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PV PANEL WASTE RECYCLING: IMPORTANCE, CHALLENGES, AND PROGRESS

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The exponential growth of photovoltaic (PV) systems worldwide has made solar energy a key component of sustainable electricity generation. However, as the first generations of PV panels approach the end of their 25- to 30-year lifespan, the industry is facing an increase in PV panel waste, which is expected to reach between 60 and 78 million tons worldwide by 2050. This impending influx of discarded panels poses a significant threat to the environment due to the potential release of toxic materials (lead and tin) and the loss of valuable resources (silicon, silver, aluminium, copper, etc.). This paper examines the importance of PV panel waste recycling, highlighting the need for sustainable practices, the technical and economic challenges and recent advances in recycling technologies. The main challenges for efficient recycling are discussed, focusing on the technical complexity of PV module design and the economic barriers. The paper also identifies future directions, including the further development of recycling technologies through ongoing research and development to increase efficiency and reduce costs. Overcoming these challenges will enable the PV industry to turn the problem of panel waste into opportunities for innovation, economic growth and sustainable development. Effective end-of-life management of PV panels is critical to ensure that solar energy remains a truly clean and sustainable solution for future generations, supporting global environmental commitments and facilitating the transition to a circular economy.