Journal of Modern Education Review, ISSN 2155-7993, USA
February 2021, Volume 11, No. 2, pp. 251–260
Doi: 10.15341/jmer(2155-7993)/02.11.2021/015

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Modern Education for Energy

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Abstract: The response of the new generation needs to address, in order to handle the complex electromechanical equipment of this new age, requires an education that complies and provides a wide spectrum of knowledge. This paper suggests an innovating new educational approach of the electromechanical studies setting from the beginning the Conservation of Energy Principle. The variables and the equations of energy changes are presented in a simple way so it is possible to examine the features of the energy processes with only two variables in generalized form. In this way, it is easier then to understand the different forms of energy as they present. The goal is that the students are getting to understand easier the energy transforms and transfers in a wider knowledge field in order to join later as new professionals a more wide field of electromechanical jobs. Lastly, the extension of the laws of nature to the social field can provide with a better understanding of some social phenomena also.

Key words: education, energy, physics, society, laws

1. Introduction

The education of today's new generation seems to be behind of time, is what says the OECD 2016 review, ranking our students, of the age of 15, below average, with the difference of 2.5 educational years from the firsts. The low rate of assimilation of scientific knowledge at the average level of trainees is unfortunately not improved with the improvements in educational techniques that are constantly being tested.

This low rating does not justify the time and energy put by the teachers and students, in this era where the demands of the rapidly developing technology and a dynamically evolving modern society are extremely high. In different courses there are taught subject like calculations of power, calculation of conductivity and resistance of conductors, losses of energy, repeating in fact the same theme in a specialized way in each form of energy considered. Our education is still based in the specialization of the 19^{th} and 20^{th} century which was adapted to the demands of that era's industrialized society (Anthoulias, 2017) while teaching separately the knowledge of the different fields of engineering like mechanics, fluid mechanics, thermodynamics, electrical science, magnetism, lighting etc. We still teach how to solve one variable problems, while nowadays it is necessary to solve the multiple variables problems. In the future the "uneducated" one, would be the one who has not learned to learn (Novikov, 2008). According to Heraclitus of Ephesus "No man ever steps in the same river twice", meaning by extension, that the tools of yesterday are not effective in the situations of today. The goal of the school education is not the general acquisition of knowledge but to prepare and educate the students for the society they are living, while defying the best methodology to do so (Lomakin, 2006). The OECD review shows us the direction in which

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our education needs to head to. We shouldn't stay with the existing methodology of education, in the highly advancing demands of post-industrial society (Bell, 1973). The methodology of today's education may be fine for the 20th century, but the nowadays students would be called to work with the technological equipment of today and of course of the second half of the 21st century also, with whatever that means for their competitiveness. There will be the need for workers with adaptability to new ideas, expanded possibilities to handle different topics, with interdisciplinary and social education (UNESCO, 2002).

The general presentation of all the following fields was based in the theoretical courses structures of mechanical and electrical specializations in high school and college education for example Mechanics, Fluid Mechanics, Thermodynamics, Heat Transfer, Optics and Electrical science ets.

This paper, called "Modern education for energy", has as a target to present a different innovation approach of the education for the students of mechanical and electrical sciences and the creation of a new educational material for the effective learning that presents the laws of different forms of energy in their general expression. In that way the students acquire bigger possibilities for solving problems based on physics laws, while spending less time and energy on that.

2. Fundamentals

The processes of nature as well as the human activities that mainly concern mass and energy are summarized in Scheme1 which shows the similarity in their management procedures.

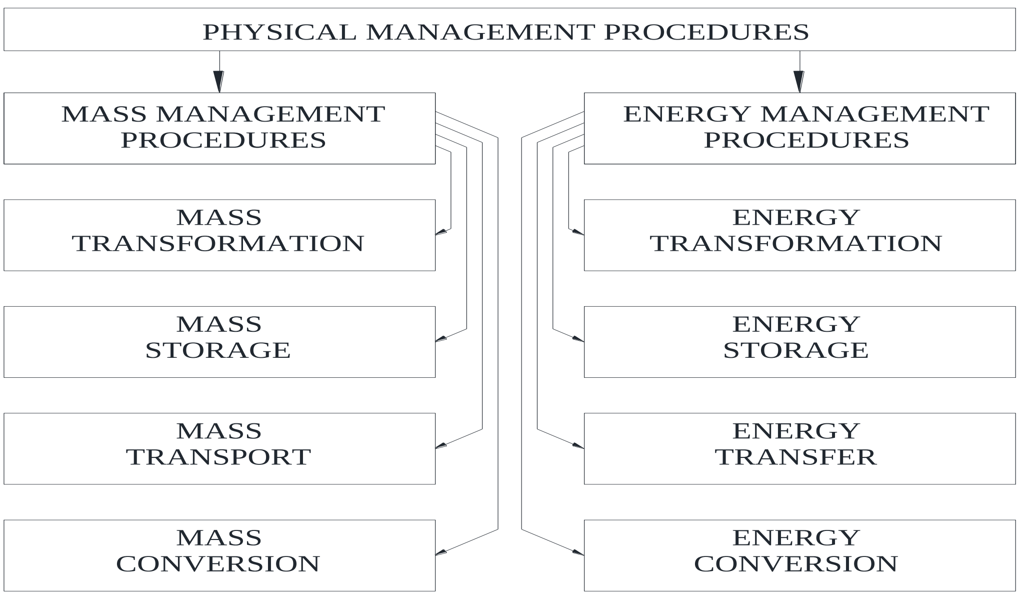


Figure 1 Process Manipulation Mass and Energy

Mass can change shape (state) without changing the material. For example water changes from ice all the way to steam but the material as quality (chemical substance) and the quantity do not change, just transforms. Mass can also be **converted** from one material to another material like, for example, in the chemical reaction of hydrogen and oxygen to water $\mathbf{2H_2 + O_2 = 2H_2O}$ where both parts of the reaction (before and after) stay at the same quantity, according to Conservation of Mass Principle.

Energy can also change its parameters without change its form. The mechanical pendulum is a characteristic case where the energy **transforms** from dynamic to kinetic energy and reverse back, while maintaining the total as it was **E = Ed + Ek,** according to Conservation of Energy Principle. Energy can also be converted from one form to another, like for example thermal energy is converted into electricity or vice versa.

The above natural processes are expressed by the two basic principles in nature, i.e., the Conservation of Mass Principle and the Conservation of Energy Principle. Both are the specific expressions of the more general idea written by Democritus "Nothing is made of nothing and nothing is destroyed to make anything" known as the Principle of Democritus. The present paper deals only with energy transformations and energy transfers due to the limited time of the conference.

2.1 Power

Power, in any form of energy, is the work of the unit time. Power is determined by the parameters of dynamic and kinetic energy as expressed each time in the respectively form of energy, as shown in Table 1.

Table 1 The Power in Different Form of Energy

Form of energy	Parameters of energy				Work/times
	Dynamic		Kinetic		Power [W]
Mechanical, linear motion	Force	**F**	Linear velocity	**V**	**N = F.V**
Mechanical, rotary motion	Torque	**M**	Rotation speed	**ω**	**N = M.ω**
Mechanical, static fluid	Force		Linear velocity	**V**	**N = F.V**
Mechanical, dynamic fluid	Pressure	**P**	Rate of flow	**Q**	**N = P.Q**
Light energy	Luminosity	**B**	Area of light	**S**	**N = B.S**
Thermal energy by conductivity	Temperature	**T**	Heat low	**Pθ**	**N = T.Pθ**
Thermal energy by radiation	Intensity	**A**	Area of radiation	**S**	**N = A.S**
Electrical energy	Voltage	**U**	Intensity of current	**I**	**N = U.I**
Generalized form	Potential difference	**ΔΔ**	Flow	**Po**	**N = ΔΔ.Po**

In all energy forms, the power **N** is the product of the Potential Difference **ΔΔ** with the Flow **Po** which is mathematically formulated

$$\mathbf{N = \Delta\Delta.Po} \text{ and measured in [W]} \quad (1)$$

where **ΔΔ** = Potential difference, parameter of dynamic energy

Po = Flow, parameter of kinetic energy

2.2 Energy Transformation

Energy transformation are realized to all forms of energy in order to change its available parameters $\mathbf{\Delta\Delta_1}$ and $\mathbf{Po_1}$ which are the expressions of dynamic and kinetic components of energy, in the desired parameters $\mathbf{\Delta\Delta_2}$ and $\mathbf{Po_2}$, reinforcing one against the other component, keeping constant their Sum **E = Ed + Ek**, according to the Conservation of Energy principle. This can be expressed-mathematically with the equation of power

$$\mathbf{\Delta\Delta_1.Po_1 = \Delta\Delta_2.Po_2} \text{ measured in [W]} \quad (2)$$

where 1 and 2 = indicators to parameters in the sides of transformer

In the ideal form, without taking into account the energy losses.

For the realization of the energy transformation while in reality it is expressed by the equation:

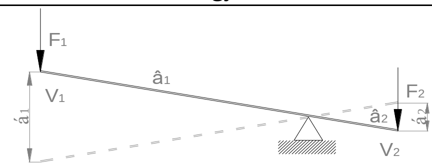
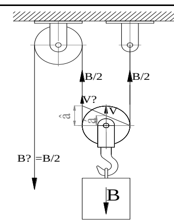
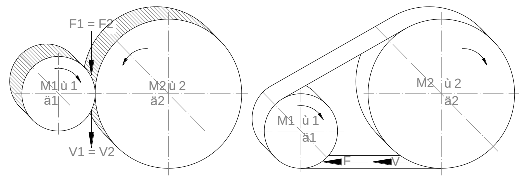
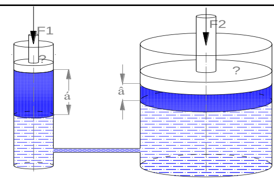
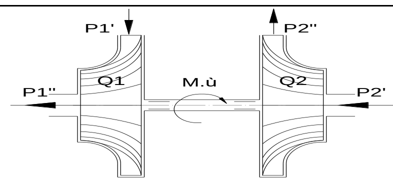
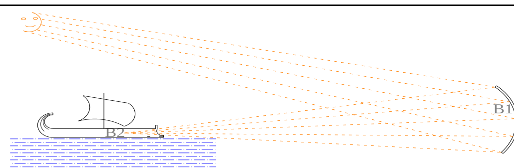
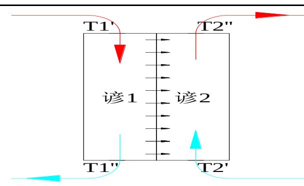
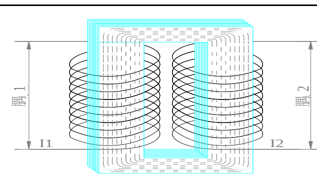
$$\Delta\Delta_1.Po_1.\eta = \Delta\Delta_2.Po_2 \text{ measured in [W]} \quad (3)$$

where **η** = energy efficiency.

1 and 2 = indicators to parameters in the sides of transformer

The equations and schematic representation of known energy transformations of different forms of energy as well as their generalized form are given in Table 2.

Table 2 Calculation of Energy Transformer and Their Schematic Presentation

Form of energy	Scheme of energy transformers
Transformation of mechanical energy linear motion (Archimedes lever) $\mathbf{F_1.V_1.\eta = F_2.V_2}$	
Transformation of mechanical energy linear motion (Archimedes polyspast) $\mathbf{B_\sigma.V_\sigma.\eta = B.V}$	
Transformation of mechanical energy rotation motion $\mathbf{M_1.\omega_1.\eta = M_2.\omega_2}$	
Transformation of mechanical energy static fluid (hydraulic press) $\mathbf{F_1.V_1.\eta = F_2.V_2}$	
Transformation of mechanical energy dynamic fluid (turbine - turbocompressor) $\mathbf{\Delta P_1.Q_1.\eta = \Delta P_2.Q_2}$	
Transformation of Light energy (focusing of light) $\mathbf{B_1.S_1.\eta = B_2.S_2}$	
Transformation of thermal energy (heat exchanger) $\mathbf{\Delta T_1.P\theta_1.\eta = \Delta T_2.P\theta_2}$	
Transformation of electrical energy (electrical transformer) $\mathbf{\Delta U_1.I_1.\eta = \Delta U_2.I_2}$	
$\mathbf{\Delta A_1.Po_1.\eta = \Delta A_2.Po_2}$	General equation of energy transformation

Energy transformation in all forms of energy take place with a specific relation called transformation ration and in ideal condition is equal to

$$\boldsymbol{\lambda\mu} = \frac{\Delta\Delta_1}{\Delta\Delta_2} = \frac{Po_2}{Po_1} \quad (4)$$

while the real conditions are

$$\boldsymbol{\lambda\mu} = \frac{\Delta\Delta_1}{\Delta\Delta_2} \cdot \eta = \frac{Po_2}{Po_1} \quad (5)$$

and are presented in Table 3.

Table 3 Ratio of Transformation Different Energy Transformers

Transformation of different form of energy		**Ratio of transformation the energy transformers**
Mechanical energy linear motion	**$F_1.V_1.\eta = F_2.V_2$** =>	$\lambda\mu = \frac{F_1}{F_2}.\eta = \frac{V_2}{V_1} = \frac{\beta_2}{\beta_1}$
Mechanical energy rotary motion	**$M_1.\omega_1.\eta = M_2.\omega_2$** =>	$\lambda\mu = \frac{M_1}{M_2}.\eta = \frac{\omega_2}{\omega_1} = \frac{d_1}{d_2}$
Mechanical energy static fluid	**$F_1.V_1.\eta = F_2 . V_2$** =>	$\lambda\mu = \frac{F_1}{F_2}.\eta = \frac{V_2}{V_1} = \frac{d_1^2}{d_2^2}$
Mechanical energy dynamic fluid	**$\Delta P_1.Q_1.\eta = \Delta P_2.Q_2$** =>	$\lambda\mu = \frac{\Delta P_1}{\Delta P_2}.\eta = \frac{Q_2}{Q_1}$
Light energy	**$B_1.S_1.\eta = B_2.S_2$** =>	$\lambda\mu = \frac{B_1}{B_2}.\eta = \frac{S_2}{S_1} = \frac{S_2}{S_1}$
Thermal energy	**$\Delta T_1.P\theta_1.\eta = \Delta T_2.P\theta_2$** =>	$\lambda\mu = \frac{\Delta T_1}{\Delta T_2}.\eta = \frac{P\theta_2}{P\theta_1}$
Electrical energy	**$\Delta U_1.I_1.\eta = \Delta U_2.I_2$** =>	$\lambda\mu = \frac{\Delta U_1}{\Delta U_2}.\eta = \frac{I_2}{I_1} = \frac{n_2}{n_1}$
General form Conforming with the **Conservation of Energy Principle**	**$\Delta\Delta_1.Po_1.\eta = \Delta\Delta_2.Po_2$** =>	$\lambda\mu = \frac{\Delta\Delta_1}{\Delta\Delta_2}.\eta = \frac{Po_2}{Po_1} = \chi\mu$

Where b_1 και b_2 = the lever of transformer type Archimedes lever

d_1 και d_2 = diameter of wheel transformer the rotation motion

d_1^2 και d_2^2 = diameter square the piston of the hydraulic press

n_1 και n_2 = number of windings of the electrical transformer

The transformation ratio **λμ** of each energy transformer is determined by the specific characteristic **χμ** where **λμ = χμ**: such as the ratio of the lever's lengths into lever transmission, the ratio of diameters in rotation transmission, the ratio of the squares of diameters of pistons in the hydraulic press, the ratio of the mirror surface in the light energy, the ration of number of windings to electrical transformers etc.

From Tables 1, 2, and 3 is found that the power of energy transformations and the ratio of transformation in each form of energy are expressed by the same equations, so that they can be expressed in their generalized form as:

- Power of energy transformation $N = \Delta\Delta.Po$ (6)
- Ideal equation of power the energy transformation $\Delta\Delta1.Po1 = \Delta\Delta2.Po2$ (7)
- Real equation of power the energy transformation $\Delta\Delta1.Po1.\eta = \Delta\Delta2.Po2$ (8)
- Ideal ratio of energy transformation $\boldsymbol{\lambda\mu} = \frac{\Delta\Delta_1}{\Delta\Delta_2} = \frac{Po_2}{Po_1}$ (9)
- Real ratio of energy transformation $\boldsymbol{\lambda\mu} = \frac{\Delta\Delta_1}{\Delta\Delta_2}.\eta = \frac{Po_2}{Po_1}$ (10)

that represents the Conservation of Energy Principle called Principle of Democritus.

2.3 Energy Transfers

Energy transfer is also a process. In order to be achieved is required a potential difference **ΔΔ** and a conductor with conductivity **Aγ**. With these data **ΔΔ** and **Aγ** the flow **Po** is created through the conductor which for each form of energy is formulated mathematically with the equation

$$\mathbf{Po = \Delta\Delta.A\gamma} \quad (6)$$

In electrical science the reverse concept of conductivity **Aγ** is usually used**,** i.e., the resistance **Aν,** where $\mathbf{A\nu} = \frac{\mathbf{1}}{\boldsymbol{A\gamma}} = \frac{\boldsymbol{\Delta\Delta}}{\boldsymbol{Po}}$, which is known this ratio $\boldsymbol{A\nu} = \mathbf{R} = \frac{\boldsymbol{\Delta U}}{\boldsymbol{I}}$ as Ohm's law and easily understood in Figure 2.

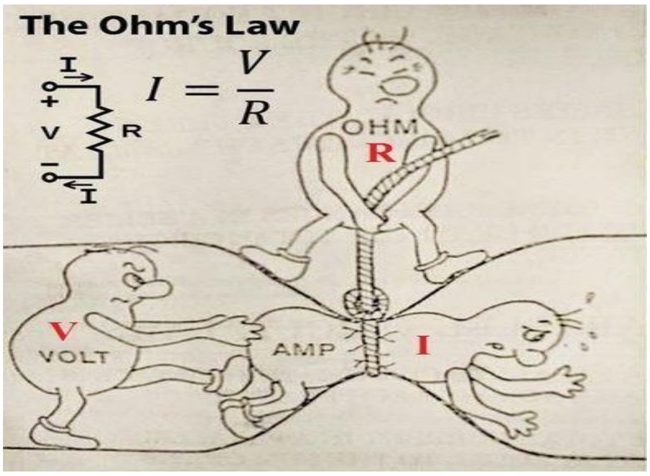


Figure 2 Schematic Representation of Ohm's Law

Ohm's law $\mathbf{R} = \frac{\boldsymbol{V}}{\boldsymbol{I}}$ is a special expression of the resistance $\mathbf{A\nu} = \frac{\boldsymbol{V}}{\boldsymbol{I}} = \frac{\boldsymbol{\Delta\Delta}}{\boldsymbol{Po}}$ in the electrical science. In generalized form there is resistance $\mathbf{A\nu} = \frac{\boldsymbol{\Delta\Delta}}{\boldsymbol{Po}}$ for all forms of energy. The same goes for the conductivity $\mathbf{A\gamma} = \frac{\mathbf{1}}{\boldsymbol{A\nu}} = \frac{\boldsymbol{Po}}{\boldsymbol{\Delta\Delta}}$ that is the inverse of the resistance **Aν**.

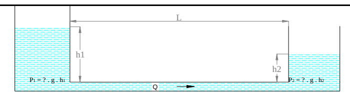
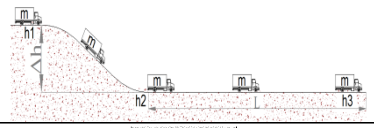
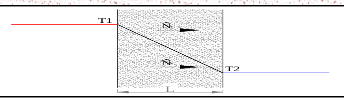
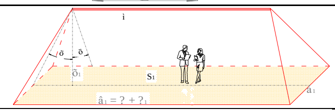
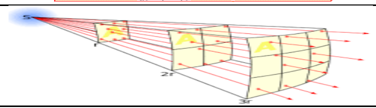
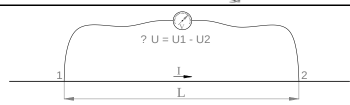
In all forms of energy in order for the energy transfer to take place, a driving force is required, which is the Potential Difference **ΔΔ** and depending on the conductivity **Aγ** of the conductor (or those who prefer the resistance **Aν** on the conductor, **Aν = 1/Aγ**) the flow **Po** in the conductor is determined.

The mathematical formulation of the flows **Po** and the conductivity **A**γ, for the various forms of energy are presented in Table 4 as well as their generalized formulation.

In all forms of energy, the flow **Po = ΔΔ.Aγ** is the product of potential difference **ΔΔ** with the conductivity **Aγ,** increases by the increase potential difference **ΔΔ** and the increase of conductivity **Aγ**.

In all forms of energy, the conductivities $\boldsymbol{A\gamma} = \frac{\boldsymbol{Po}}{\boldsymbol{\Delta\Delta}}$ are the ratio of flow **Po** to potential difference **ΔΔ**. For the calculation of conductivity **Aγ** there is always the ratio **S/L** which is the cross section **S** of the conduit to the length **L** of conduit, expressing one of the main characteristics of the conduit through which the flow. Each form of energy during its transfer may have specific features, but the same basic principles remains the same.

Table 4 The Mathematic Equation for Flow and Conductivity of Conduit

Energy transfer	**Flow**	**Conductivity of conduit**	**Scheme of energy transfer**
Transfer of fluid load	Q = ΔP.Aγ	$A\gamma = \frac{Q}{\Delta P} = \frac{Q.2.d.S}{Q^2.\rho.\xi}.\frac{\boldsymbol{S}}{\boldsymbol{L}}$	
Transfer of solid load	Po = Δh.Aγ	$A\gamma = \frac{Po}{\Delta h} = \frac{m.g.\sqrt{2.g}}{\Delta h\,.\sqrt{\mu.L}}$	
Transfer of heat by conductivity	Pθ = ΔT.Aγ	$A\gamma = \frac{P\theta}{\Delta T} = \frac{\lambda\ .\ \boldsymbol{S}}{\Delta T.\ \boldsymbol{L}}$	
Transfer of heat by radiation	Pθ = ΔA.Aγ	$A\gamma = \frac{S}{\Delta A} = \frac{S}{E_{\theta\alpha}}.\frac{\boldsymbol{S}}{\mathbf{L}}.\frac{{\upsilon_0}^2}{(\upsilon_1+\upsilon_0)}$	
Transfer of light energy	S = ΔB.Aγ	$A\gamma = \frac{S}{\Delta B} = \frac{S}{I_o.(\frac{e^{-\mu L}}{{r_1}^2} - \frac{1}{{r_0}^2})}$	
Transfer of electric energy	I = ΔU.Aγ	$A\gamma = \frac{I}{\Delta U} = \frac{I}{I}.\sigma.\frac{S}{L}$	
Generalized formulation	Po = ΔΔ.Aγ	$A\gamma = \frac{Po}{\Delta\Delta}$	

Whit the potential difference **ΔΔ** and the flow **Po**, which are parameters of the dynamic and kinetic energy of the flow, three different important characteristics are identically defined in all flows, of all forms of energy (Koumbakis, 2019).

- The power of flow, which is N = ΔΔ.Po
- the conductivity of conductor $\boldsymbol{A\gamma = \frac{Po}{\Delta\Delta}}$
- the resistance of conductor $\boldsymbol{A\nu = \frac{\Delta\Delta}{Po}}$

Power transfer, as process, in order to take place also requires energy which means that the input power to each power transmission line is greater than that off their output power. Meaning that $\mathbf{N_i > N_o}$ or in equation $\mathbf{N_i\text{-}N_L = N_o}$ where $\mathbf{N_L}$ is the power of the energy losses and it is equal to $\mathbf{N = \Delta\Delta_L.Po}$.

Flow Po based on the Conservation of mass Principle stays constant. So it follows that $N_i = \Delta\Delta_i.Po - \Delta\Delta_L.Po = \Delta\Delta_o$. Po and $(\Delta\Delta_i - \Delta\Delta_L) = \Delta\Delta_o$

that is true for all transfers of all forms of energy according to Conservation of Energy Principle (Principle of Democritus).

It is concluded that by teaching the behavior of energy in a generalized form, the student can easily understand how flow is created and the behavior of flows of all forms of energy. The flow exist, i.e., Po > 0, when there is a positive potential difference ΔΔ > 0 which is its generative cause.

The power **N** of flow is the product of the potential difference **ΔΔ** and the flow **Po** that created and it is **N = ΔΔ.Po**.

Precondition for the creation of each flow is the dynamic energy which expressed by the potential difference **ΔΔ** must be positive **ΔΔ** > 0.

This is also shown in the schematic representation of the equilibrium (balance) states in Figure 3.

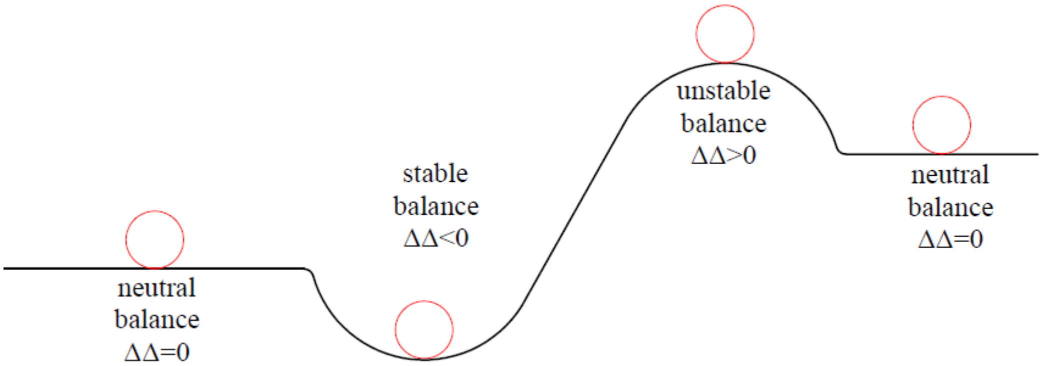


Figure 3 States of Balance in Relation to the Potential Difference ΔΔ

The flow **Po** expressing the kinetic energy is the obvious result the potential difference **ΔΔ** that expresses the dynamic energy. In any form of energy the flow **Po** can not exist without a positive potential difference **ΔΔ > 0** and a positive conductivity **Aγ > 0** which is also proved by the mathematical formulation of the flow **Po = ΔΔ.Aγ**, which applies to all flows.

3. Application of Conclusions of Energy Flows to Physical and Social Flows

From the energy flows it is concluded that flow **Po** exists, i.e., **Po** > **0** when there is a generative cause which is the positive potential difference **ΔΔ** > **0**. The magnitude of the flow **Po** is determined by the product of the potential difference **ΔΔ** and the conductivity **Aγ** of the conductor through the flow **Po = ΔΔ.Aγ.** It is observed that, like energy flows, the natural flows behave similarly, e.g., winds, sea currents, water currents, migratory flows of birds, animals and fish obey the same rules of these energy flows. Flows are generated by a positive potential difference **ΔΔ** > **0** and are allowed to flow from the positive conductivity **Aγ** > **0** of conductor, forming the magnitude of the flow **Po = ΔΔ.Aγ.**

The flows are created by the energy potential difference **ΔΔ** so the laws that define them work in all the flows, energy, physical, flows of natural and social origin, migration and refugee flows.

In migration-refugee flows the potential difference **ΔΔ** is as in the natural flows the lack of energy (lack of food), energy in its extended sense (material and spiritual food).

This potential difference **ΔΔ** refers also as the difference of misery of people's population in relation to the degree of misery of other nearby or distant populations. When the potential difference (of misery) is zero **ΔΔ = 0** then people are in an indifferent state of equilibrium and the migration-refugee flows are zero **Po = 0**.

When the misery increases, coming of different measures of values, like economic reasons, security, politics, religious, employment, causes an increase in the number of people (according to the Gauss's graph about crowd's behavior) that forced to abandon their hometown, taking the risk of the journey to the unknown, the migration-refugee life and the compromise with other values for their survivor.

One of the most significant factors to cause the positive difference potential **ΔΔ** > **0** is the economic one which expresses the material food, i.e., the immediate expression of energy. This is why the migration-refugee flows compile with the laws of energy. The larger the misery difference (**ΔΔ** potential difference) the larger crowds are affected, forming the size of the **Po** migration-refugee flow. The product of the difference potential **ΔΔ** and the flow **Po** determines the strength of the migration-refugee flow **N = ΔΔ.Po** and the impacts of its arrival.

3. Conclusions

From the analysis of energy transformation and energy transfer it can be concluded that the different forms of energy behave identically.

The energy transformations of all forms of energy they have scope to change the available parameters of potential difference $\mathbf{\Delta\Delta_1}$ and flow $\mathbf{Po_1}$, which are the expressions of dynamic and kinetic energy, in the desired parameters of difference of potential $\mathbf{\Delta\Delta_2}$ and flow $\mathbf{Po_2}$**,** reinforcing one at the expense of the other, but keeping constant the sum of the energies expressing **E = Ed + Ek.**

Energy transformations are carried out according to the general form of energy transformation equation ΔΔ1.Po1.η = ΔΔ2.Po2 and the ratio transformation each form of energy where is $\boldsymbol{\lambda\mu = \frac{\Delta\Delta_1}{\Delta\Delta_2} . \eta = \frac{Po_2}{Po_1}}$ determined by the characteristics χμ of the transformer. With the two parameters ΔΔ and Po are determinates the

- The power of transformer **N = ΔΔ.Po** and
- The ratio of transformation $\boldsymbol{\lambda\mu = \frac{\Delta\Delta_1}{\Delta\Delta_2} . \eta = \frac{Po_2}{Po_1}}$

The energy transfer of the various forms of energy are energy flows and require a positive difference $\mathbf{\Delta\Delta > 0}$ and a conductor with a positive conductivity $\mathbf{A\gamma > 0}$ for the flow to flow **Po.** As the flow **Po** passes through the conductor creates the resistance **Aν** (**Aν** = 1/**Aγ**) which needs to interact with the difference potential **ΔΔ**, generative cause of the flow **Po**. In order the flow **Po** to pass through the conductor requires energy consumption which in the unit of time is the power of the energy losses $\mathbf{N_L = \Delta\Delta_L.Po.}$

The identical way of creating and behaving in the different forms of energy makes it possible to understand the flows in the generalized form of their laws. With the two parameters of the flow in generalized form, i.e., the potential difference **ΔΔ** and the flow **Po**, are determined, by their product and ratio, other basic characteristics of the flow such a power, conductivity and resistance:

- The power of flow **N = ΔΔ.Po**
- The conductivity of conduit $\boldsymbol{A\gamma = \frac{Po}{\Delta\Delta}}$
- The resistance of conduit $\boldsymbol{A\nu = \frac{\Delta\Delta}{Po}}$

So the student can easily understand that each form of energy can have peculiarities but the basic principles of flows remain the same. The concept of flow is not limited to mechanical, hydraulic, thermal, light and electrical flows, it is flow in general. Flows are also the natural, migratory flows, the productive flow, the economic flow as well as the social flows. All flows are governed by the same rules because they are the result of energy processes in the broadest sense of the word energy. Students are given the opportunity to understand energy flows in general in all forms of energy and with the same rules to understand even partially the physical and social flows.

It is reasonable that the presentation at the conference could not be the complete reflection of the vision for energy education expressed in its generalized form. More and more details can be found by those who are interested in the basics of mechanical and electrical sciences in the book “About Energy” published in 2019 in Thessaloniki.

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