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Editorial: Low-grade thermal energy conversion and utilization

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Editorial on the Research Topic
Low-grade thermal energy conversion and utilization

Low-grade thermal energy conversion and utilization play a crucial role in sustainable energy strategies and environmental conservation. While high-grade thermal energy sources like fossil fuels have traditionally dominated energy production, their limited availability and environmental impact have shifted focus towards harnessing low-grade thermal energy. Technologies such as ocean thermal convertors, thermoelectric generators, organic Rankine cycles, and heat pumps are being increasingly utilized to convert low-grade thermal energy into useful forms such as electricity or heating. This has significant implications for industries, buildings, and transportation, enabling more efficient energy use and reducing greenhouse gas emissions.

The future of low-grade thermal energy conversion and utilization looks promising with ongoing advancements in materials science, engineering, and renewable energy technologies. Improved efficiency in converting low-grade heat into electricity, coupled with energy storage solutions, could revolutionize energy systems by integrating renewable and waste heat sources into the grid. As global efforts intensify to combat climate change and achieve sustainability goals across the globe, the importance of low-grade thermal energy conversion and utilization will continue to grow, driving innovation and adoption of clean energy solutions.

Ocean thermal energy conversion (OTEC) is crucial for sustainable energy development due to its potential to harness vast amounts of renewable energy from the oceans. Oceans cover about 71% of the Earth's surface and possess immense thermal energy stored in temperature differences between surface waters and deeper layers. OTEC systems can tap into this energy through heat exchangers, generating electricity without emitting greenhouse gases or depleting finite resources. Xiao and Gulfam put forwarded opinion, emphasizing the use of OTEC for several applications, ranging from the power generation and refrigeration to desalination. It is noteworthy that the first OTEC factory was erected in 1930, and since then, both open and closed-cycle plants had been established. Overall, this technology offers a reliable and consistent energy source, especially for coastal regions, contributing to energy security and mitigating climate change impacts. Additionally, OTEC facilitates the diversification of energy portfolios, reducing reliance on fossil fuels and promoting a more sustainable energy mix. However, certain limitations still exist in OTEC in spite of great technological advancements, for example, efficiency is much less than that of Carnot's cycle, i.e., around 8% when the surface seawater is at 29°C and deep seawater is

4°C. Chen and Huo also declared that the low efficiency of OTEC plants in the biggest problem in their practical development.

Thermoelectric power generation is increasingly important in the context of sustainable energy production. This technology allows us to convert waste heat into electricity, reducing energy waste and environmental impact. The research is underway on enhancing the thermoelectric properties of the materials involved in the fabrication of thermoelectric devices, and there are rising concerns on the temperature dependent material properties, as mentioned by Xu et al. In all, the future of thermoelectric power generation looks promising as researchers work on improving efficiency and scalability, making it viable for widespread adoption. With the growing emphasis on renewable energy and energy efficiency, thermoelectric power generation holds significant potential in contributing to a cleaner and more sustainable energy landscape.

Organic Rankine cycles (ORCs) play a crucial role in harnessing energy from low-grade heat sources, such as industrial waste heat, solar energy, biomass energy, ocean thermal energy and geothermal resources. They enable the conversion of heat into electricity using organic fluids with lower boiling points than water, making them ideal for applications where traditional steam-based cycles are not efficient. There are plenty of working fluids being engaged in improving the energy and exergy efficiencies of ORCs, for example, Liu et al., put forwarded that n-hexane can surpass several other organics. The future of ORCs is emerging, especially in the context of renewable energy systems and waste heat recovery. Advancements in ORC technology, including the development of more efficient organic fluids and improved system designs, are expected to drive their widespread adoption in various industries, contributing significantly to energy efficiency and sustainability efforts.

Loop heat pipes (LHPs) are critical in thermal management systems, especially in electronics, spacecraft, and high-performance machinery. They efficiently transfer heat over long distances using phase change principles, ensuring precise temperature control and preventing thermal damage. Zhao et al., presented that LHPs are the promising heat transfer devices with further research on the thermal performance of a condenser in LHP. The future of LHPs is promising as they continue to evolve with advancements in materials and design, enabling them to handle higher heat loads and operate in extreme conditions. As the demand for compact and reliable thermal management solutions grows, LHPs are expected to play a vital role in various industries, ensuring optimal performance and longevity of sensitive equipment.

In conclusion, low-grade thermal energy conversion and utilization technologies such as thermoelectric power generation, organic Rankine cycles (ORCs), and loop heat pipes (LHPs) are crucial pillars of sustainable energy and thermal management systems. They enable the efficient conversion of waste heat into useable energy, contributing to energy efficiency, reduced environmental impact, and enhanced resource utilization.

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Conflict of interest

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