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EDITORIAL
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Editorial: Frontiers in Energy Research: Rising Stars

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Editorial on the Research Topic

Frontiers in Energy Research: Rising Stars

Science thrives on innovation and spirit of enquiry and thus encompasses change, renewal, and a constantly evolving body of thought. It is precise from this perspective that young scientists provide essential impetus for advancement in science and technology with creative new ideas, strategies, and methods.

In few scientific disciplines are these new impulses as important as in energy research: ensuring access to affordable, reliable, sustainable, clean, and modern energy for all (Sustainable Development Goal 7) is an immense challenge for humanity in the face of the consequences of global climate change and increasing geopolitical conflicts.

This Research Topic of articles, "*Frontiers in Energy Research: Rising Stars*," provides a glimpse into the versatility of high-quality energy research, driven by internationally recognized researchers in their early stages of independent careers. These articles address key technologies for a path toward sustainable renewable energy practices with energy storage and hydrogen and biogas and biomass utilization.

Three articles under this Research Topic focus on electrochemical energy storage. Hereby, two research articles highlight ionic liquid electrolytes for high performance and safe operation of lithium ion batteries based on intrinsic conductivity, wide potential window, and negligible volatility of the ionic liquids. In one article, Penley et al. used the density functional theory to predict the solvation and coordination of lithium ions—crucial properties determining the solubility of lithium salts and the ability of lithium ions intercalating into the active electrode materials. By calculating the dissociation energies of lithium ions, the authors were able to predict the coordination of the lithium ions in the tailored ionic liquid electrolytes. In the other study, Zettl and Hanzu studied the ionic conductivity of a type of hybrid solid electrolytes consisting of a metal–organic framework and an ionic liquid. Such hybrid electrolytes may be considered a bridge between the classical liquid and solid electrolytes. In the third mini-review article, Liu and Wang examined the recent development in the molecular layer deposition technique for preparing the thin-film electrodes and electrolyte of rechargeable batteries. This is a highly interesting technique that allows to tailor thin-film battery materials by depositing hybrid organic–inorganic materials at a nanoscale level and with well-tunable and unique properties that conventional electrode materials lack.

Not only an efficient storage of electrical energy but also the storage of hydrogen is an important task and challenge, requiring a trade-off between storage density, energy expenditure, cyclic stability, and safety. Here, hydrogen storage in solid-state compounds can be considered a safe storage

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method. Yet, research still has to identify the ultimate storage material. Parameters like the thermodynamics and kinetics of hydrogen adsorption and desorption and the resistance to contamination are only some aspects to be considered. In his research article, Zbigniew Łodziana applied surface energy calculations for $LaNi_5$ and TiFe as alloys relevant for hydrogen storage—highlighting, for example, the strong binding energies of CO, CO_2, and H_2O at the alloy surfaces, thus blocking the active sites for dissociative hydrogen adsorption.

The major source of renewable hydrogen is probably the electrochemical water splitting. Yet, it can also be harnessed from biomass, for example, *via* steam reforming. This technology, however, requires "high-value" biomass—biomass with a low water contents—as feedstock. Worldwide, however, huge quantities of low-value biomass (e.g., aqueous waste streams) remain unexploited and require energy-extensive treatment to remove their carbon load before being discharged into the environment. Ochonma et al. studied the thermodynamic limits for an enhanced hydrogen production, combined with an inherent carbon removal from low-value aqueous biomass components. In their process, which takes place at considerably reduced temperatures and pressure as compared to conventional high-temperature reforming, the authors aimed to utilize the effect of coupling thermodynamically downhill carbon mineralization reactions for *in situ* CO_2 capture to enhance hydrogen evolution.

In addition to hydrogen, methane (in the form of biogas) is a promising energy carrier, which can be stored more easily than hydrogen and for which the existing natural gas infrastructure can be exploited. However, the high CO_2 contents of biogas (up to 50%) lower its calorific value. Hence, various biogas upgradation technologies are under intense investigation to increase the methane content to the desired level. In their article, Roy et al. used microbial electrosynthesis, a microbial electrochemical technology, for biogas upgrading. In this technology, microorganisms convert CO_2 (with the help of electric energy) to generate organic compounds. The authors could demonstrate a combined benefit of microbial electrosynthesis—an increase of the methane contents of the used biogas and a production of acetic acid in the liquid phase.

It is not only the carbon dioxide content that can be problematic for the energetic use of biogas but also impurities such as hydrogen sulfide and siloxanes. Thus, in solid oxide fuel cells (SOFCs), which can directly utilize biogas for electrochemical energy conversion, these impurities, even at low concentrations, can potentially damage the fuel cell's electrocatalyst. In their study, Tian and Milcarek studied the effect of cyclic and linear siloxane contaminations on the nickel-yttria-stabilized zirconia (Ni-YSZ) anode of a solid oxide fuel cell. By means of detailed electrochemical and postmortem analysis, they showed cyclic siloxanes to possess the strongest degradation effects and identified silicon and silicon carbide as major siloxane decomposition products.

Two further research studies under this Research Topic address very different aspects of solar energy and wind power. Shargaieva et al. devoted their article to the crystallization mechanism of methylammonium lead iodide perovskite from different solvents. These perovskites are a novel type of semiconductors that show great potential for solution-processed optoelectronic devices including solar cells. Hereby, the performance of the respective device is intrinsically determined by the quality of the solution-processed halide perovskite thin films. The findings of this study allow a deeper understanding of the different roles that solvents play in the formation process of halide perovskite semiconductors, and they allow predicting optimum preparation conditions. In contrast to this materials science approach, the study by Zhao et al. addressed deficits in the prediction of large-scale wind power bases. Until now, the calculation of the power output of wind power bases assumes the wind power to be homogeneous for an entire region, neglecting heterogeneities and thus accepting large deviations in the simulation results of the wind power output. To obtain more accurate power output landscapes of large-scale wind power bases, the authors proposed a power output scene simulation method considering power station clustering and cluster correlation. They verified the validity and rationality of the new simulation method using physical data from the wind power base of the downstream Yalong River basin.

AUTHOR CONTRIBUTIONS

US wrote the first draft, and all other authors revised and added to it.

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