# Chapter 15
# Opportunities and Challenges in Solar Photovoltaic Waste Management

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## ABSTRACT

*With the current global overexploitation and depletion of coal resources, it has become necessary to shift toward renewable energy sources to fulfil the world's energy requirements. Among these alternatives, solar energy stands out as the most promising solution. The sun, known for its life-enhancing properties, showers the Earth with an abundant amount of energy. In the case of India, for instance, the country receives an impressive 5000 trillion kWh of energy annually, with a substantial portion of the nation enjoying daily solar radiation ranging from 4 to 7 kWh per square meter. India has demonstrated worthy expertise in harnessing solar energy. Following coal extraction, solar energy developed as the most dependable and widespread energy source capable of meeting the world's energy demands. The study addresses the essential facts of solar waste management as it currently exists in India in addition to the challenges related to managerial policy. Waste management will improve as solar panel installations expand.*

## 1. INTRODUCTION

Solar energy has emerged as a prominent solution to provide for the rising energy needs of expanding populations. Solar photovoltaic technology efficiently converts solar energy into electricity, contributing

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to climate change mitigation. While the progress and adoption of solar photovoltaics have positively impacted energy system decarbonization, it is crucial to address the proper disposal of end-of-life solar panels to prevent potential toxic waste concerns. As solar installations continue to expand globally, there is a growing emphasis on effectively managing the end-of-life phase of solar PV panels. These panels house valuable metals like silicon, silver, and copper, which can be salvaged and reused, thus lessening the need for new raw materials. This trend aligns with the principles of a circular economy, where materials are recycled and repurposed, minimizing waste. Moreover, the domain of solar PV waste management carries the potential to generate employment opportunities, spanning roles in collection, recycling, and component reclamation. The ultimate concern is environmental protection. Currently, India is projected to generate around 200,000 tonnes of solar photovoltaic waste by 2030, and this figure is anticipated to escalate to 1.8 million tonnes by 2050. Globally, solar waste might surge to an estimated 60 million tonnes by that time. To curb the adverse impact of ongoing expansion, solar waste has been newly classified under waste electrical and electronic equipment, aiming to mitigate its potential repercussions (Rathore, N., & Panwar, N. L., 2022). India has only recently started using solar panels; therefore, the nation now has little waste building up. However, predictions show that the amount of this waste is expected to increase dramatically, ranging from 4.4 to 7.5 million tonnes by the year 2050. Despite India's well-developed infrastructure for recycling electronic waste, there are currently no explicit standards for the end-of-life handling of solar PV panels. Instead, the General Waste Law's guidelines for waste management apply to how their waste is handled (Majewski, P., et al., 2021). Sufficient disposal and recycling processes are imperative to prevent the release of hazardous substances, such as cadmium and lead, inherent in solar panels, into the ecosystem. Establishing a robust recycling infrastructure remains a significant hurdle in various regions, delaying the efficient handling of accelerating waste volumes. Due to the hazardous elements present, careful management and disposal techniques are required to avert environmental contamination. A lack of uniform regulatory frameworks and policies for PV waste management across differing jurisdictions complicates the recycling endeavor. The intricate composition of solar panels, incorporating diverse materials, necessitates innovative technologies to effectively extract and segregate components. The economic feasibility of recycling hinges on factors like recycling costs versus the value of the reclaimed materials. There exists a notable gap in awareness and education among consumers and industries regarding the significance of proper PV waste management, which has led to improper disposal practices. Despite their impressive 25–30-year lifespan of producing clean energy, the improper handling of end-of-life solar photovoltaic modules can pose environmental risks. This concern becomes more critical as the global utilization of photovoltaics expands rapidly, contributing substantial clean energy.

India will face significant challenges in the future when it comes to handling the management and disposal of solar PV waste. This area has been neglected for a long time and is known for its informal, unscientific approach, necessitating immediate attention (Sheoran, Sharma, and Kumar, 2020). The implementation of an online PV waste monitoring system, whether in the early phases or during the end-of-life phase, could be helpful in easing these worries. A system like this would make it easier to track discarded modules extensively, giving regulatory agencies and other stakeholders the information, they need to create useful policies and procedures. Solar PV waste is still substantially excluded from these rules, despite India having adopted the E-waste Management Rules of 2016 (CPCB 2018), which significantly differ from the 2011 version by including the idea of extended producer responsibility (EPR). This raises questions regarding the likelihood of improper disposal, including the use of open dumping grounds or unregulated landfills (EU 2021). The appropriate handling of PV waste is hampered by the