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To explore biomimicry potential for the energy industry, three promising biomimetic strategies will be presented at various scales and operational examples given to illustrate them: collection of renewable energy with systems composed of abundant materials, combination of energy flow with matter cycle and the reduction of energy loss.

First, the coming energy transition represents the switch from a technological world tapping into a finite stock of carbon-based energy carriers (such as oil or coal), to a technological world forming energy stocks from flows of non-carbon-based energy carriers (such as photon or water). From a biological standpoint, it's the integration of the role of primary producer within our technological world. This is a profound emancipation and a considerable reduction of the weight that today lies on the biosphere's shoulder. Such transition only appears as a solution if the systems built to perform such energy collection are made with abundant material, leaving aside rare earth elements and other polluting materials. In the current state of knowledge, any other solutions are just shifting the problem elsewhere. This requirement on matter isn't optional, it's just the other face of the same coin and as such can't be distinguished from the energy transition. The replacement of Rare Earth Element (REE) in energy systems has been extensively studied by many research teams, targeting sugar-based battery [1], bio-inspired, heavy-metal-free, dual-electrolyte liquid battery [2], nickel-centred proton reduction catalysis in a model of [NiFe] hydrogenase [3], or the replacement of platinum group metal electrodes by [FeFe] hydrogenase [4].

Secondly, if flows of non-carbon-based energy carriers are considered as the main inputs of our global system, then the living world invites us to store energy in the form of matter (such as solar fuel or H2). Coupling energy and matter is a key foundation of living beings' relation with their environment. If we only reject in the atmosphere the matter we've taken from it, then the overall equation evens out (which is almost the case for the living world) and the rising in the quantity of polluting gases can finally stop. In order to reach this objective, numerous initiatives focused on transferring one of the key biological energy processes to technology: photosynthesis. Since Pr. Nocera initial work on the artificial leaf at MIT [5], artificial photosynthesis has been studied step by step by various research teams all around the world [6], [7], [8] to make it an operational reality. Recent advancement in the industrial sector shows promising appropriation of research results, such as the Rheticus project by Evonik and Siemens lunched in 2019 (https://press.siemens.com/global/en/pressrelease/research-project-rheticus). If artificial photosynthesis gives human society the ability to improve photosynthesis' original yield (around 1% in leaves), it should not be forgotten that this apparent low efficiency may be the cost for a highly robust, eco-designed, and multifunctional system. Biomimicry invites us to change our point of view toward multifunctional optimization rather than a clear maximisation of only a few functions which only happens facing extreme constraints in the living world (like systems that survive to high temperature and water loss in the desert which are highly adapted but not at all adaptable).

Finally, energy use is a key selective pressure in the living world, which means that with time, biological systems that aren't optimized from an energetic standpoint, disappear. Modern energetic and political crisis lead humanity to face such a critical selective pressure, and, with time, to select systems for their ability to properly distribute energy without loss at the network scale and to perform functions with as little use of external of energy as possible, at the scale of product. Such a switch towards a proper allocation of energy to relevant systems while promoting sobriety is a key success factor of the transition to come. Amongst the most promising axes for improvement, building insulation [9], transversal valorisation of heat loss, drag management [10], material production at ambient pressure and temperature, systems multifunctionality, systems self-sufficiency in energy, systems circadian cycle behaviour (variable functioning during the day or at night), etc. can be mentioned. From the standpoint of power network, such needs to properly regulate energy consumption is driven by energy savings, the ability to face perturbations and to adapt to an evolving energetic model (specifically with renewable energy). As an example of the use of biomimicry to support such network design and management, researchers have studied the mechanisms allowing plants cells to regulate their energetic homeostasis and use these learnings to formalize a framework to improve the design of smart microgrid [11].

Overall, Biomimicry is a way to find solutions to do better. Massive investments are now required to develop these clean technologies and change our approach of innovation to reach a more environmentally friendly and energy sober society.

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