ew) + (Δ Eq) = (Ew2- Ew1) + (Eq2- Eq1)

(Δ E) = m (Δew) + m(Δeq) = m(ew2- ew1) + m(eq2- eq1)

Work and Heat

Work (W) is equal to the change in work energy. W = (Δ Ew) = (Ew2- Ew1) = m(ew2- ew1)

Heat (Q) is equal to the change in heat energy. Q = (Δ Eq) = (Eq2- Eq1) = m(eq2- eq1)

If… The change in Energy (Δ E) = change in Work Energy (Δ Ew) + change in Heat Energy (Δ Eq)

Then…. The change in Energy (Δ E) = Work (W) + Heat (Q)

General Energy Equations Summary

E = Ew + Eq = m (ew) + m(eq) : all energy has two components work energy and heat energy

W = Δ Ew : work is equal to the change in work energy

Q = Δ Eq : heat is equal to the change in heat energy

Δ E = Δ Ew + Δ Eq = m (Δew) + m(Δeq) = W + Q : change in energy is equal to work plus heat

Step 6… Apply the general equations above to a system:

System is the transfer of energy between two mediums. Based on the definition of a system two mediums are required and each with their own set of general equations: Medium "a" and Medium "b"

Medium "a"	**Medium "b"**
$\Delta Ea = \Delta Ewa + \Delta Eqa = Wa + Qa$	$\Delta Eb = \Delta Ewb + \Delta Eqb = Wb + Qb$
$\Delta Ewa = ma (ewa_2 - ewa_1)$	$\Delta Ewb = mb (ewb_2 - ewb_1)$
$\Delta Eqa = ma (eqa_2 - eqa_1)$	$\Delta Eqb = mb (eqb_2 - eqb_1)$
$\Delta Ea = ma [(ewa_2 - ewa_1) + (eqa_2 - eqa_1)]$	$\Delta Eb = mb [(ewb_2 - ewb_1) + (eqb_2 - eqb_1)]$
$\Delta Ea = Wa + Qa$	$\Delta Eb = Wb + Qb$
$Wa = ma (ewa_2 - ewa_1)$	$Wb = mb (ewb_2 - ewb_1)$
$Qa = ma (eqa_2 - eqa_1)$	$Qb = mb (eqb_2 - eqb_1)$
$Ea = Wa + Qa$	$Eb = Wb + Qb$
$\boxed{\Delta Ea = \Delta Ewa + \Delta Eqa = Wa + Qa}$	$\boxed{\Delta Eb = \Delta Ewb + \Delta Eqb = Wb + Qb}$

Use these two definitions and the equations established for each medium to define the Laws of Energy.

Step 7 …The First Law of Energy

The First Law of Energy states that "energy can not be created or destroyed *within a system*." This law is a copy of the Conservation of Energy but narrows the focus to be "within a system" the interaction between two mediums. Therefore the energy can not be created or destroyed during the energy exchange between two mediums.

Or the total change in energy "within a system" must be zero.

$$\Delta Ea + \Delta Eb = ma (\Delta ea) + mb (\Delta eb) = 0$$

For this equation to be equal to zero… The absolute value of (Δ Ea) is equal to the absolute value of (Δ Eb). Assume for this discussion that medium "a" is the energy source releasing energy within the system. (Δ Ea) is (-). And medium "b" is the sink, absorbing energy therefore… Δ Eb is (+)

These statements can be represented on the top portion of each block in the System Diagram below:

Weber's 1st Law of Thermodynamics

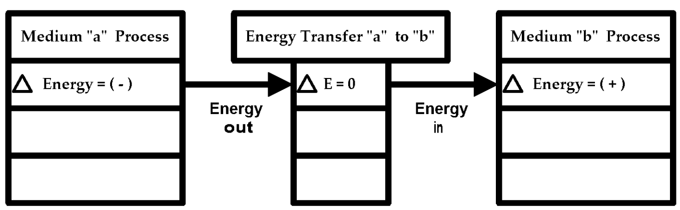

Fig. 2

The system diagram above shows three components;

Medium "a" process….displays the change in energy being released (-) from medium "a" … **(-Δ Ea)**

Medium "b" process… displays the change in energy being absorbed (+) from medium "b" … **(+Δ Eb)**

Energy Transfer "a" to "b"….the net change in energy between two mediums is equal to zero.

The First Law of Energy is "the change in energy within a system can not increase or decrease". Therefore the energy transferred from medium "a" can not be greater or less than the energy absorbed by medium "b".

Step 8 …The Second Law of Energy

The second law of energy deals with the decay of available work energy (work) into unavailable work energy (heat) during the transfer of energy within a system. This law is based on the following statement:

"Work can create heat… but heat can not create Work."

When energy is transferred within a system the energy available to do work can be converted to energy unavailable to do work….but energy unavailable to do work will not convert to energy to do work.

Another way to state this: **"The available work energy within a system can not increase."**

These statements are based on the assumption that *"all energy has two components and they are "work energy" and "heat energy.* *System* is the transfer of energy between two mediums.

Based on these statements the "Total change in work of a system must be (-) or (0)." If the total change in work of a system was **(+)** then the work energy absorbed by one medium would be greater than the work energy released by other medium. This would be a violation to all existing laws of Thermodynamics.

The byproducts of the energy transfer which is the work energy and heat energy of each medium can be represented on the bottom portion of each block in the System Diagram below:

Weber's 2nd Law of Thermodynamics

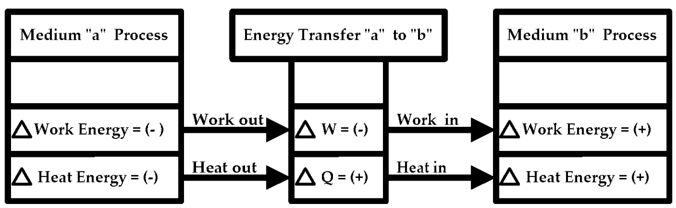

Fig. 3

This diagram shows the exchange of work energy and heat energy between the two mediums. Assume medium "a" is the source and the change in energy is (-). Then medium "b" is the sink and the change in energy will be (+).

Change in work energy medium "a" = $-\Delta$ Ewa = -Wa

Change in heat energy medium "a" = $-\Delta$ Eqa = -Qa

Change in work energy medium "b" = $+\Delta$ Ewb = +Wb

Change in heat energy medium "b" = $+\Delta$ Eqb = +Qb

Total change in work within a system **= (-) = [(-Δ Ewa) + (+Δ Ewb)] = [(-Wa) + (+Wb)]**

For the system's net work to be **= (-)** the energy available to do work removed from medium "a" must be greater than or equal to the energy available to do work added to medium "b". NO work can be created within a system….

Absolute value **(-Wa)** greater than or equal to absolute value **(+Wb)**

If the total change in work within a system is (-) …. then the total change in heat is (+)

Total change in heat within a system **= (+) = [(-Δ Eqa) + (+Δ Eqb)] = [(-Qa) + (+Qb)]**.

Therefore the … absolute value **(-Qa)** less than or equal to absolute value **(+Qb)**

To maintain the First Law of Energy

[Total change in work in a system (-)] plus [Total change in heat in a system (+)] must be equal to zero.

[(-Wa) + (+Wb)] + [(-Qa) + (+Qb)]. = 0

The total work used by the system is equal to the total heat gain by the system.

[(- System Net Work)] + [(+ System Net Heat)] = 0

Step 9…Establish a time frame:

The transfer of energy between two mediums must be evaluated on the same time frame (i.e. time stamp). During each step of the energy transfer relationship each medium must maintain the first and second laws of energy. At any time the energy released from medium "a" must be equal to the energy absorbed by medium "b". Also the available work energy released from medium "a" must be less than or equal to the available work energy absorbed by medium "b". "**Time and available work energy are irreversible**."

Step 10… Display the information.

Develop a system that shows the data of the flow of energy, work and heat. The following system diagram is the transfer of energy between an isolated hot and cold container. At the moment the hot container comes in contact with the cold container the energy transfer moves towards equilibrium. The energy from the hot container transfers to the cold container and is displayed below using a "Weber System Diagram":

H2O	Temp	Pressure	Volume	Entropy	Enthalpy	uq / hq	hw	Pv work	Tmh
491.69	°R	psia	ft³/lbm	Btu/lbm-°R	Btu/lbm	Btu/lbm	Btu/lbm	Btu/lbm	°R
1- Initial	580	14.7	0.016	0.16533	88.425	81.29	7.13	0.04	534.84
2- Final	560	14.7	0.016	0.13027	68.445	64.05	4.39	0.04	525.41
(2 - 1)	-20.0	0.0	0.00	-0.03506	-19.980	-17.24	-2.74	0.00	-9.4
2	lbm /hr		0.000	-0.07012	-39.960	-34.48	-5.48	0.00	

Energy	Heat	Work
0.000	1.245	-1.245

H2O	Temp	Pressure	Volume	Entropy	Enthalpy	uq / hq	hw	Pv work	Tmh
491.69	°R	psia	ft³/lbm	Btu/lbm-°R	Btu/lbm	Btu/lbm	Btu/lbm	Btu/lbm	°R
1- Initial	540	14.7	0.016	0.09394	48.465	46.19	2.27	0.04	515.89
2- Final	560	14.7	0.016	0.13027	68.445	64.05	4.39	0.04	525.41
(2 - 1)	20.0	0.0	0.00	0.03633	19.980	17.86	2.12	0.00	9.5
2	lbm /hr		0.000	0.07265	39.960	35.72	4.24	0.00	

Fig. 4

Observations:

1. The total energy transfer is conserved with no energy being created or destroyed.
2. Notice the system net work (- 1.245) is converted to heat. (+1.245).
3. Remember, work and heat are byproducts of the transfer of energy.

This new methodology also describes how a medium decays without the transfer of energy simple by converting the work energy in a medium into heat energy. The energy of the medium doesn't change, just the ability to do work. The figure below title "Isolated Medium Decay" shows that all available energy to do work (work) decays into unavailable energy to do work (heat) within an isolated medium. Therefore:

"The available work energy within an isolated medium can not increase"

Isolated Medium Decay

H2O	Temp	Pressure	Volume	Entropy	Enthalpy	uq / hq	hw	Pv work	Tmh
491.69	°R	psia	ft³/lbm	Btu/lbm-°R	Btu/lbm	Btu/lbm	Btu/lbm	Btu/lbm	°R
1- Initial	1168.8	800	0.792	1.5536	1345.0	763.9	581.1	117.2	865.73
2- Final	1077.9	14.7	43.590	1.9836	1345.0	975.3	369.7	118.5	678.06
(2 - 1)	-90.9	-785.3	42.80	0.4300	0.0	211.4	-211.4	1.3	-187.67
1	lbm /hr		42.798	0.4300	0.0	211.4	-211.4	1.3	

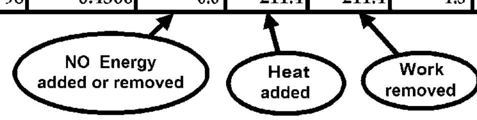

Fig. 5

Notice that the work energy of 221.4 Btu is converted to 211.4 Btu of heat energy with no energy change.

Step 11…Conclusion

This methodology represents all energy such as thermal, light, magnetic, chemical and etc.

Therefore the laws of energy would be:

First Law of Energy states "energy can not be created or destroyed *within a system*." Therefore the total change in energy within a system must be zero. .

Second Law of Energy states that "Work can create heat… but heat can't create work". When energy is transferred within a system the energy available to do work can create to energy unavailable to do work...but energy unavailable to do work can not create energy available to do work. This law states that if a medium does not transfer energy the medium will self-decay from energy available to do work to energy unavailable to do work.

Both of these laws meet the requirements of the existing laws of thermodynamics:

The first law of Thermodynamics states: "that energy can neither be created nor destroyed". The second law of Thermodynamics states simply no perpetual machines are allowed. "The work effect can't be greater than the energy supplied."

Assuming the energy of the universe is constant. This approach can be used to describe the transfer of energy within the universe and how the universe will come to a halt from the lack of energy available to do work.

Step 12…Reference

"*Weber's Thermodynamics Notes*" by Fred J. Weber, P.E.

This book can be viewed online at www.wrenchtime.com