E-Waste Resource Engineering & Management: Waste-to-Wealth initiatives

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Electrical and electronic devices have become an integral part of modern lifestyles. Due to high obsolescence, consumers often replace their electronic gadgets at an alarmingly fast rate, which leads to the generation of electronic waste. India ranked as the third-largest e-waste generator in the world. However, most of the e-waste generated in the country is handled by the informal sector, and rudimentary methods are followed for the recovery of valuable metals from e-waste. Since e-waste contains many toxic materials, improper disposal, as well as recycling practices, pose serious threats to human health and the environment. On the other hand, e-waste is often referred to as an 'urban mine' due to the presence of valuable metal contents in it. The recovery and reuse of these valuable metals from e-waste provide an opportunity to create resource efficiency and a circular economy for a sustainable future.

To address the problems related to e-waste management and also to promote resource recovery and circular economy, a Centre of Excellence (CoE) on E-waste management has been established at C-MET Hyderabad. It aims to build a sustainable e-waste management ecosystem across the country with the vision to establish a self-sustainable technology hub capable of effectively managing India's e-waste. The CoE operates in five different verticals, which include: i) PCB recycling; ii) lithium-ion battery (LIBs) recycling; iii) spent permanent magnets recycling; iv) spent solar cell recycling; and v) skill development and awareness **(Fig. 1)**.

In order to recover precious metals from spent PCB, environmentally benign recycling technology has been developed through a pyrometallurgical route with a processing capacity of 1000 Kg PCB per day (Fig.2). All the process equipment required for recycling have been designed and fabricated indigenously, and CoE is offering turnkey solutions to industries for PCB recycling.

Similar to PCBs, a cost-effective technology has also been developed for the selective recovery of various metal contents from the discarded LIB. The assorted battery recycling process is patented, and the technology is being transferred to more than 20 industries for commercial exploitation.

Furthermore, the CoE has achieved a technology readiness level (TRL) of 4 for the recovery of rare earth present in spent permanent magnets through the hydrometallurgical route. Scalable technology for the recovery of valuables from the end of Si solar cells is also developed at 10 Kg solar cells/batch, and 5N pure silicon is recovered for further usage.

CoE has also inked a pact with M/s Greenko Energies Pvt. Ltd. Hyderabad, one of the largest renewable energy companies in India, for scaling up the technologies developed under CoE.

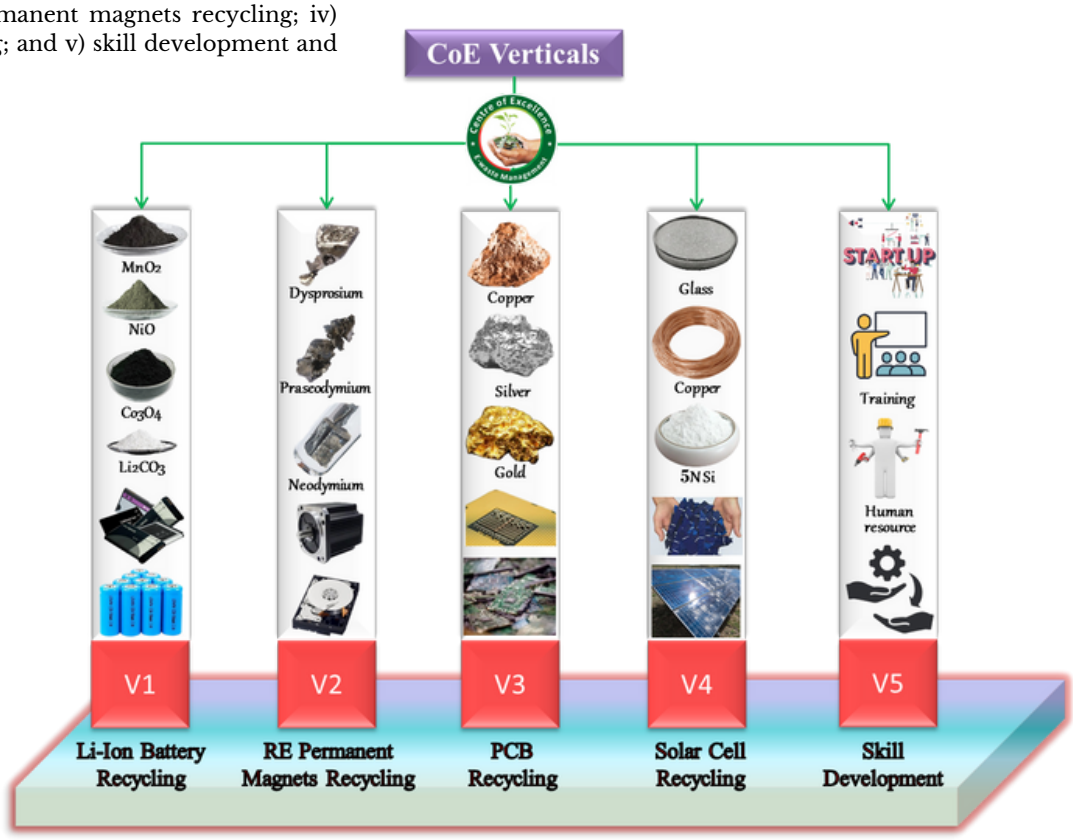

Fig. 1: Different verticals in CoE on E-waste Management

Fig. 2a): Rotary tilting furnace for PCB recycling

Fig. 2b): Recovery of metal fractions

In addition to recycling efforts, the CoE also provides skill development and awareness training to informal sectors, SMEs, start-ups, and industries, formalizing the informal sector and empowering the development of e-waste management infrastructure. To create expert manpower in the e-waste field, C-MET and IIT Hyderabad have jointly initiated a regular MTech course in 'E-waste Resource Engineering & Management (EREM)' in the academic year 2020.

This course not only generates expert manpower but also facilitates collaborative research projects, providing further insights into R&D activities such as the application of artificial intelligence (AI) for the collection and sorting of e-waste and its components. These collaborative efforts have also led to the development of novel spin-off technologies for effective e-waste management. The ground-breaking M. Tech. program, resulting from the dynamic collaboration between IITH and C-MET, aims to revolutionize e-waste management on both national and global levels.

It aligns with the visionary goals of Swachh Bharat, Make in India, Aatma Nirbhar Bharat, and Waste-to-Wealth initiatives. By nurturing a new generation of innovative minds and equipping them with the necessary knowledge and skills, this program has the potential to reshape the management of e-waste to achieve the goals of a sustainable and prosperous future.

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