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## Presenting Author: Wanlin Guo

Co-Authors: Zhuhua Zhang, Xuemei Li, Jun Yin

Institute of Nano Science, Nanjing University of Aeronautics and Astronautics.

Nanjing, 210016, China

wlguo@nuaa.edu.cn

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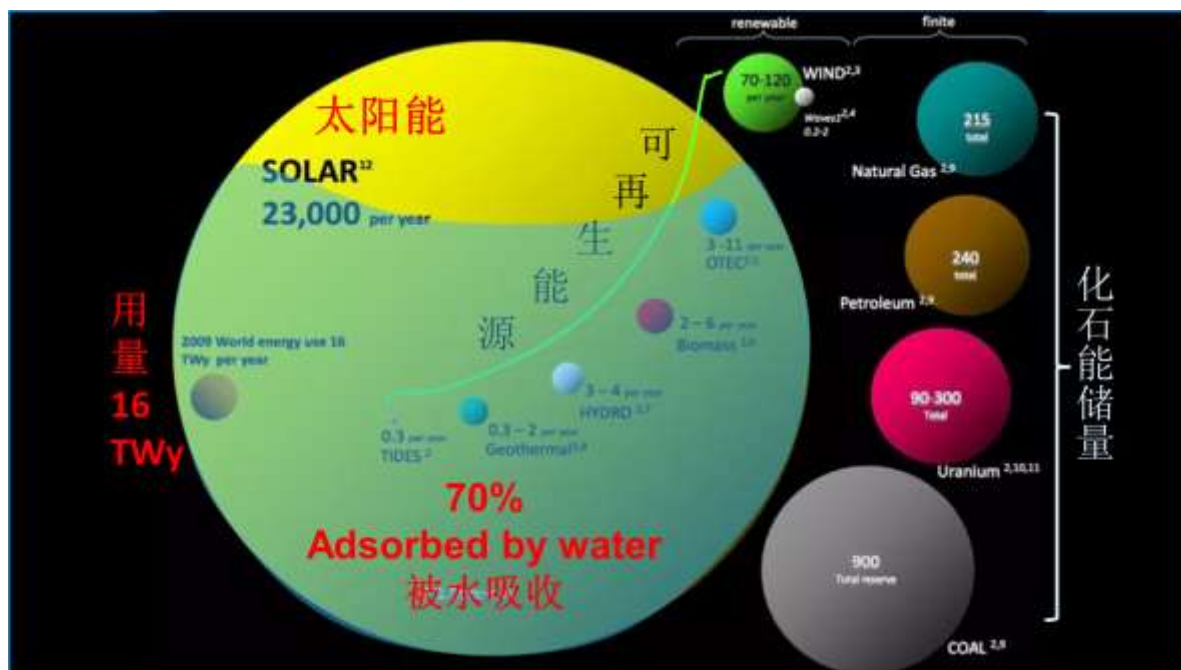
# Emerging Hydrovoltaic Technology

Water is not only the essence of life, but also the largest energy carrier on earth. Water covers about 70% of the earth's surface, absorbing 70% of the solar energy arriving the earth, and in the atmosphere it can exist in liquid, gaseous and solid states. In human history, through a variety of scientific principles, such as running water driven wheel, steam locomotives, water driven generator as well as the electrokinetic effects, the potential energy or kinetic energy of water can be converted into useful mechanical motion and electrical energy according to the principles of classical mechanics and electromagnetic dynamics. In recent years, we have theoretically and experimentally investigated the fluid-solid-electric coupling functionalization of graphene and other two-dimensional materials. It is found that carbon nanostructures can generate electricity from water energy by direct interaction with water, even by natural water evaporation from cheap carbon nanomaterials, a phenomenon that we termed as hydrovoltaic effect, which potentially extends the technical capability of water energy harvesting and enables creation of self-powered devices. Here, starting by presenting the water energy on the earth, fundamental properties of water and water-solid interfaces, we discussed basic mechanisms of harvesting water energy by carbon nanostructured materials and key aspects pertaining to water-carbon interaction. Experimental advances in generating electricity from water flows, waves, especially natural water-evaporation were then reviewed to show correlations in mechanisms and potential for integration, offering a prospect of harvesting energy from the nature cycle of water on the earth. Main challenges in promoting the energy conversion efficiency and scaling up the output power will be outlined, and finally discuss potential development and applications of the hydrovoltaic technology.

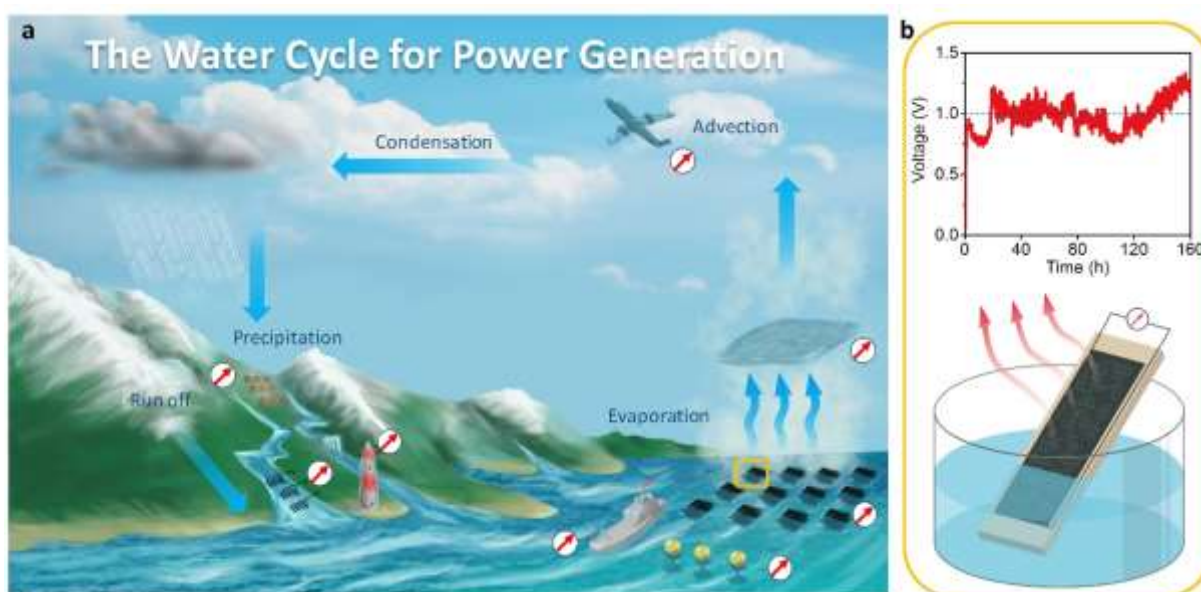
## References

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## Figures



**Figure 1:** About 70% solar energy arrive the earth is adsorbed by water and half of adsorbed energy consumed by natural evaporation. The world energy consumption, reproducible energy, and the primary energy sources are illustrated in proportional to the solar energy.



**Figure 2:** Harvesting the energy from the water cycle of the earth. (a) Devices for the energy harvesting(ref.6). (b) Electricity generation from natural water evaporation in ambient environment by carbon nanomaterials (ref.5).