SEE - Society Energy and Environment: *The "Zeroth Religion" for Everybody!*

Energy and Entropy: *Holistic Reasoning of Nature Laws - Fundamentals and Future Challenges*

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Synopsis (PDF):

"If an educated person has to be aware of the literary work of Shakespeare, then that person should also be aware of the 'Entropy' concept...
... Nothing occurs locally, nor globally in the universe, without mass-energy exchange/conversion and entropy production."

Energy, as the 'building block' of all material and space existence, and as the cause for all (re)creations in time, could be metaphorically considered as the most basic '*Zeroth Religion*' - with all due respect to the '*First Religion*' - the way the *Zeroth Law* of thermal equilibrium is more basic than the grandiose *First Law* of energy conservation in Thermodynamics. Energy is more than universal currency. The world view, from inside to outside, is only possible, figuratively and literally, through the energy prism. From shining stars to rotating planets, to global water, atmospheric and life cycles, to evolution, industrialization and modernization of civilization, energy is the cause and measure of all there has been, it is, and will be.

Entropy is the most used and often abused concept in science, but also in philosophy and society. Further confusions are produced by some attempts to generalize the entropy with similar but not the same concepts in other disciplines. What is the underlying nature of 'entropy' and why does it always increase? Why is entropy so intriguing and mysterious, unique and universal, as if it is a miraculous property of natural, material systems? How does it encompass and quantify all processes at all natural space and time scales, governed by the *Second Law* of Thermodynamics? And many other elusive and debatable issues, as if *entropy* is among the deepest unresolved mysteries in nature, defying our common sense.

Energy is the cause for all processes across all space and time scales, including global and historical changes. Energy is both the cause and consequence of formation and transformation within the universe at the grand scale, down to the smallest sub-nano structures within an atom nucleus and electromagnetic radiation - everything we are capable of observing and comprehending. Energy warms our planet Earth and keeps it alive. It moves cars and trains, and boats and planes. Energy bakes foods and keeps them frozen for storage. It heats and lights our homes and plays our music. Energy makes our bodies to grow and alive, and allows our minds to think. Through centuries people have learned how to harvest and use energy in different forms in order to do work more easily and live more comfortably.

Zooming in through the space and history from the formation of our planet Earth some 4.5 billion years ago, it has been changing ever since due to energy exchanges or "energy flows" in different astrophysical, geological, thermo-physical, electro-chemical, biological, and intellectual processes. Hundreds of millions of years ago, life emerged from the oceans and transformed the landscape. Just a few million years ago the first human species evolved and began their own process of interaction with the environment, our planet Earth. About one million years ago our own species, *homo sapiens*, first appeared, strived most of the history and boomed with agricultural and industrial revolution, after learning how to harvest, control and use energy.

The human metabolism, to maintain life, is approximately equal to the dietary energy-rate reference value of 2000 *kcal/day*, which is equivalent to 97 *Watt*. Human sustained working power is about 75 *W* or one tenth of the "horse power." The human muscular power bursts may be a hundred times greater than the basal metabolic or sustained power. In comparison, the World's population is over 7 billion with total energy consumption about 2.2 *kW/c* (*per capita* or person), compared to over 0.3 billion population and 11.3 *kW/c* in the U.S. (the total energy rate in *kW* needs to be scaled by usual 33% efficiency to be qualitatively compared with electrical energy rate in *kW*). The corresponding *per capita* electricity consumption rates are about 0.3 *kW/c* and 1.5 *kW/c* in the World and the U.S., respectively.

All energy coming to the Earth surface is 99.98 % solar, 0.018% geothermal and 0.002% tidal-gravitational. About 15 *TW* (*Tera-Watt*, or 2.2 *kW/capita*, i.e. per person) the world energy consumption rate now, represents only 0.008%, a tiny fraction of the solar energy striking Earth, and is about 6 times smaller than global photosynthesis (all life), the latter is only 0.05% of total solar, and global atmospheric water and wind are about 1% of solar energy. As an ultimate energy source for virtually all natural processes, the solar energy is available for direct 'harvest' if needed, and is absorbed by vegetation and water surfaces on Earth, thus being the driving force for natural photosynthesis, and in turn for biosynthesis processes, as well as natural water cycle and all atmospheric processes. The solar radiation power density incident to the Earth atmosphere, known as the *Solar Constant*, is 2 $cal/min/cm^2$ or 1.4 kW/m^2, which after taking into account average day/night time (50%), varying incident angle (50%) and atmospheric/cloud scatter and absorption (53%), reduces to only $0.5 \cdot 0.5 \cdot 0.47 = 11.7\%$ of the Solar Constant, or about 165 W/m^2 at the Earth surface, as all-time average.

Let us not be fooled by lower oil prices now due to unforeseen technological development and economic recession! If the man-made *Global Warming* is debatable, the two things are certain in not distant future: (1) the world population and their living-standard expectations will substantially increase, and (2) the fossil fuels' economical reserves, particularly oil and natural gas, will substantially decrease. The difficulties that will face every nation and the world in meeting energy needs over the next several decades will be more challenging than what we anticipate now. The traditional solutions and approaches may not solve the global energy problems. New knowledge, new technology, and new living habits and expectations must be developed to address both, the quantity of energy needed to increase the standard of living world-wide and to preserve and enhance the quality of our environment.

However, regardless of imminent issues about the fossil fuels and related environmental impact, the outlook for future energy needs and environmental sustainability is encouraging. Energy conservation "with existing technology" (insulation, regeneration, cogeneration and optimization with energy storage) has real immediate potential to substantially reduce energy dependence on the fossil fuels and enable use of alternative and renewable energy sources. There are many diverse and abundant energy sources with promising future potentials, so that

mankind should be able to enhance its activities, standard and quality of living, by diversifying energy sources, and by improving energy conversion and utilization efficiencies, while at the same time increasing safety and reducing environmental pollution.

After all, in the wake of a short history of fossil fuels' abundance and use (a blip on a human history radar screen), *the life may be happier after the fossil fuel era*! More at: www.kostic.niu.edu/energy

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Brief Biography of the Speaker:

Milivoje M. Kostic, Ph.D., P.Eng., *Professor Emeritus* of Mechanical Engineering at Northern Illinois University, Licensed *Professional Engineer* in State of Illinois (USA) and *Editor-in-Chief of Thermodynamics* of Entropy Journal, is a notable researcher and scholar in energy fundamentals and applications, including nanotechnology, with emphasis on conservation, environment and sustainability. He graduated with the University of Belgrade highest distinction (the highest GPA in ME program history), obtained Ph.D. at University of Illinois at Chicago as a Fulbright scholar, appointed as NASA faculty fellow, and Fermi and Argonne National Laboratories faculty researcher. Professor Kostic also worked in industry and has authored a number of patents and professional publications, including invited articles in prestigious energy encyclopedias. He has a number of professional awards and recognitions, is a frequent keynote plenary speaker at international conferences and at different educational and public institutions, as well as member of several professional societies and scientific advisory boards. More at www.**kostic**.niu.edu

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Professor Kostic's teaching and research interests are in Thermodynamics (a science of energy, the *Mother of All Sciences*), Fluid Mechanics, Heat Transfer and related fluid-thermal-energy sciences; with emphases on physical comprehension and creative design, experimental methods with computerized data acquisition, and CFD simulation; including nanotechnology and development of new-hybrid, POLY-nanofluids with enhanced properties, as well as design, analysis and optimization of fluids-thermal-energy components and systems in power-conversion, utilizations, manufacturing and material processing. Dr. Kostic came to Northern Illinois University from the University of Illinois at Chicago, where he supervised and conducted a two-year research program in heat transfer and viscoelastic fluid flows, after working for some time in industry.

Kostic received his B.S. degree with the University of Belgrade Award as the best graduated student in 1975. Then he worked as a researcher in thermal engineering and combustion at The Vinca Institute for Nuclear Sciences, which then hosted the headquarters of the International Center for Heat and Mass Transfer, and later taught at the University of Belgrade in ex-Yugoslavia, Serbia now (MFB). He came to the University of Illinois at Chicago in 1981 as a Fulbright grantee, where he received his Ph.D. in mechanical engineering in 1984. Subsequently, Dr. Kostic worked several years in industry. In addition, he spent three summers as an exchange visitor in England, West Germany, and the former Soviet Union.

Dr. Kostic has received recognized professional fellowships and awards, including multiple citations in Marquis' "Who's Who in the World" and "Who's Who in Science and Engineering."; the Fulbright Grant; NASA Faculty Fellowship; Sabbatical Semester at Fermilab as a Guest Scientist; and the summer Faculty Research Participation Program at Argonne National Laboratory. He is a frequent reviewer of professional works and books in Thermodynamics and Experimental Methods. Dr. Kostic is a licensed professional engineer (PE) in Illinois and a member of the ASME, ASEE, and AIP's Society of Rheology. He has a number of publications in refereed journals, including invited state-of-the-art chapters in the Academic Press series Advances in Heat Transfer, Volume 19, and "Viscosity" in CRC Press' Measurement, Instrumentation and Sensors Handbook; as well as invited reference articles: Work, Power, and Energy in Academic Press/Elsevier's Encyclopedia of Energy; Extrusion Die Design in Dekker's Encyclopedia of Chemical Processing; and Energy: Global and Historical Background, and Physics of Energy, *both in* Taylor & Francis/CRC Press Encyclopedia of Energy Engineering and Technology. Professor Kostic is a member of the Graduate Faculty at Northern Illinois University.