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# A compatible standard policy measure to tackle solar photovoltaic waste in Indian scenario

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**Abstract.** Expeditious evolution of solar photovoltaic industry has triggered transformation in energy sector across the world. After the concluded durability of the PV panels amount of junk originates. This junk is directed into the category of solid waste. With the increasing solar power plant installations in India the amount of waste to be accumulated in the nearby years to come will be a matter of grave concern. Hasty action should be taken by the Indian policy makers and other non-governmental agencies to process the solar photovoltaic recycling policies at commercial level in an economically sustainable manner. This paper inspects the prospective requisite of PV reprocessing legislation by investigating the current reprocessing arrangements of the commercialized first and second generation solar PV materials. Emphasis is also laid on the hazardous effects of the waste on human body. Quantity of reclaimed material is considered and its economic importance is analysed. Architectural liability is put at the utmost front for curbing out the havoc to be created by piling up of the junk photovoltaic materials through economically feasible policy framework. Through this article effective solar PV reclaiming policy framework is proposed for the Indian government which will foster new socio-economic, environmental and employment opportunities.

**Keywords:** Photovoltaic waste, end life, recycling policy.

## 1. Introduction

Detrimental eventuality caused by the use of conventional resources and the growing energy needs marked the boom of solar PV industry [1]. Endorsed by the bureaucratic undertaking and declining expenses, the solar firms are thriving promptly in India and around the world [2]. At the initial stages of their wheel of life PV panels account no ambiance spoliation [3]. Life cycle reassessment is done to study environmental repercussions involved throughout fabrication, positioning and knocking down conditions [4]. Major health impacts are also related with discarding of solar panels in junkyard [5, 6] as they contain dangerous elements like Cd, Te, Pb, etc. capable of being life threatening [7, 8].

In case of certain thin film and amorphous Si solar cell modules comprising a PV array, additional disposal problems are likely to be caused due to the presence of cadmium and arsenic. Emissions at reclaiming stage proved to be toxic for the biological species i.e. humans, marine life and terrestrial life etc. [9, 10]. Among the PV materials various generations are included. The first generation includes the c-Si, second generation includes thin film (a-Si, CdTe, CIGS). 85% of the PV market share is governed by the c-Si [2, 11]. Currently large number of c-Si panels are available for the reclaiming process due to their greater commercialization [12, 13].

Many firms like Deutsche, Solar AG, Solar world AG, Solar cell Inc. (SCI) and Pillington Solar Int. (PSI) are involved into the reclaiming process. The solar e-waste contains toxic metals like Pd, Cd, In, As, Te, Se which causes damage to kidney, liver, CNS, bones, skin etc. [14–18]. This paper emphasizes the gravity of reprocessing of solar waste due to high economic value of the metals like Si, Cu, In, Ag, Ga, Te



which reduce the architectural cost of the new solar PV materials [10, 19, 20]. Reclaiming methods of waste PV materials play an important role in economic sustainability [21].

A growing number of literature have been carried out for the analysis of solar PV recycling policies across the globe while Indian scenario still lacks the policy framework and incentives to be provided for reclaiming process [22]. Due to increasing efficiencies of the solar PV materials the amount of waste to be accumulated in near future is increasing, material recovery is insisted to avoid the detriment of valuable materials at the end of wheel of life. Indium cannot be recycled fully due to high blow out percentage [3]. Consciousness among the PV firms and community should be enhanced for the environmental impacts. Framing policies for reclamation across the world can be a leverage to reduce the taxes [23].

## 2. Methodology

A comprehensive analysis of the first and second generation material is carried out based on the life span reassessment of existing PV technology in market. Among the first and second generation solar PV materials Te, In, Si, Cd, Se are reclaimed through chemical process. The amount of retrieved PV material from the panels depends upon the width, density. Its profit can be calculated by taking the current price in the market .Further landfill waste yard can be calculated [22] .

After the end of wheel of life of solar panels the decommissioned and the damaged solar modules can have their own fate. Till now the regular scenario was to either dump in junkyards or practice landfilling of PV waste, but with the increasing technology efficiency the amount of solar PV installations being accumulated is increasing drastically. Some of the typical reclaiming methods like mechanical, chemical and thermal methods are also applied. Figure 1 further depicts the end of wheel of life of solar PV modules.

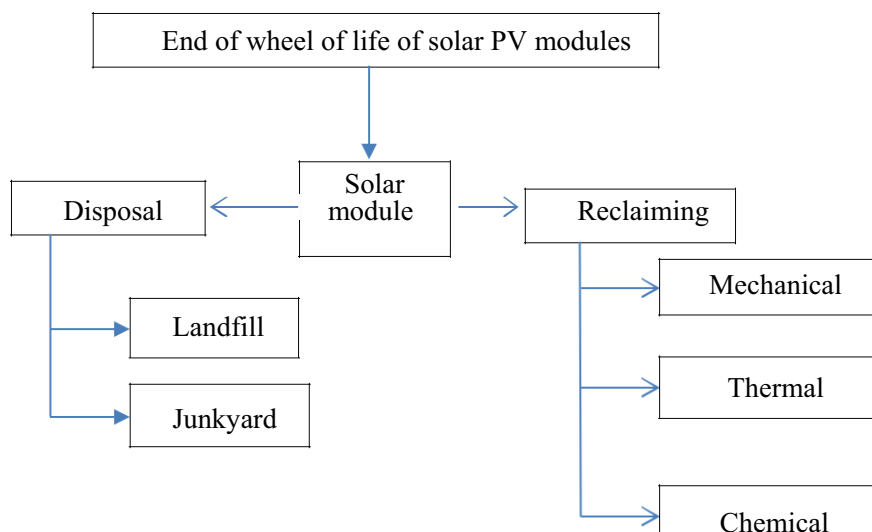


Figure 1. Fate of solar module after end of wheel of life

Various PV firms like First Solar, Deutsche Solar, Solar cells Inc. (SCI), Pillington Solar International (PSI) have initiated the PV reclaiming programmes. SCI is indulged in recovering the backing film, EVA by the pyrolysis at 500 °C. First solar has developed methods to reclaim the CdTe panels by acid treatment and precipitation reactions. Deutsche Solar operated on the damaged panels through thermal treatment followed by the chemical treatment. The Financial Rewarding (F.R) of the reclaiming process can be estimated as:

$$F.R = \frac{n}{i} (r.i \times q.i \times c.i)$$

Here r.i is redemption rate, q.i is the quantity of waste (kg/ton) and c.i is the cost of target material.

### 3. Legislative framework for solar PV recycling in India

With the macroscopic proliferation of solar photovoltaic installations the PV waste is also getting accumulated in huge amount. Photovoltaic scrap management methods and defining recycling policy framework is very critical for solar panel waste management, especially in India where recycling of PV material is not practiced extensively. The hazardous materials utilized for the manufacturing of solar PV panels is either left untreated or they are not recycled once their life cycle is completed. This causes detrimental effects for the environment [24, 25]. This calls for a rigid policy framework which can govern and enforce the compulsory assemblage, resumption and recycling of solar PV materials. The proposed legislative strategy for recycling of solar PV panels is depicted below in Figure 2.



Figure 2. Proposed Solar PV Reclaiming Policy Framework for Indian Government

#### 4. Conclusion

The paper presents a compatible standard policy framework for solar PV recycling in both rural and urban India. With everyday target achievement of new solar PV plant, the waste accumulation has reached to million tons. The PV waste left without treatment possess serious detrimental effects on ecosystem, though solar PV recycling is still not practiced to full-fledged industrial scale in India. Treacherous planetary waste spawned by the decommissioning of solar PV materials can't be thrown in garbage. There has to be a stringent plan for their management. The implementation of a legislative PV recycling structure in emergent nations especially in Indian scenario will be a great life savior to tackle the havoc which is to be originated in times to come. Comprehensive analysis is carried out on existing PV reclaiming methods carried out by various PV firms. An affirmative response to this policy from Indian government will effectively curb the future forecast of the PV scrap disaster.

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