# Comment
# Constructal law in technology, thermofluid and energy systems, and in design education
# Comment on "The Constructal Law and the evolution of design in nature" by Bejan and Lorente

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It has been said many times in one form or another that there is nothing more understandable and practical than a simple theory. As engineers and scientists, we are always looking for a simple theory, law or equation in every engineering science to explain behaviours and to use as design tools. Examples of such simple theories are Bernoulli's law in fluid mechanics [1], the first and second laws in thermodynamics [2], Fourier's law in conduction heat transfer [3] and Newton's law for convective heat transfer [4].

Design, on the other hand, has been viewed by many as the subject (I am specifically not using the word "science") which is an art in which the engineering sciences are creatively synthesised and where industry experience is preferable and in many cases essential. It may involve considerable research, thought, modelling, interactive adjustment and redesign. What it surely is not - is the application of a simple theory.

Because of the lack of industry experience, many university professors find it challenging to teach design to engineering students. Optimisation methods [5] have, however, been developed recently with many objective functions, which now make it possible to conduct designs [6-8] that rely on optimisation procedures. The objective functions now include not only "engineering science parameters" such as dimensions, temperatures and heat transfer rates, but also parameters that quantify parameters such as economics, safety, aesthetic, manufacturability, maintainability and impact on the environment. It shows that design is in many cases not an art anymore and that very good designs can be produced by people with very little industry experience and that optimum designs should be driven by a simple law. However, all these designs are not about the time direction of the "movie" of design generation and evolution and it is not about optimally end design, destiny or entropy. The concept that constructal law defines in physics is "design" (configuration) as a phenomenon in time.

The outstanding review by Bejan and Lorente [9] shows how constructal law, since its discovery in 1996, by Bejan [10], has distinguished itself from many others in that it is not limited to physics or specifically thermodynamics or heat transfer. It is applicable to many other fields outside the natural sciences such as geography, the design of human movement, wealth and communication. What it does where many other equations, laws or theories fail is to unite all fields including design. Constructal law is a theory about the time direction of global optimisation and it explains in a simple manner the shapes that arise in nature. Flow architecture comes from a principle of maximisation of flow access, in time, and in flow configuration that is free to morph. This theory is unlike the belief that nature is fractal, and it allows engineers to analyse systems with boundary conditions under constraints in a pursuit to optimality.

Applications where constructal law was successfully used in technology, thermofluids and energy systems and in the education of design are with the design of microchannels to be used in the cooling of heat sinks [11], obtaining an increase in the heat transfer rate density by using wrinkled entrance regions [12], multiscale plate assemblies [13], pin-fins [14], microchannel heat sinks [15], rotating cylinders in cross-flow [16] and the thermodynamic

optimisation of the integrated design of solar thermal cycles [8]. The road to future advances with the constructal law is wide open.

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