



## **The unavoidable uncertainty of renewable energy and its management**

Demetris Koutsoyiannis

National Technical University of Athens

Conventional energy systems gave the luxury of a fully controllable and deterministically manageable energy production. Renewable energies are uncertain and often unavailable at the time of demand. Wind and solar energies are highly variable, dependent on atmospheric and climatic conditions and unpredictable. The related uncertainty is much higher than commonly thought, as both the wind and sunshine duration processes exhibit Hurst-Kolmogorov behaviour. Lack of proper modelling of this behaviour results in overestimation of wind and solar energy potentials, and frequent “surprises” of persisting low (or high) production. Proper modelling of the uncertainty is a necessary step for renewable energy management. This latter requires both structural measures—in particular integration with pumped storage hydropower systems—and optimization methodologies for the operation of large-scale hybrid renewable energy systems. These key ideas are illustrated with a case study for a big district of Greece.