# PV WASTE MANAGEMENT IN INDIA

## Comparative Analysis of State of Play & Recommendations

EU- India: Technical Cooperation – Energy Project
DCI/ASIE/2014/343-602 LOT

# ABOUT EU-INDIA TCP

The EU-India Technical Cooperation Project: Energy (EU-India TCP) was set up by the Government of India and the European Commission in 2014 as an effective instrument for working together on renewable energy and energy efficiency.

The project supports the government's efforts to promote clean energy and facilitates the uptake of sustainable technologies by the public and private sectors. The project complements, and is supportive to building the capacity of the Ministry of New and Renewable Energy (MNRE), Bureau of Energy Efficiency (BEE), and partner states through identification, evaluation, and implementation of need-based work as directed by MNRE or BEE.

- technical advisory services
- reviewing model documents
- developing web-based applications and providing IT assistance
- conducting training workshops and seminars
- facilitating study tours

The primary activities performed by the project are listed here: The continuous assessment of the effectiveness of the project permitted the evolution of the activities to address the changing priorities of the partner states.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# EXECUTIVE SUMMARY

This study aims to analyse the current state of play of the PV waste management landscape in India and to provide recommendations on how to enhance the policy framework around it. A comparison of the EU and Indian regulatory settings and main policy drivers is carried out, as well as an analysis of the PV module waste market in India, including the amount of waste generated and current waste treatment practices. Based on these assessments, a number of short-, mid- and long-term policy recommendations are included.

There are important similarities and differences between both regions for waste treatment regulations relevant for waste generated from PV systems. In both regions, PV modules are considered as "one product, one equipment" – one does not apply a waste law to "components" of an equipment.

Whereas PV modules and inverters are under the scope of the EU WEEE Directive, the Indian E-Waste (Management and Handling) Rules are not applicable to PV modules and inverters because these E-Waste Rules only apply to two categories of electrical and electronic equipment that do not include PV products. In contrast, in the EU there is a so-called "open scope" whereby each electrical and electronic equipment falls under the scope of the WEEE Directive since August 2018.

Both the European WEEE Directive and the Indian E-Waste Rules are based on the Extended Producer Responsibility (EPR) principle, foresee mandatory collection targets and are mainly focused on "consumer electronic waste".

There are comprehensive Industrial Solid Waste Rules in place in India, but they do not include solar PV within their scope, whilst the European Union has its Waste Framework Directive which settles the basis requirements for each waste type irrespective of Extended Producer

Responsibility legislation or other specific legislation which might come on top. Crystalline silicon (c-Si) PV modules are not considered as hazardous waste under the Indian Hazardous and Other Waste Rules.

**Looking at the current policy framework around end-of-life PV products in India, findings show that the following measures should be explored in the short term:**

01 **Impose a landfill ban for solar PV modules;**

02 **Implement a legislative framework for a mandatory Extended Producer Responsibility (EPR)** for equipment coming from the Renewable Energy Industry whereby the industry proposes through a five-year management plan its objectives and how to achieve these under supervision if the MNRE and/or MOEF;

03 **Create a self-standing EPR legislation for PV modules** (potentially for all PV equipment or all Renewable Energy equipment) separately from the E-Waste Rules. As PV technology, which is currently not included in the scope of the E-Waste Rules, will become the cornerstone of the energy transition, it is recommended to set out a separate piece of legislation instead of being included in the E-Waste Rules legislation;

04 **Allow the Indian PV industry to propose a sustainable and long-term solution** for the waste generated by a PV system taking into account that PV modules have a very long lifetime and today's generated waste is by far not attractive to enable big industrial waste treatment capacity for PV modules.

Based on the results and recommendations of this report, the development of a draft piece of legislation for PV end-of-life management should be carried out. The new legislative framework could include in the scope modules, inverters and other PV system components. While it is too early to determine whether inverters and other PV components should be part of the same legislation for PV modules or rather be part of the E-Waste Rules, it will be key to ensure synergies across the different pieces of legislation and to optimise the economic, social and environmental dimensions in waste collection and treatment.

The Indian PV recycling legislation could be inspired by lessons learned in Europe, the EU being the only region with an existing regulatory framework for the end-of-life management of PV modules. Therefore, it is important to remember that the European WEEE Directive (similar to its Indian counterpart) is a piece of legislation, which was originally established for purely household appliances and consumer electronics. The WEEE legislation is not specifically designed for PV appliances or commercial or industrial electrical and electronic equipment. Therefore, it is recommended to invite first the Indian PV Industry to propose a management plan for the end-of-life phase of their products such as PV modules, inverters and batteries, to allow its assessment by the MNRE and to conclude based upon the accompanying discussions if and how legislative support would benefit for the Indian society.

Compared to current installation levels, the annual Indian PV market is expected to grow significantly across all three scenarios investigated in the study. Assuming that PV systems installed in 2020-2030 have a lifetime of at least 30 years, any capacity installed during this period will reach the end-of-life stage not before 2050.

Given that ground-mounted solar constitutes the vast majority of PV capacity, and that the residential segment is only a fraction of rooftop installations, it can be concluded that the greatest bulk of end-of-life PV waste will be deriving from business-to-business (B2B) relations.

According to the analysis carried out in the context of this study, by the year 2030 India will generate a cumulative mass of PV module waste of 11 kilo tonnes (kt) in the Low scenario, 21 kt in the Medium scenario, and 34 kt in the High scenario. These waste streams are relatively very small compared to waste volumes generated from modules reaching their expected end of life. The latter would start accumulating only around after the year 2040 and will become rapidly the most relevant waste source.

Different overall policy approaches and a range of EPR policies, instruments and measures are available for PV waste management in India. A general overview of possible business models, EPR scheme options and financing options for the EPR scheme as well as for addressing orphan and existing products is provided in the table below.

| Overall policy approach | | | | | | |
|---|---|---|---|---|---|---|
| Business-as-usual (BAU) | | Improved Business-as-usual (BAU+) | | | Extended Producer Responsibility (EPR) | |
| **EPR scheme options** | | | | | | |
| Take-back requirements | Economic instruments | | | | Performance standards | Other |
| Product take-back | Deposit/ refund | Advance disposal fee | Product/ material tax | Combined upstream tax/subsidy | Minimum recycled content requirement | Industry-based measures, government measures |
| **EPR financing options** | | | | | | |
| Internalisation of waste management costs | | | | Visible fee | | |
| **Financing options for orphan and existing products** | | | | | | |
| Advance disposal fees | Fees paid at the time of purchase | Last owner pays | | Insurance | | Phase-in |

Compared to a BAU scenario or to an improved BAU (BAU+) scenario whereby a landfill ban is introduced, this study recommends the Extended Producer Responsibility approach as the best one for the Indian context, as it constitutes the most effective means to perform sound PV waste management. It is advised to implement an EPR law for PV modules which sets the principle of a Producer Responsibility for PV modules and – where required – other products of a PV system, such as inverters and batteries.

Several EPR policy instruments and measures are available to governments to help them meet their stated goals and objectives. They are product take-back, deposit/refund, advance disposal fees, product/material taxes, combined upstream tax and subsidy and minimum recycled content requirements. Policymakers should review these different instruments to identify which might best meet their particular needs. The point of intervention for the instrument selected depends on the point where the market fails to internalize the impacts from the disposal of products at their post-consumer stage. The instrument or mix of instruments that would best meet policy goals should be selected.

Governments need to select the responsibility model and assign precise responsibilities to both physical and financial responsibility. Decisions on the allocation of responsibility should be made in view of the policy goals, product characteristics, market dynamics, actors in the product chain and resources needed to implement the policy. The national government, state and local authorities, the retailer, the consumer and the final owner of the waste all play important roles under EPR – measures should take into account all these stakeholders. In several cases, a Producer Responsibility Organisation (PRO) could be a useful option for managing and collecting products in lieu of each producer establishing its own separate system.

It is plausible that complete removal of free rider behaviour may not generate sufficient environmental benefits to justify the administrative costs to minimise free riders. Policymakers and PROs need to analyse the incentives they create for the various actors operating in an EPR system through different pricing structures and legal liabilities, to ensure that these are consistent with the ultimate goals and objectives of the EPR program and with overall economic efficiency. Under mandatory EPR programs, government enforcement against free riders may be needed to assure fairness to producers that carry out their EPR responsibilities. Decisions with regard to orphan and existing products must be also taken into account.

Most EPR schemes cover partly or fully the net costs for the management of waste that has been separately collected, as well as administrative, reporting and communication costs relative to the operation of collective schemes. For photovoltaic modules, the administrative costs shall be similar as in each EPR-environment. The challenge is the operational costs, where almost no waste occurs whilst the fixed administrative costs exist. The creation of provisions or funding for future waste management is crucial in order to be able as solar industry to manage the upcoming waste environmentally sound in the future. A draft financing model for an Advanced and Visible Disposal Fee is therefore very recommendable.

Recommendations for the setting of an EPR system, the proposal for a fee calculation, as well as the proposal for the organisational structure of a PRO are included in the report.

From a stakeholder survey carried out during the drafting of this study it can be concluded that stakeholders in India are concerned about the PV waste and its management in the country in coming years and are willing to consider a fee to create a fund which is managed by an industry body to facilitate this process and manage India's PV waste. Among the manufacturers who participated in this survey almost 80% of them were willing to take PV end-of-life responsibility. Over 90% of stakeholders believed a Management Organization steered by the PV industry itself is the best way to handle a fund for future waste management of PV modules.

**Looking at the medium- and long-term time horizon (5-10 years), the following actions should be explored:**

1. Develop sustainable product policies for PV modules, inverters and systems, such as Ecodesign and Ecolabel, based on globally recognised standards and a methodology that take into account the full product lifecycle;
2. Consider including sustainability criteria in national renewable energy auctions, based on a point-based system, to reward products with the lowest environmental impact;
3. Periodically re-assess rules on PV waste recycling to keep pace with the evolution of the sector;
4. Set up joint EU-India Horizon 2020 calls for R&D projects on PV recycling technology or innovative equipment.

CHAPTER 01

# INTRODUCTION

## 1.1. Context

The last few years have witnessed a major global shift towards renewable and sustainable modes of energy generation. With increasing focus on solar energy and subsequent capacity addition, the PV solar sector is growing rapidly. In India, solar energy and its implementation was first addressed during the 6th Five Year Plan (1980-85). However, solar energy in India did not receive the desired momentum until recently when the National Solar Mission was launched as one of the several measures under the National Action Plan on Climate Change in 2010. The mission was launched initially with a target of 20 GW by 2022 which was later revised to 100 GW. Under the revised targets, the ground mount solar systems of 60 GW and 40 GW of solar systems on rooftops are proposed to be installed by the year 2022. By the end of 2019, India has installed around 35 GWAC of solar PV capacity on ground and rooftops across the country[1].

As everywhere else in the world, the prodigious penetration of PV technology in India will generate waste. Solar PV modules are durable and long-lasting products and are expected to last 30 years or even longer. Thus currently, PV module waste generation as a result of end-of-life has very limited effects in the short and medium term, considering the fact that majority of PV systems have been installed after 2010. However, PV waste is not only generated once the expected end-of-life stage of the PV module is reached but also during transportation, installation and operation of the PV system. It is therefore important to carry out an assessment of PV waste generation over the next decades to provide solutions for a sustainable energy economy and to prevent adverse environmental impacts which could arise from the wrong practices of disposal of end-of-life PV modules and their components.

## 1.2. Objectives

This report has the following key objectives:

- Comparison of the EU and Indian regulatory settings and main policy drivers
- Analysis of the PV module waste market in India, including the amount of waste generated, current waste treatment practices
- Short-term (2020-2025) policy recommendations for India for setting up a PV module waste collection and financing mechanism based on the Extended Producer Responsibility (EPR) approach, adapted to the Indian context

[1] *Differently from most of the EU countries, installed capacity in India is always expressed in GWAC. The DC/AC conversion rate used in this study is 1.2.*

- Proposal of the deposit fee and financing for management of PV waste – how much, where, who?
- Medium to long-term (2025-2030) recommendations for improving the EPR policy, proposals of R&D policy and programs between India and EU in relation to for example eco-design, improving treatment of PV modules waste etc.The report can thus be a starting point for the design and the implementation of a lean and mean legislative framework for Renewable Energy Equipment and its post-consumer waste.

## 1.3. About the Project

This report is developed in cooperation among the EU India Technical Cooperation Project (IDOM), SolarPower Europe, PV CYCLE & National Solar Energy Federation of India.

**IDOM (Consortium leader)** is an international firm of independent professional services in the fields of engineering, consulting and architecture, backed by an experience that goes back to 1957. In a global world, IDOM has become a global and multidisciplinary firm made up of over 3,500 professionals, located in 40 permanents and various project offices distributed 40 countries across 5 continents. With projects in 125 countries, it has offices in 20 countries, Algeria, Argentina, Brazil, Chile, Colombia, UAE, Slovenia, Spain, United States, India, Mexico, Poland, Portugal, United Kingdom, Senegal, Malaysia, Peru, Turkey, Canada. IDOM's journey in India started in 2012, the New Delhi office has more than 100 multidisciplinary professionals who share common goals and work practices. IDOM Indian experts counts on vast experience in successfully, delivering and providing services in all disciplines of engineering, consultancy and architecture.

IDOM is an association of professionals linked by work and the common ownership of the firm (100% of the capital is distributed between the staff currently working in the company), cooperating to achieve greater human and professional development, while offering the best service to the Client.

**The EU-India Technical Cooperation Project Energy** is formed under the joint collaboration of European Union and Government of India. The project is operational since September 2014 and has provided its assistance to Bureau of Energy Efficiency (Ministry of Power), Solar Energy Corporation of India (SECI) and the Ministry of New and Renewable Energy (MNRE). The project provides beneficiaries and participants with the opportunity to enhance their technical and institutional capacity. The major aim is to create enabling environment for implementation of climate friendly energy efficient technologies through increasing awareness amongst public and private sectors. You may know more about the project by clicking the link: https://faqs.solar/about-the-programme/

**SolarPower Europe** is the voice of the Solar industry in Europe, with more than 200 members active along the whole solar PV value chain. SolarPower Europe's mission is to shape the regulatory environment and enhance business opportunities for Solar in the European market providing its -global membership with a strong voice towards European decision makers. It develops award winning business intelligence and best practices reports on markets, industry

and technologies, informing its members and external stakeholders on the latest trends of the PV industry. The association is acknowledged as an essential content provider for European political stakeholders – including EU institutions and opinion leaders. SolarPower Europe is registered as an international non-profit making organisation under Belgian law.

**NSEFI** is an umbrella organization of all solar energy stakeholders of India. This apex solar organization works in the area of policy advocacy and is a National Platform for addressing all issues connected with solar energy growth in India. It consists of leading international, National and regional companies and includes Solar Developers, Manufacturers, EPC Contractors, Rooftop Installers, System integrators, and Balance of Plant suppliers and manufacturers, Small and Medium Enterprises and works in a complimentary manner with the Central and State Governments for achieving India's national solar target of 100 GW by 2022. NSEFI Covers all activities: Solar PV, solar thermal (Both Small and big) off-grid, Rooftop solar, Micro and Mini grids, Rural electrification, solar agricultural Pumps, encouragement to R&D, capacity building, spreading awareness etc-with an avowed goal of Making Solar Energy Affordable for all.

**PV CYCLE** is a non-for-profit member-based organization which offers both collective and tailor-made waste management and legal compliance services for companies and waste holders around the world. With the mission in mind to always offer members and their customers best-in-class solutions, PV CYCLE has become the preferred waste management partner for companies with extensive sustainability needs. Solutions are known for setting the benchmark and include all aspects of waste management. PV CYCLE offers members and waste holders better access to take-back and can ensure recycling rates above the industry standards. The organization includes a broad range of electrical and electronic equipment, batteries, packaging and industrial waste in its portfolio, and has national representations and partnerships throughout the globe.

The recommendations of the study are based on the authors' best knowledge at the time of publication and do not necessarily reflect the position of EU-India Technical Cooperation Project: Energy Solar Power Europe, NSEFI, PV CYCLE or their respective members.

*Meeting with MNRE to discuss the work plan for the effective management of PV waste in India*

From the left: Mrinal Madas (Member, EU India TCP), Marek Zaborowski (Team Leader, EU India TCP), Dr. Rajesh Kumar (Scientist E, MNRE), Shri. Amitesh Sinha (Joint Secretary, MNRE), Máté Heisz (Head of International Cooperation, SPE), Subrahmanyam Pulipaka (CEO, NSEFI)

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Subrahmanyam Pulipaka is the youngest chief executive officer of National Solar Energy Federation of India (NSEFI). He is the recipient of BRICS Energy for Thought - Young Scientist award - 2018. He is an alumnus of BITS Pilani and is also the founding chairman of India Africa Youth Energy Forum (IAYEF), a platform dedicated to nurture future energy leaders in the Indian subcontinent and African continent. He also started series of Youth Energy Dialogues for carrying forward the youth centric energy revolution dialogues in different cities in India as well as different countries in Africa. He has been involved in active research on the reliability of solar photovoltaics since last 4 years and was one of the youngest researchers to represent India at many international forums. Apart from this, he has also been actively involved in solar skill development and policy deliberation activities and addressed various intergovernmental sessions in India, Russia and Rwanda.

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Mrinal Madas has a Master's degree in Power Management and a Bachelor of Engineering in Power from National Power Training Institute. He is presently working under the EU India Technical Cooperation project since Dec 2016 as a member of the PV Rooftop Cell. Till date, Mrinal has been instrumental in managing numerous solar projects and developed business for renewable energy generating companies in India.

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CHAPTER 02

# THE REGULATORY FRAMEWORK IN INDIA AND THE EUROPEAN UNION

## 2.1 Overview of European Waste and Extended Producer Responsibility regulatory framework for PV modules, inverters and batteries

### 2.1.1. The Waste Electrical and Electronic Equipment (WEEE) Directive

The WEEE Directive 2012/19/EU entered into force in each Member State on 14 February 2014. This recast Directive is the successor of the original WEEE Directive 2002/96/EC, which entered into force on 13 August 2005 in each Member State. The WEEE Directive imposes the responsibility for the disposal of Waste Electrical and Electronic Equipment (WEEE) on the manufacturers or distributors of such equipment or more precisely on the companies, which are putting for the first time such equipment on the territory of a Member State of the European Union (referred to as "producers" in the WEEE Directive's terminology).

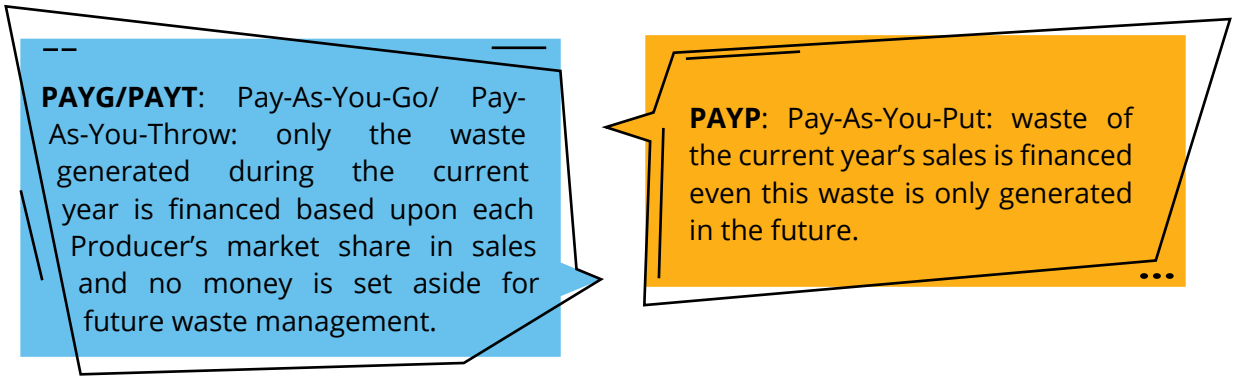
The WEEE Directive is an example of the Extended Producer Responsibility (EPR) principle, which is "an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle".[2]

In practice, EPR implies that the first put-on-the-market companies (producers, importers) take over the responsibility for collecting or taking back used goods and for sorting and treating their post-consumer waste. This requires that those companies establish an infrastructure for collecting WEEE, in such a way that "Users of electrical and electronic equipment from private households should have the possibility of returning WEEE at least free of charge". The directive saw the formation of national "producer compliance schemes", into which manufacturers and distributors paid an annual fee for the collection and recycling of associated waste electronics from household waste recycling centres.

The WEEE Directive distinguishes between historical and new WEEE. The distinction between the financial mechanism to be applied for new WEEE and historic WEEE is that producers bear individual financial responsibility for new WEEE. Meanwhile, as producers could not influence the design of products placed on the market before the directive came into force, the WEEE Directive assigns collective responsibility for this historic WEEE on all producers on the market when the costs to manage it will arise.

[2] *OECD (2001) Extended Producer Responsibility: A Guidance Manual for Governments, OECD, March, Paris, 164p*

The financing mechanisms for Extended Producer Responsibility consist mainly of two options or a combination of these options:




Historical waste, i.e. waste generated today of products sold before the starting date of the EPR, is collectively financed by all actors on the market today; this is the result of the International Accounting Standards Board and their IFRIC 6 decision of 2005.

Besides defining the parties that are responsible of financing, reporting and information on end-of-life management, the Directive outlines, for the various WEEE categories, recovery and recycling targets, requirements on how to handle waste, as well as provisions on waste classification, labelling and registration.

In order to comply with all the obligations of the WEEE Directive, this legislation allows that the Producer or Importer can choose how to solve all these challenges: either individually or by joining a collective scheme such as PV CYCLE (see below).

Even though the WEEE Directive has initially been construed for Electrical and Electronic Equipment (EEE) consuming electricity, the 2012 Directive has put since 2014 for the first time EEE under its scope which generates electricity, i.e. photovoltaic modules.

Besides PV modules, also inverters are under the scope of the WEEE legislation.

PV modules are part of Category 4 in the WEEE Directive. This Category has the following treatment target: 85% of the WEEE shall be recovered, and 80% shall be prepared for re-use and recycled.

As from the year 2019, there are two options to calculate the collection rate for all WEEE in each Member State:

- Minimum percentage of 65% of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, OR
- Alternatively, 85 % of WEEE generated on the territory of that Member State.

The latter – WEEE Generated Target – is an important calculation method for PV modules due to very low return rate during the first 12 to 20 years.

For this WEEE Generated target the European Commission has published the Regulation 2017/699 establishing a common methodology for the calculation of the weight of electrical and electronic equipment (EEE) placed on the market of each Member State and a common methodology for the calculation of the quantity of waste electrical and electronic equipment (WEEE) generated by weight in each Member State.

Additionally, the Commission has published a WEEE calculation tool (for WEEE Generated) – in fact a Macro Excel - which is customized for each Member State and is set up and made available by the Commission.

***Implementation of the WEEE Directive at EU Member State level***

It is important to understand the value of a "Directive" in the European legal context. A Directive is binding to each Member State of the European Union; each country of EU-28 must transpose the European law into national legislation and only then this national WEEE Law is addressed to the companies (producers or importers).

Hereby the Member States must respect the minimum requirements imposed by the European Directive. However, each Member State is allowed to "gold-plating', a term to characterise the process where an EU directive is given additional powers when being transposed into the national laws of member states.

In relation to WEEE, we notice for example differences in the transposition and the execution of the financing obligation mechanisms across all Member States. Presenting this for some EU-countries is outside the scope of this study.

***PV CYCLE***

PV CYCLE is a collective take-back and recycling scheme meaning that it organises the registration, the reporting of the amount of PV modules put on the market of each EU-28 country and the collected waste amounts towards public authorities (upstream WEEE-compliance) and the organization of the collection, recycling and final recovery of PV modules and inverters (downstream WEEE-compliance) on behalf of its participants.

PV CYCLE's operations are financed through monthly or quarterly fees depending on the reporting obligations in each Member State.

### 2.1.2. The Restriction of Hazardous Substances (RoHS) Directive

The Directive on the Restriction of the use of certain Hazardous Substances (RoHS) in electrical and electronic equipment (Directive 2002/95/EC), introduced in 2003, recast in 2013 (Directive 2011/65/EU) and last amended in 2017, complements the provisions laid out in the WEEE Directive. Objective of the RoHS Directive is to reduce and substitute certain hazardous substances used in EEE – lead (Pb), cadmium (Cd), mercury (Hg), hexavalent chromium (Cr6+) and certain flame retardants (PBB, PBDE) – with safer alternatives. The RoHS Directive sets maximum concentration levels of these substances.[3]

[3]*The maximum concentration level is set at 0.1%, except for cadmium (0.01%) by weight.*

Since 2013 and still at present state, PV modules are permanently excluded from the scope of the RoHS Directive.

### 2.1.3. The Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

The Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (EC 1907/2006) is the EU Regulation overseeing the use of chemicals, addressing the production and use of chemical substances and their impacts on human health and the environment.

This legislation mandates that all companies manufacturing or importing relevant quantities[4] of chemical substances in the EU, register such substances with the European Chemical Agency. In the registration, they must identify the risks connected to the substances they produce and import, and illustrate how these risks are managed.

The Regulation also addresses the use of a number of substances of very high concern (SVHC). These substances, identified in a Candidate List, cannot be used unless the company is given an authorisation.

### 2.1.4. Sustainable product policies

The European Commission is currently considering the implementation of a number of sustainable product policies for PV modules, inverters and systems. These measures include both mandatory instruments (Ecodesign, Energy Label) and voluntary instruments (EU Ecolabel, Green Public Procurement), which are undergoing a process assessing their impact on market and product sustainability. Some of the criteria provisionally laid out in the draft measures include performance requirements and information disclosure on material content, dismantlability, repairability, recyclability and presence of hazardous substances. The expected timeframe for entry into force of the first set of these provisions is 2023-2024.

### 2.1.5. Landfill Directive

The Landfill Directive 1999/31/EC has the objective to prevent and reduce as much as possible the negative effects on the environment, in particular on surface water, groundwater, soil, air, and on human health from the landfilling of waste by introducing stringent technical requirements for waste and landfills.

The Landfill Directive defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Landfills are divided into three classes: landfills for hazardous waste; landfills for non-hazardous waste; landfills for inert waste.

Most of the EU Member States have introduced a landfill ban for untreated waste (including PV modules), separately collected waste such as the products covered by EPR-regulations (such as PV modules).

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[4] *1 tonne or more per year per company.*

## 2.1.6. The Waste Framework Directive

The Waste Framework Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called "end-of-waste" criteria), and how to distinguish between waste and by-products. As such, it is an essential piece of legislation that must be considered in the context of recycling and treating any type of waste, including PV modules.

This Directive introduces the "polluter pays principle" and the "Extended Producer Responsibility" (EPR). It incorporates provisions on hazardous waste and waste oils, and includes two new recycling and recovery targets to be achieved by 2020: 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste. This Directive requires as well that Member States adopt waste management plans and waste prevention programmes.

The European Commission adopted in 2020 an ambitious Circular Economy Package, which includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs.

The revised legislative proposal on waste sets clear targets for reduction of waste and establishes an ambitious and credible long-term path for waste management and recycling. To ensure effective implementation, the waste reduction targets in the new proposal are accompanied by concrete measures to address obstacles on the ground and the different situations across EU Member States.

**Key elements of the revised waste proposal include:**

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling;
- Simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- Concrete measures to promote re-use and stimulate industrial symbiosis –turning one industry's by-product into another industry's raw material;

Economic incentives for producers to put greener products on the market and support recovery and recycling schemes (e.g. for packaging, batteries, electric and electronic equipment, vehicles).

### 2.1.7. Battery Directive

The EU legislation on waste batteries is embodied in the Batteries Directive 2006/66/EU and amended in 2013. It intends to contribute to the protection, preservation and improvement of the quality of the environment by minimising the negative impact of batteries and accumulators and waste batteries and accumulators. It also ensures the smooth functioning of the internal market by harmonising requirements as regards the placing on the market of batteries and accumulators. With some exceptions, it applies to all batteries and accumulators, no matter their chemical nature, size or design. Thus, also the batteries used for the storage of energy generated by PV systems are under the scope of this European legislation.

To achieve these objectives, the Directive prohibits the marketing of batteries containing some hazardous substances, defines measures to establish take-back schemes aiming at high level of collection and recycling, and fixes targets for collection and recycling activities. The Directive also sets out provisions on labelling of batteries and their removability from equipment.

It also aims to improve the environmental performance of all operators involved in the life cycle of batteries and accumulators, e.g. producers, distributors and end-users and, in particular, those operators directly involved in the treatment and recycling of waste batteries and accumulators. Producers of batteries and accumulators and producers of other products incorporating a battery or accumulator are given responsibility (EPR) for the waste management of batteries and accumulators that they place on the market.

## 2.2. Overview of the Indian regulatory framework for WEEE and RoHS

### 2.2.1. E-Waste (Management and Handling) Rules[5]

India's e-waste regulation (for both management and handling) was crafted in 2011 and became effective from 1 May 2012. Prior to the enactment of this rule, e-waste was covered under the Hazardous Waste Management (HWM) Rules. Under the ambit of Environmental Protection Act 1986, the E-Waste (Management and Handling) Rules, 2011 were enacted which brought into force to enable recovery and/or reuse of useful material from e-waste, thereby reducing the hazardous wastes destined for disposal, to ensure the environmentally sound management of all types of e-waste and to address the safe and environment friendly handling, transporting, storing, and recycling of e-waste. This 2011 act was the first time, where the Extended Producer Responsibility (EPR) as a concept was introduced in India manufacturers liable for safe disposal of electronic goods.

[5] *http://greene.gov.in/wp-content/uploads/2018/01/EWM-Rules-2016-english-23.03.2016.pdf*

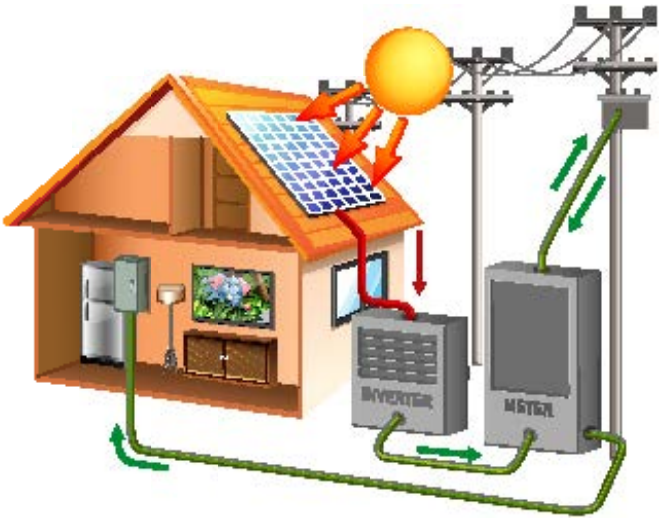
In supersession of the 2011 Rules, the E-Waste (Management) Rules, 2016 were enacted and came into effect from 1 October 2016. Through this supersession, the Manufacturers, dealers, refurbishers and Producer Responsibility Organisations (PRO) were also brought under the ambit of these Rules. An option was given for setting up of a PRO as an additional channel for implementation of EPR by Producers. Further, collection mechanism-based approach was adopted for collection of e-waste by Producers under EPR. Furthermore, the applicability of the Rules was expanded to cover components, consumables, parts and spares of EEE in addition to the equipment covered under the Rules.

In March 2018, the E-Waste Rules were amended by the Ministry of Environment, Forest and Climate Change to facilitate and streamline the implementation of an environmentally sound management of e-waste in India. The objective of these amendments is to formalize the e-waste recycling sector by channelizing e-waste generated in the country towards authorized dismantlers and recyclers. To undertake the activities prescribed for PROs under these new Rules, the PROs were to apply for Central Pollution Control Board (CPCB) registration. This amendment is considered as a progressive one in India's journey of handling e-waste as the requirement of PROs to register with CPCB would ensure continuous monitoring by CPCB thereby ensuring accountability from PROs.

As per these revised targets, 10% of the quantity of waste generated shall be collected during 2017-2018 and there shall be a 10% increase every year until the year 2023. After 2023, the E-Waste collection target is fixed at 70% of the quantity of waste generation.

The responsibilities of the various entities, producers; consumers (including bulk consumers); collection centres; dismantlers and recyclers, are defined, together with the procedures for obtaining registration and authorisation from the pollution control entities including sample forms. For producers, collection centres, dismantlers and recyclers, an application for a Grant of Authorisation must be made within three months of the start of the Rules, (i.e.) by 31st July 2012, with the authorisation having a five year validity being made up to 90 days later.

In the E-Waste (Management and Handling) Rules "e-waste" is defined as "electrical and electronic equipment (EEE), whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes". EEE is defined as "equipment which are dependent on electric current or electro-magnetic field in order to become functional". This EEE definition includes inverters.




PV modules and inverters are currently outside the scope of the E-waste Rules. The E-Waste Rules apply to the two e-waste categories defined in Schedule I of the Rules: (i) information technology and telecommunication equipment and

(ii) consumer electrical and electronics. Neither PV modules nor inverters are listed among the identified EEE categories.

Even though the components of a solar PV system – PV modules and inverters – are currently not included in the E-Waste Rules, this piece of legislation could be considered as a reference legislation by both the Indian authorities as well as the Indian solar industry. For example, MNRE's Guidelines for setting up grid-connected solar power plants state that "the developers will ensure that all solar PV modules collected from their plant after their end-of-life are disposed-off in accordance with the "E-waste (Management and Handling) Rules". However, today, there are neither any regulations nor any standards for PV waste management in India.

The E-Waste Rules also cover the restriction of hazardous substances (RoHS) in electronic and electrical components and equipment. It is applied on producers and distributors involved in the manufacture, sale, and processing of electronic and electrical equipment or components. Under the RoHS provisions, cost for sampling and testing shall be borne by the government for conducting the RoHS test. If the product does not comply with RoHS provisions, then the cost of the test will be borne by the Producer.

Similarly to the European RoHS Directive, the Indian E-Waste Rules restrict the use of lead (Pb), cadmium (Cd), mercury (Hg), hexavalent chromium (Cr6+) and certain flame retardants (PBB, PBDE) in EEE appliances. The thresholds are the same as in the EU RoHS Directive.[6] Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit flip chip packages, is exempted. This means that if PV modules were included under the scope of the E-Waste Rules, crystalline silicon PV modules would be significantly below the thresholds. However, Cadmium-Telluride (CdTe) PV modules may present a cadmium concentration above the cadmium concentration threshold of 0.01% by weight.

In the European Union, PV modules, being a key sustainable technology for the decarbonisation of the energy system, are exempted from the requirements related to the use of hazardous substances in electrical and electronic equipment.

Regarding E-waste storage, the E-waste law has no definition of this notion and it requires that every relevant actor (manufacturer, producer, bulk consumer, collection center, dealer, refurbisher, dismantler and recycler) may store the e-waste for a period not exceeding one hundred and eighty days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection.

[6] *The maximum concentration level is set at 0.1%, except for cadmium (0.01%) by weight.*

## 2.2.2. Hazardous and Other Wastes (Management and Transboundary Movement) Rules

The Hazardous and Other Wastes Rules[7] is a complex legislation because it combines the former Hazardous Waste Rules of 1998 and the Transboundary shipment of Non-Hazardous and Hazardous Waste into and towards countries outside India.

The latter is simply the logical implementation of the International Basel Convention; in Europe, this is implemented by the Waste Shipment Regulation 1013/2006.

"Other waste" means waste specified in Part B and Part D of Schedule III for import or export and includes all such waste generated originally within India.

**Examples of "other waste" are:**

Waste electrical and electronic assemblies or scrap (including printed circuit boards) not containing components such as accumulators and other batteries, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Schedule II constituents (such as cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed, to an extent that they do not possess any of the hazardousness characteristics

Glass wastes in non-dispersible form: Cullet and other waste and scrap of glass except for glass from cathode-ray tubes and other activated glasses

The Hazardous and Other Wastes (Management and Transboundary Movement) Rules define hazardous waste as any waste which by virtue of any of its physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances and include wastes generated mainly from the 36 industrial processes (e.g. oil and pharmaceutical industry) referred under Schedule I of these Rules. In addition, some wastes become hazardous by virtue of concentration limits as well as hazardous characteristics listed under Schedule II whereby the defined concentration limits are based on the Toxicity Characteristic Leaching Procedure (TCLP) (Class A) and based on Total Threshold Limit Concentration (TTLC) (Class B).[8]

[7] *http://iwma.in/HWM%20Rules.pdf*
*https://vikaspedia.in/energy/environment/waste-management/hazardous-waste/environment-ministry-notifies-hazardous-waste-management-rules-2016*

[8] *https://en.wikipedia.org/wiki/Toxicity_characteristic_leaching_procedure*

The hierarchy in management of hazardous waste is to reduce, reuse, recycle and re-process and final option of disposal of wastes having no potential for value addition, in disposal facilities in an environmentally sound manner. The disposal facilities may only have a secured land fill (SLF) or may have an incinerator alone for organic wastes or combination of secured landfill and incinerator.

Crystalline silicon PV modules, which compose the great majority of the Indian installed PV fleet, are classified as non-hazardous waste when tested applying the USEPA TCLP Method 1311 in line with the testing requirements imposed by the Hazardous and Other Waste Rules.[9,10] In state-of-the-art PV modules concentration levels of relevant metals, including mercury, arsenic, barium, cadmium, chromium, lead, selenium and silver are below the limits defined by the Hazardous and Other Waste Rules Schedule II (Class A).

Solar glasses containing antimony create a potential environmental risk when disposed improperly. Antimony containing solar module glass is used globally to improve the stability of the solar performance of the glass upon exposure to ultraviolet radiation and sunlight. An advisory study conducted by MNRE indicated that the antimony concentration in solar glass was in the range of 0.13 and 0.29 mg/l (TCLP), while the threshold set by the Hazardous and Other Waste Rules is 15 mg/l[11]. Therefore, the tested antimony containing solar glass waste does not fall in the category of hazardous waste. However, waste antimony glass has potential to leach antimony in wet conditions including wet landfill conditions. In 2019 MNRE issued a draft blueprint[12] in which the issue was addressed, highlighting that antimony leaching would take place when waste solar glass is disposed on land through unsecured manner. Still, the leaching of antimony from solar glass would occur only in a worst-case end-of-life management scenario in which modules are dumped in an uncontrolled landfill and the solar glass is completely crushed.

For CdTe PV modules, the TCLP values may be above the concentration limits. However, the results obtained in a study from 2017 indicate that a high fraction of the Cd and Te in CdTe modules could be potentially released if non-encapsulated CdTe solar modules are discarded in municipal landfills.[13] Leaching of Cd and Te is expected to occur mainly during the acidic phase of a landfill in which low pH values are dominant. The actual Cd concentrations in a given landfill would depend on the amount of PV modules disposed, module design, module fragment size, climatic conditions, landfill management and design, etc.

For CIGS PV modules, aluminum, copper and selenium were the most abundant materials while gallium – which is said to have apoptotic (cell-fatal) and carcinogenic properties if present in compound form – was found to make up 2.4% of the metal composition, with indium having

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[9] *https://repository.asu.edu/attachments/191176/content/Krishnamurthy_asu_0010N_17317.pdf*

[10] *https://www.epa.gov/sites/production/files/2015-12/documents/1311.pdf*

[11] *MNRE (2017): Concept Note/ Blue Print on Management of Antimony Containing Glass from End-of-Life of the Solar PV Panels.*

[12] *https://mercomindia.com/mnre-recycling-solar-panel-glass/*

[13] *Ramos-Ruiz et al. (2017): Leaching of cadmium and tellurium from cadmium telluride (CdTe) thin-film solar panels under simulated landfill conditions; Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5607867/*

a 13.14% share.[14] This reference to  a scientific paper is only a reference. Taking into account the waste legislation and the classification of what is hazardous or non-hazardous waste, we notice in general that CIGS PV Panels are classified as non-hazardous waste. To classify a waste as hazardous waste, the threshold for Selenium is usually 3% weight and the average amount of Selenium in a CIGS panel is 0,020% weight.

It is relevant to highlight that, were a landfill ban on solar PV modules implemented, the risk of leaching of antimony and other hazardous substances would be minimised.

Other PV system equipment, including inverters[15], wiring and other BoS components, are not considered as hazardous waste.

The Hazardous and Other Wastes Rules (HOWR) also defines an "Occupier" in relation to any factory or premises as a person who has, control over the affairs of the factory or the premises and includes in relation to any hazardous and other wastes, the person in possession of the hazardous or other waste.

A "(treatment) facility" In the HOWR means any establishment wherein the processes incidental to the generation, handling, collection, reception, treatment, storage, reuse, recycling, recovery, preprocessing, co-processing, utilisation and disposal of hazardous and, or, other wastes are carried out;

The occupiers of facilities may store the hazardous and other wastes for a period not exceeding ninety days and shall maintain a record of sale, transfer, storage, recycling, recovery, pre-processing, co-processing and utilisation of such wastes and make these records available for inspection.

in the HOWR, "Storage" is defined as storing any hazardous or other waste for a temporary period, at the end of which such waste is processed or disposed. The occupiers of facilities may store the hazardous and other wastes for a period not exceeding 90 (ninety) days and should duly maintain a record of sale, transfer, storage, recycling, recovery, pre-processing, co-processing and utilisation of such wastes and these records should be made available for inspection.

Main conclusion is that the HOWR is only related to hazardous waste and how this needs to be stored, treated and – when applicable – how hazardous waste and a list of so-called other (non-hazardous) waste must be shipped into and outside India.

### 2.2.3. Batteries (Management and Handling) Rules (2001)

The Batteries (Management and Handling) Rules of 2001 is only applicable to lead-acid batteries.

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[14] *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5607867/ and Initial metal contents and leaching rate constants of metals leached from end-of-life solar photovoltaic waste: An integrative literature review and analysis, PreetiNain,ArunKumar, 2019.*

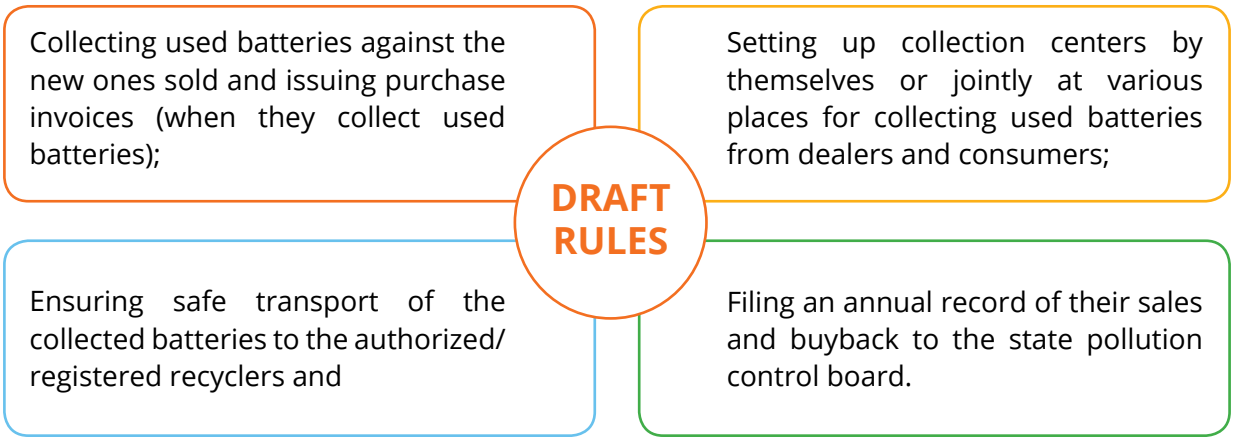
[15] *https://susproc.jrc.ec.europa.eu/solar_photovoltaics/docs/Draft_Report_Task4%20Master%20REV%20-%20to%20publish.pdf*

End of February 2020, the Ministry of Environment, Climate and Forest Change released the Draft Battery Waste Management Rules, 2020.

The draft Rules will be applicable to various stakeholders involved in the life of batteries or its components, consumables, and spare parts which make the product operational. These include every manufacturer, producer, collection center, importer, assembler, dealer, recycler, consumer, and bulk consumers.

The Draft Rules will cover all types of batteries. It will also apply to all appliances into which a battery is, or maybe incorporated. As the storage of energy generated from PV systems is usually stored through lithium-ion batteries, the batteries used within a PV system might within a certain timeframe covered by Indian Extended Producer Responsibility legislation.

The responsibilities of manufacturers and dealers under the Draft Rules can be summarized as follows:




## 2.2.4. Solid Waste Management Rules[16] and Construction and Demolition Waste Management Rules[17]

These Solid Waste Management Rules apply to solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste and treated bio-medical waste.

Excluded are industrial waste, bio-medical waste and e-waste, lead-acid battery waste and radio-active waste.

The Construction and Demolition Waste Management Rules of 2016 apply to waste comprising of building materials, debris and rubble resulting from construction, re-modeling, repair and demolition of any civil structure.

[16] *https://c40-production-images.s3.amazonaws.com/other_uploads/images/1939_SWM-Rules-2016.original.pdf?1536934757*

[17] *https://dpccocmms.nic.in/SPCB_DOCUMENTS/MSW.pdf*

Neither PV modules nor other equipment of a PV System are covered by one of these two Rules.

### 2.2.5. Industrial Solid Waste

A true legislation dedicated to only Non-hazardous Industrial Solid Waste does as such not exist in India. Only for Hazardous Industrial Solid Waste, there is the reference to the HOWR of 2016.

Today, without any specific legislation in place for photovoltaic modules, and being non-hazardous waste, the only reference for waste management could have been rules related to Industrial Non-hazardous Solid Waste.

Moreover, for arriving at an appropriate solution for better management of industrial solid waste, assessment of nature of waste generated is also essential.

Management of Industrial Solid Waste (ISW) is not the responsibility of local bodies. Industries generating solid waste have to manage such waste by themselves and are required to seek authorizations from the respective State Pollution Control Boards (SPCBs).

Assessment of industrial solid waste management problem greatly varies depending on the nature of the industry, their location and mode of disposal of waste.

Moreover, for arriving at an appropriate solution for better management of industrial solid waste, assessment of nature of waste generated is also essential.

Industries are required to collect and dispose of their waste at specific disposal sites and such collection, treatment and disposal is required to be monitored by the concerned State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) in Union Territory.

The following problems are generally encountered in cities and towns while dealing with industrial solid waste

- There are no specific disposal sites where industries can dispose their waste;
- Mostly, industries generating solid waste in city and town limits are of small-scale nature and even do not seek consents of SPCBs/PCCs;
- Industries are located in non-conforming areas and as a result they cause water and air pollution problems besides disposing solid waste;
- Industrial estates located in city limits do not have adequate facilities so that industries can organise their collection, treatment and disposal of liquid and solid waste;

- There is no regular interaction between urban local bodies and SPCBs/PCCs to deal such issues relating to treatment and disposal of waste and issuance of licenses in non-conforming areas.

## 2.3. Current PV waste management practices in India

As PV waste management is not regulated in India, different players take different approaches when dealing with PV module waste.

### 2.3.1 Developers: Storage of the PV modules

As the disposal of the PV modules waste generated during the installation and operation have a financial impact on the developer, a majority of them store the damaged PV modules within their premises, waiting for an economical solution to carry out the disposal.

Today, there is a risk that waste PV modules end up in uncontrolled or not environmentally sound disposal operations such as uncontrolled or illegal landfills or in open land.

### 2.3.2 Developers: Treatment, recycling, recovery or disposal on a voluntary basis

A minority of producers owing to their internal environment management systems manage their organisations responsibilities including the end of life management of their products.

For e.g. ISO 14001 describes the principles and framework for life cycle assessment (LCA) of the company's products and operation. Under such frameworks a few organisations including the module manufacturers and the installers in association with other waste recyclers are working towards the disposal of the damaged and the "end of life" PV modules.

These installers collect and store the discarded PV modules on site until they reach a predefined number, which is required for enabling the treatment process. Hereby, the holders of PV modules waste dispose these PV modules with the assistance of environmentally sound waste treatment plants.

As PV modules are "as such" in India not included in any of its waste management rules unless the rules applicable of industrial solid waste, the waste treatment plants sometimes classify themselves these PV modules waste as hazardous or e- waste.

The cost of collection, transportation and disposal is borne by the owner or holder of the waste and depends on the quantity of the PV modules Waste being disposed. Due to the absence of volume of PV modules waste , the treatment capacity and infrastructure and limited experience, the treatment plants in India are or not interested in creating capacity and infrastructure (see the notion of no volume !) or are able to extract only a portion (20% by weight) of the PV module, i.e. the aluminium frames and the junction box. The remaining part of the PV modules is disposed of in the TSDFs on payment of the TSDF stated fees, which ranges around Rs. 20-35 per kg.

### 2.3.3 The approach of PV module manufacturers on PV modules damaged during transportation

NSEFI has conducted interviews with the eight module (and cell) manufacturers in India to understand the storage, treating, recovery & recycling of PV module waste. Many of them expressed the concern that there is no policy for dealing with the waste generated by PV modules as they are neither included in e-waste, nor in hazardous waste. Currently when modules get damaged during the transportation and installation phase they are not dumped into landfills and the module waste is dealt in the following way where approximately 50% of the total material is revived back:

01 Part of frame that is taken down is sold in the form of scrap (by weight).

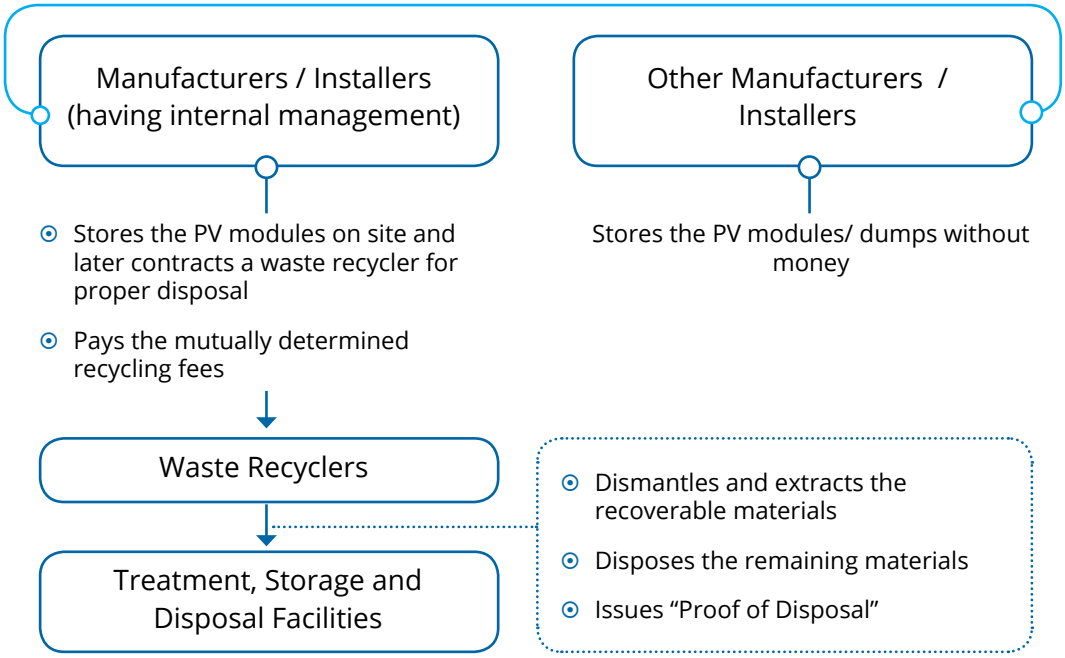
02 Junctions and cables, since they fall in the category of e-waste and are recycled as per the e-waste regulations.

03 Glass laminate is recycled to some extent or is disposed as general waste mostly.

04 Most of the times the silicon cells are used as cut cells for modules with lower ratings

Economically speaking, the best way to get the value back of modules damaged will be to set up the infrastructure for recycling and enabling policies through the help of government of India and in this regard, they were also open about considering business models like of PV CYCLE.

**Figure 1 – PV waste management existing scenario. Source: PV Rooftop Cell.**



### 2.3.4 Observations

1 A part of the owners or holders of the PV modules waste still bear the cost involved in disposing, storing the damaged PV modules within their premises.

2 The fee for dumping and disposing the waste in India is not properly defined and due to the lack of rules and inspection, the PV modules waste have a risk ending up in uncontrolled landfills or in open land.

3 A few holders or owners of PV modules waste having their internal environment management system, follow an informal practice to manage the PV modules waste.

4 The treatment facilities classify the PV module waste (or its components) as hazardous waste or e-waste in India. In general, around 20% of the waste is recovered and the remaining part is treated by TSDFs upon payment of disposal fees. This results in cost implications to the owner or holder of the PV modules waste. However, there is also the "Polluter Pays'-principle which is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organisation for Economic Co-operation and Development (OECD) and European Union countries. It is a fundamental principle in US environmental law.

5 The manufacturers opined that it is very often difficult for them to get the modules back to the manufacturing unit. In this contrast, they would like the government to look into distributing collection points across the country, especially at the locations where solar installations are highly concentrated to optimize the cost of transportation & enable efficient recycling mechanism. This according to them will de-stress their logistical involvement and will also help generate more jobs.

6 The interviewees expect the government to explicitly specify in its policies the responsibility of manufacturers & developers, so that process of collection, transport, storage & treatment goes on seamlessly.

## 2.4. Conclusions

There are important similarities and differences between both regions for waste treatment regulations relevant for waste generated from PV systems.

- Main drivers for the environmentally sound waste management of equipment related to PV systems in the European Union are:
    - Landfill ban for unsorted waste and for waste which can be recycled;
    - Extended Producer Responsibility requirements for inverters;
    - Extended Producer Responsibility requirements for PV modules. For PV modules the WEEE Directive is not the best legislation to be part of due to the fact that the WEEE Directive is originally a "consumer waste driven legislation focusing on

only electricity consuming equipment" whilst PV modules would fit better in a separate EPR-legislation whether or not together with other Renewable Energy Equipment;

- The IPPC-Directive which is the basis for any permit or license to operate for any business as well for any waste treatment activity where the key elements are to have at the end an Integrated Pollution Prevention Control for any commercial and industrial activity towards emissions to water, air and soil.

- In both regions, PV modules are considered as "one product, one equipment" – one does not apply a waste law to "components" of an equipment. For example, a junction box, cables of a PV module are all an integrated part of a PV installation and thus the applicable waste laws apply to PV modules. An inverter is an inverter. A battery is a battery.

- In the waste and recycling management industry, one talks about "materials" such as ferro or non-ferro metals, HDPE-plastics or LDPE-plastics etc, glass cullets and the like.

- Most importantly, whereas PV modules and inverters are under the scope of the EU WEEE Directive, the Indian E-Waste (Management and Handling) Rules are not applicable to PV modules and inverters because these E-Waste Rules only apply to two e-waste categories (i) IT and telecommunication equipment and (ii) consumer electronics. Legal-technically an inverter falls under the Indian definition of E-waste but an inverter does not fall under the scope of e-waste because the scope only covers two categories of electrical and electronic equipment whilst in the EU there is an so-called "open scope" whereby each electrical and electronic equipment falls under the scope of the WEEE Directive since August 2018.

- Both the European WEEE Directive and the Indian E-Waste Rules are based on the Extended Producer Responsibility (EPR) principle, foresee mandatory collection targets and are mainly focused on "consumer electronic waste'.

- There are comprehensive Industrial Solid Waste Rules in place in India, but they do not include solar PV within their scope, whilst the European Union has its Waste Framework Directive which settles the basis requirements for each waste type irrespective of Extended Producer Responsibility legislation or other specific legislation which might come on top.

- Crystalline silicon PV modules are not considered as hazardous waste under the Indian Hazardous and Other Waste Rules. While in 2019 MNRE issued a draft blueprint addressing the potential issue of antimony leaching from landfilled solar glass, leaching of antimony from solar glass would occur only in a worst-case end-of-life management scenario in which modules are dumped in an uncontrolled landfill and the solar glass is completely crushed. However, even in this scenario antimony concentration would be significantly below the threshold set by the Hazardous and Other Waste Rules. A ban on landfilling PV modules would virtually eliminate the risk of leaching of antimony and other substances.

- Lead acid batteries are covered by the current Batteries Rules (2001) and Lithium ion batteries are covered by the recent published draft Batteries Rules (2020).

## 2.4. Recommendations

Looking at the current policy framework around end-of-life PV products in India, preliminary findings show that the following measures should be explored[18]:

- Impose a landfill ban for solar PV modules;
- Implement a legislative framework for voluntary or mandatory Extended Producer Responsibility for equipment coming from the Renewable Energy Industry because the majority of its activities are Business-to-Business (B2B) whereby the industry proposes through a five years management plan its objectives and how to achieve these under supervision if the MNRE and/or MOEF. One of the elements which shall be taken into account is the draft blueprint of the MNRE related solar modules with antimony-containing glass (SPACG).
- A self-standing EPR legislation for PV modules should be created separately from the E-Waste Rules. As PV technology, which is outside the scope of the E-Waste Rules, will become the cornerstone of the energy transition, it is recommended to set out a separate legislation instead of adapting rules from the E-Waste Rules legislation.
- Allow the Indian PV industry to propose a sustainable and long-term solution for the waste generated by a PV system taking into account that PV modules have a very long lifetime and today's generated waste is by far not attractive to enable big industrial waste treatment capacity for PV modules.

It recommended to develop a separate piece of legislation in India to make sure PV modules (and other equipment of a PV system) follow the Ecodesign rules, are adequately collected, treated and financed.

The development of such a piece of legislation can be supported by the current study taking into economic, technological, social and environmental characteristics of India including:

- Technologies for material recovery[19]
- Collection and recycling business models (deposit systems, subsidy systems etc.)
- Recycling fees and cost implications for electricity costs and Indian solar businesses
- Implementation roadmap

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[19] *While an overview of the available technologies for material recovery is outside the scope of this study, it is relevant to highlight that the environment around the development of PV module recycling technology from the perspective of both the private and public sectors has gained significant traction in the recent years. IEA-PVPS study End-of-Life Management of Photovoltaic Panels: Trends in PV Module Recycling Technologies (2018) reported 178 PV recycling patents had been filed. Of those, 128 focused on c-Si technology and another 44 were for compound technologies, including thin-film modules.*

Once this preparatory study has been conducted, a separate piece of Indian legislation for the end-of-life management of PV modules should be developed. The new legislative framework should include in the scope inverters and other PV system components. While it is too early to determine whether inverters and other PV components should be part of the same legislation for PV modules or rather be part of the E-Waste Rules, it will be key to ensure synergies across the different pieces of legislation and to optimise the economic, social and environmental dimensions in waste collection and treatment.

The Indian PV recycling legislation could be inspired by lessons learned in Europe. Therefore, it is important to remember that the European WEEE Directive (similar to its Indian counterpart) is legislation, which was originally established for purely household appliances and consumer electronics. The WEEE legislation is not specifically designed for PV appliances or commercial or industrial electrical and electronic equipment. Differences include the following:

- Traditional EEE appliances consume electricity rather than generating electricity;
- Traditional EEE appliances are consumer goods, whereas PV systems and their accompanying equipment (PV modules, inverters, batteries) part of a long-term investment and part of a sustainable energy policy mix;
- Traditional EEE appliances are daily in physical contact with consumers, which is not the case for the equipment of PV systems.

Therefore, it is recommended to invite first the Indian PV Industry to propose a management plan for the end-of-life phase of their products such as PV modules, inverters and batteries, to allow its assessment by the MNRE and to conclude based upon the accompanying discussions if and how legislative support would benefit for the Indian society.

CHAPTER 03

# PV WASTE GENERATION SCENARIOS IN INDIA

## 3.1. Key Findings

The prodigious penetration of PV technology and Balance of Systems (BOS) equipment shall generate at one point in time post-consumer waste. The solar PV modules are considered to be durable and would generally last 30 years or even more. Thus currently, PV module waste generation is not significant considering that only 570.000 tons of PV modules have been installed before the end of 2016. The vast majority of PV modules – 2.175.000 tons – was installed in the period 2017-2019.

PV module waste is not only generated after the end-of-life of the PV module. The origin of PV module waste consists of several types:

- Damaged PV modules during transportation;
- Damaged PV modules during installation;
- Damaged PV modules due to bad weather conditions;
- Damaged PV modules due to a technical failure in the first year(s) of their life; and
- End-of-life or end-of-use PV modules after 30+ years.

Besides post-consumer waste, an additional waste stream is constituted by waste generated in the manufacturing phase. However, as this study looks at post-consumer waste, the waste generated during manufacturing has not been taken into consideration.

The biggest share of PV modules waste is accounted for by the end-of-life (EoL) discarded PV modules. EoL modules will constitute by far and large the main source of PV waste in the long run; however, considering the 30 years lifetime, the waste streams deriving from EoL PV modules will become significant only in the early 2040s. Before this period, this waste amount will be negligible.

However, in order to understand the amount of PV modules waste flows in the coming decades, it is important to consider non-EoL-waste flows. This will contribute to a sustainable energy economy and to prevent adverse environmental and economic impacts which could arise from the wrong practices of disposal of PV modules and their components.

A three-step approach was undertaken to project the PV waste that will be generated in India by the year 2030. Firstly, the annual and cumulative growth of the installed PV capacity in India has been estimated under three scenarios. In addition, a number of assumptions have been made with regard to PV module weight, PV annual replacement rates, and PV modules damaged during transportation and construction. Based on these scenarios, the mass of PV waste generated due to early failures or damages (i.e., during transportation, installation and operation) was derived.

According to the analysis carried out in the context of this study, by the year 2030 India will generate a cumulative mass of PV module waste of 11 kilo tonnes (kt) in the Low scenario, 21 kt in the Medium scenario, and 34 kt in the High scenario. The waste generated due to the end of life of the PV modules would start accumulating only around after the year 2040 and will become rapidly the most relevant waste source.

**Table 1 - Total mass of PV waste, annual (kt). Source: own elaboration.**

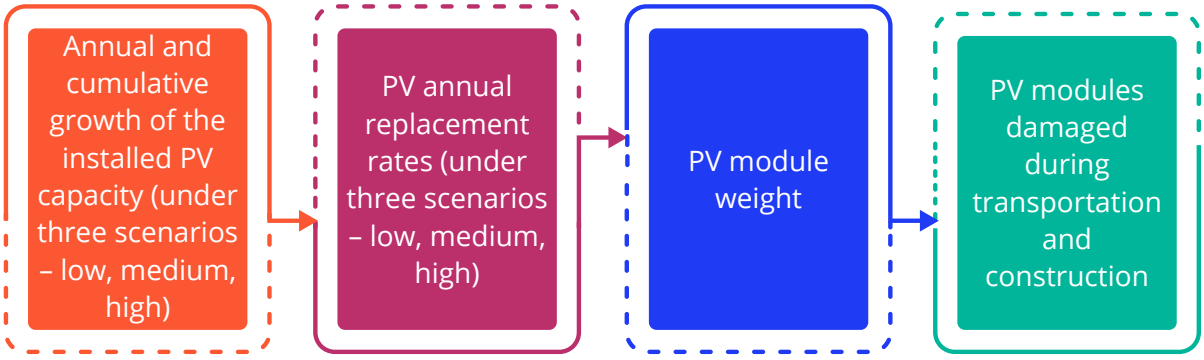
| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,8 | 0,8 | 1,0 | 1,0 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 |
| Medium scenario | 1,4 | 1,5 | 1,5 | 1,4 | 1,6 | 1,9 | 2,2 | 2,6 | 3,1 | 3,6 |
| High scenario | 1,8 | 4,7 | 4,9 | 4,8 | 4,5 | 4,0 | 3,4 | 2,8 | 2,1 | 1,5 |

**Table 2 - Total mass of PV waste, cumulative (kt). Source: own elaboration.**

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,8 | 1,6 | 2,6 | 3,6 | 4,6 | 5,7 | 7,0 | 8,3 | 9,7 | 11,2 |
| Medium scenario | 1,4 | 2,9 | 4,5 | 5,8 | 7,4 | 9,3 | 11,5 | 14,2 | 17,2 | 20,8 |
| High scenario | 1,8 | 6,5 | 11,4 | 16,2 | 20,7 | 24,8 | 28,2 | 31,0 | 33,1 | 34,6 |

## 3.2. Waste generation assumptions and scenarios

To calculate waste generation over the next decade we have made a few consequential assumptions regarding:



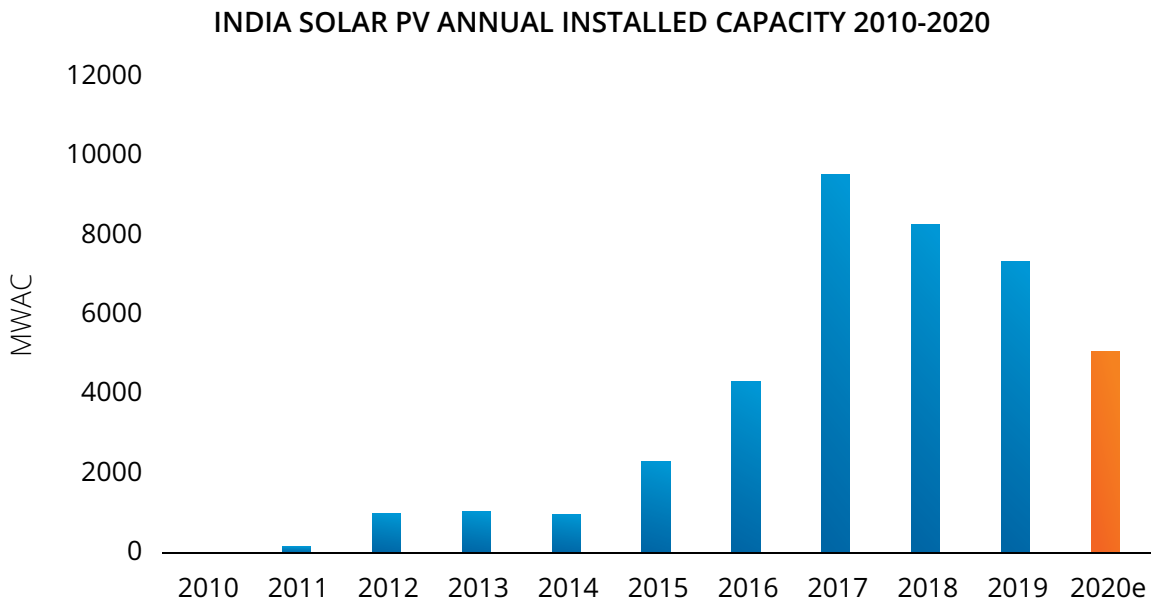
### 3.2.1. Historical data

The PV capacity annually installed in India from 2010 to 2020, expressed in GWAC and considering the calendar year, is shown in the figure below, based on NSEFI and SolarPower Europe data and 2020 estimate.

**Table 3 - Annual installed PV system capacity from 2010 to 2020. Source: NSEFI and SolarPower Europe (2020).**

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020e |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MWAC | 12 | 177 | 998 | 1044 | 984 | 2313 | 4313 | 9558 | 8286 | 7340 | 5083 |

**Figure 2 - Annual installed PV system capacity from 2010 to 2020. Source: NSEFI and SolarPower Europe (2020).**




It can be noted that the PV market effectively started in 2012, and boomed only in 2016-17. No significant amounts of EoL PV modules shall therefore be expected before 2042.

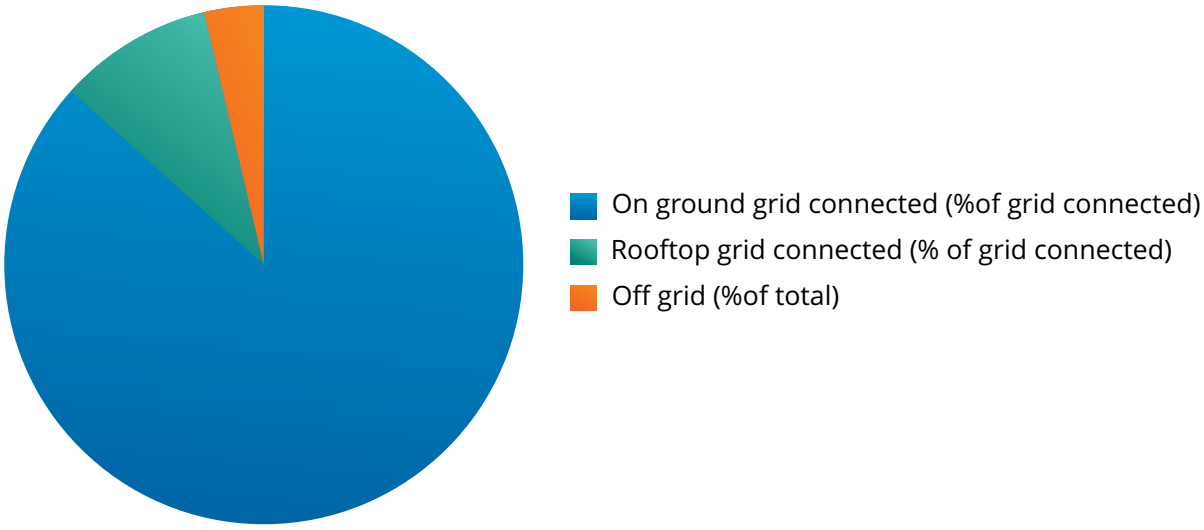
### 3.2.2. Assumptions related to the market share

The projections cover the sectoral market breakdown, it is assumed that 90% of the market of grid-connected systems belonged to the ground-mounted plants and 10% of the market was taken by the rooftop or small-scale PV rooftop systems. The share of the off-grid systems till 2020 is negligible, at the 2% - 3% level of the total market share.

Table 4 - Year-wise sectoral breakdown of PV systems capacity. Source: Own elaboration.

| MWAC | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020e |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual total capacity | 12 | 177 | 998 | 1044 | 984 | 2313 | 4313 | 9558 | 8286 | 7340 | 5083 |
| Ground-mounted % | 90% | 90% | 90% | 90% | 90% | 90% | 90% | 90% | 90% | 90% | 90% |
| Ground-mounted capacity | 11 | 159 | 898 | 940 | 886 | 2082 | 3882 | 8602 | 7457 | 6606 | 4575 |
| Rooftop % | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Rooftop capacity | 1 | 18 | 100 | 104 | 98 | 231 | 431 | 956 | 829 | 734 | 508 |
| Cumulative capacity | 12 | 189 | 1187 | 2231 | 3215 | 5528 | 9841 | 19399 | 27685 | 35025 | 40108 |

Figure 3 - Breakup of the installed PV capacity for 2019. Source: PV Rooftop Cell.




Commercial installations shared the majority of the PV rooftop systems (the detailed breakdown in not available in the literature). Given that ground-mounted solar constitutes the vast majority of PV capacity, and that the residential segment is only a fraction of rooftop installations, it can be concluded that the greatest bulk of end-of-life PV waste will be deriving from B2B relations. A B2B network for end-of-life management of PV waste would be the preferred choice to address this.

### 3.2.3. Assumptions related to the annual growth of PV generation capacity

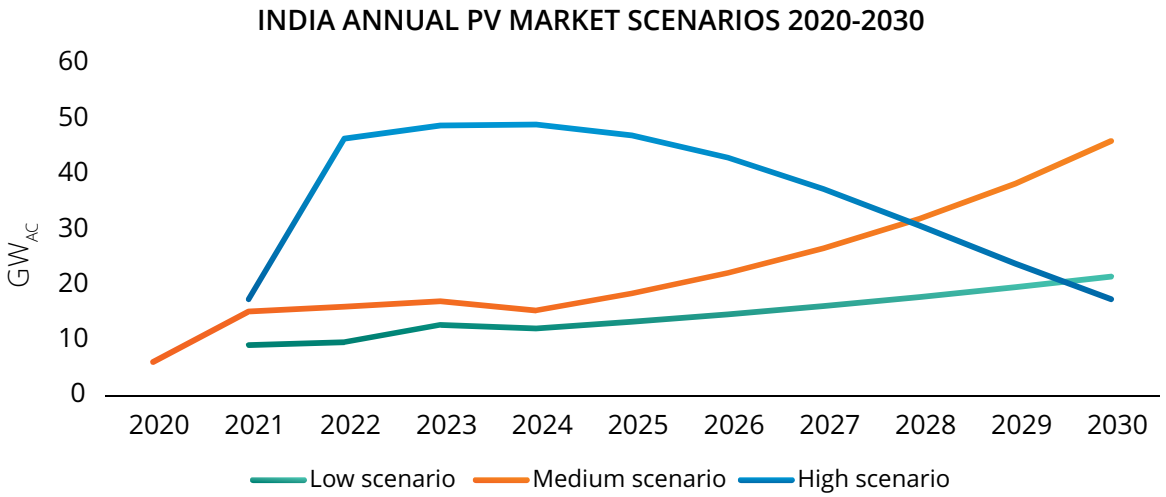
The three scenarios (Low, Medium, High) of the growth of the installed PV capacity are shown below. The Low and Medium scenarios are based on SolarPower Europe's Global Market Outlook 2020-2024 forecasts, and assume an annual growth post-2024 of 10% and 20% respectively. For the High scenario it is assumed a very steep growth rate in 2021 and

2022 taking into account the India's National Solar Mission goals (by 2022 100 GW of solar PV systems are proposed to be installed). The High scenario leads to the achievement of the 400 GW PV installation capacity in 2030.

**Table 5 – India annual PV market scenarios 2020-2030. Source: Own elaboration, based on SolarPower Europe (2020) and MNRE.**

| ANNUAL GW | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | | 9,1 | 9,7 | 12,8 | 12,2 | 13,4 | 14,7 | 16,2 | 17,8 | 19,6 | 21,6 |
| Medium scenario | 6,1 | 15,2 | 16,1 | 17,1 | 15,4 | 18,5 | 22,2 | 26,6 | 31,9 | 38,3 | 46,0 |
| High scenario | | 17,4 | 46,5 | 48,8 | 49,0 | 47,0 | 43,0 | 37,3 | 30,7 | 23,9 | 17,4 |

**Figure 4 - India annual PV market scenarios 2020-2030. Source: Own elaboration, based on SolarPower Europe (2020) and MNRE.**

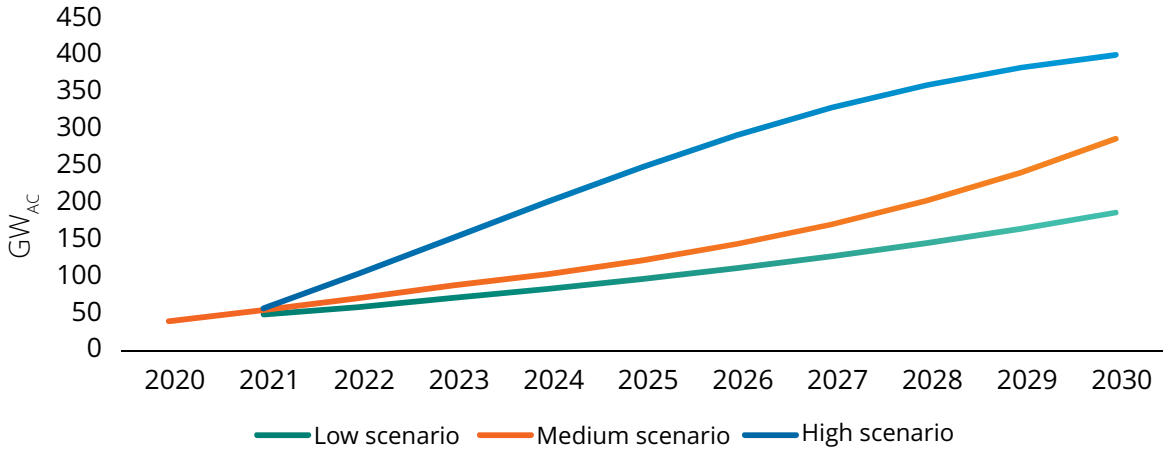



Compared to current levels, the annual PV market is expected to grow significantly across all scenarios. The Low and Medium scenarios forecast a somewhat stable level of annual installations in the next 5 years, between 9 and 18 GW installed annually. In the mid and long term, annual installations increase significantly, reaching 22-46 GW by 2030. Conversely, the High scenario assumes that national government objectives are reached – this causes a surge of installed capacity in 2021 and 2022. After peaking in 2024, annual installations decline and are at 17 GW in 2030. This results in annual installations in the High scenario to become eventually lower than in the other two scenarios, although the cumulative capacity remains significantly higher.

Table 6 - India cumulative PV market scenarios 2020-2030. Source: Own elaboration, based on SolarPower Europe (2020) and MNRE.

| CUMULATIVE GW | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | | 49,2 | 58,9 | 71,7 | 83,8 | 97,2 | 111,9 | 128,1 | 145,9 | 165,5 | 187,1 |
| Medium scenario | 40,1 | 55,3 | 71,4 | 88,5 | 103,9 | 122,3 | 144,5 | 171,1 | 203,1 | 241,4 | 287,4 |
| High scenario | | 57,5 | 104,0 | 152,8 | 201,8 | 248,9 | 291,9 | 329,2 | 359,9 | 383,8 | 401,2 |

Figure 5 - India cumulative PV market scenarios 2020-2030. Source: Own elaboration, based on SolarPower Europe (2020) and MNRE.




By 2030, cumulative installed capacity experiences a multi-fold growth across all scenarios. Under the Low and Medium scenarios cumulative capacity reaches 187 and 287 GW respectively, up from 40 GW in 2020. The High scenario capacity reaches 400 GW by 2030, in line with government ambition.

Assuming that PV systems installed in 2020-2030 have a lifetime of at least 30 years, any capacity installed during this period will reach the end-of-life stage not before 2050.

### 3.2.4. Assumptions related to the PV waste components

We can assume that till 2035 the main waste will be generated during transportation, installation or operation due to damages or early failures. Main waste components will be PV modules, whereas inverters have much lower mass. Other components like ballasts, mounting structures, wires, and other BoS are less likely to be subject to damage and early failure.

### 3.2.5. Assumptions related to the rate of transportation and installation damage

Even with careful transportation of solar modules, there are damages to PV modules; this phenomenon can be called as the “transportation damage”. It is assumed that the

transportation damage can be detected before or during the PV module installation, therefore before the start of the product lifetime. The transportation loss can occur on all transportation stages: packaging, transfer to the ship, marine shipment, transfer to trucks, during the road transportation, unpacking, etc.

The failure may also be caused during the installation of the PV system which may ultimately result in generation of PV waste.

We asked the module manufacturers and developers about the most probable value of the damage. The respondents claimed that the transportation damage is lower than 0.1% in 2020. Based on the inputs received from the stakeholders, it is assumed that the rate of transportation and installation damage is 0.1%.

### 3.2.6. Assumption of the weight (mass) of solar modules

It is assumed that for 2020 average mass of 1 MW of solar modules is around 65 kg and the weight includes frames; however, it does not include wires, mounting structures, inverters, ballasts etc. For the final calculation, additional assumption of the additional mass should be taken into account (inverters might contribute to the waste stream, but their addition would be negligible compared to PV module waste).

**Table 7 - Assumption of 1 MW PV module waste 2010-2020. Source: SolarPower Europe, PV CYCLE and NSEFI estimate.**

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| t | 100 | 96 | 92 | 88 | 85 | 82 | 78 | 75 | 72 | 69 | 65 |

**Table 8 - Assumption of 1 MW PV module waste 2021-2030. Source: SolarPower Europe, PV CYCLE and NSEFI estimate.**

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| t | 65 | 64 | 62 | 61 | 60 | 59 | 58 | 56 | 55 | 54 |

### 3.2.7. Assumption of the annual replacement rate

The values of the “replacement rate” are discovered during the interviews carried out by the EU– India TC Project with the representatives of installers and vendors. The above-mentioned value will be reconsidered in the subsequent stages as per the inputs received from the stakeholders.

**Table 9 - Annual replacement rate scenarios. Source: Interviews with the Indian installers.**

| Annual replacement rate (%) | | |
|---|---|---|
| Low scenario | Mid scenario | High scenario |
| 0,03% | 0,045% | 0,06% |

## 3.3. Calculations

### 3.3.1. Calculation of the mass of the installed capacity

The mass of the installed modules is calculated as follows:

**Table 10 - Annual PV module mass (kt). Source: own elaboration.**

| ANNUAL (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 593 | 615 | 798 | 744 | 802 | 865 | 932 | 1005 | 1084 | 1168 |
| Medium scenario | 988 | 1026 | 1064 | 942 | 1108 | 1303 | 1532 | 1802 | 2119 | 2492 |
| High scenario | 1131 | 2962 | 3047 | 3000 | 2820 | 2526 | 2150 | 1733 | 1319 | 943 |

**Table 11 - Cumulative PV module mass (kt). Source: own elaboration.**

| CUMULATIVE (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 3199 | 3751 | 4474 | 5129 | 5828 | 6577 | 7378 | 8235 | 9154 | 10139 |
| Medium scenario | 3595 | 4548 | 5522 | 6353 | 7334 | 8490 | 9853 | 11458 | 13348 | 15573 |
| High scenario | 3737 | 6624 | 9539 | 12348 | 14921 | 17149 | 18956 | 20310 | 21223 | 21742 |

### 3.3.2. Calculation of the waste generated during transportation and installation

Waste generated during the transportation and installation is as follows:

**Table 12 - Mass of PV module waste generated during transportation (kt). Source: own elaboration.**

| ANNUAL (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,6 | 0,6 | 0,8 | 0,7 | 0,8 | 0,9 | 0,9 | 1,0 | 1,1 | 1,2 |
| Medium scenario | 1,0 | 1,0 | 1,1 | 0,9 | 1,1 | 1,3 | 1,5 | 1,8 | 2,1 | 2,5 |
| High scenario | 1,1 | 3,0 | 3,0 | 3,0 | 2,8 | 2,5 | 2,2 | 1,7 | 1,3 | 0,9 |

### 3.3.3. Calculation of the waste generated during operation

Waste generated during operation is as follows:

**Table 13 - Mass of PV module waste generated during operation (kt). Source: own elaboration.**

| ANNUAL (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 |
| Medium scenario | 0,4 | 0,5 | 0,5 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 1,0 | 1,1 |
| High scenario | 0,7 | 1,8 | 1,8 | 1,8 | 1,7 | 1,5 | 1,3 | 1,0 | 0,8 | 0,6 |

### 3.3.4. Calculation of the total waste generated from new installations

The total mass of waste generated from new installations is as follows:

**Table 14 - Total mass of PV module waste from new installations, annual (kt). Source: own elaboration.**

| ANNUAL (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,8 | 0,8 | 1,0 | 1,0 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 |
| Medium scenario | 1,4 | 1,5 | 1,5 | 1,4 | 1,6 | 1,9 | 2,2 | 2,6 | 3,1 | 3,6 |
| High scenario | 1,8 | 4,7 | 4,9 | 4,8 | 4,5 | 4,0 | 3,4 | 2,8 | 2,1 | 1,5 |

**Table 15 - Total mass of PV module waste from new installations, cumulative (kt). Source: own elaboration.**

| CUMULATIVE (kt) | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low scenario | 0,8 | 1,6 | 2,6 | 3,6 | 4,6 | 5,7 | 7,0 | 8,3 | 9,7 | 11,2 |
| Medium scenario | 1,4 | 2,9 | 4,5 | 5,8 | 7,4 | 9,3 | 11,5 | 14,2 | 17,2 | 20,8 |
| High scenario | 1,8 | 6,5 | 11,4 | 16,2 | 20,7 | 24,8 | 28,2 | 31,0 | 33,1 | 34,6 |

Overall, it can be observed that total PV waste forecast from new installations deriving from transportation, installation and operation is relatively small. Annual waste does not exceed 2 kt in the Low scenario and stays below 4 kt in the Medium scenario. The High scenario anticipates a ramp up of installations in 2022 that results in 4,7-4,9 kt annually between 2022 and 2024. In cumulative terms, the total mass of PV module waste deriving from transportation, installation and operation reach 11, 21 and 35 kt in the Low, Medium and High scenario respectively.

CHAPTER 04

# POSSIBLE BUSINESS MODELS FOR PV WASTE MANAGEMENT IN INDIA

This Chapter outlines different overall policy approaches for PV waste management in India, providing an overview and comparison of the options available. It describes in detail a range of EPR policies, instruments and measures, as well as possible settings with regard to roles and responsibilities, as well as to free riding, orphan and existing products. An overview of costs is also included. Lastly, this Chapter provides a few recommendations to policymakers on how to set up and EPR system.

This section explores EPR schemes of PV modules only. Other products within a PV system such as inverters and batteries can easily be added to the programme, since these are attractive products in the waste phase due to the value of the materials in these products, whereas the value of end-of-life PV modules is lower as they are mainly composed of glass.

A general overview of possible business models, EPR scheme options and financing options for the EPR scheme as well as for addressing orphan and existing products is provided below.

**Table 16 – Overview of possible business models, EPR scheme options and financing options. Source: own elaboration.**

| **Overall policy approach** | | | | | | |
|---|---|---|---|---|---|---|
| BAU | | BAU+ | | | EPR | |
| **EPR scheme options** | | | | | | |
| Take-back requirements | Economic instruments | | | | Performance standards | Other |
| Product take-back | Deposit/ refund | Advance disposal fee | Product/ material tax | Combined upstream tax/subsidy | Minimum recycled content requirement | Industry-based measures, government measures |
| **EPR financing options** | | | | | | |
| Internalisation of waste management costs | | | | Visible fee | | |
| **EPR financing options** | | | | | | |
| Advance disposal fees | Fees paid at the time of purchase | Last owner pays | Insurance | | Phase-in | |

## 4.1. Overall policy approaches for PV waste management

Three overall policy approaches are outlined:

A) a business-as-usual scenario, maintaining the current status quo;

B) an improved business-as-usual scenario, whereby a landfill ban is introduced but the end-owner retains end-of-life management responsibility;

C) an Extended Producer Responsibility scenario, whereby, on top of a landfill ban, the producer has legal responsibility over the end-of-life management of the product. The options are described in more detail below.

### A. BUSINESS-AS-USUAL

This means to maintain the current situation whereby:

- the end-owner of the waste has to organize the waste management at the time the waste is generated, at his own costs;
- no financing is set up for the waste management of PV modules for the past, the present and the future;
- risk of uncontrolled landfilling exists;
- there is no control nor monitoring of how the waste is treated;
- overall, PV waste management is poor.

### B. BUSINESS-AS-USUAL PLUS

This means to adjust the current situation whereby:

- the end-owner of the waste has to organize the waste management at the time the waste is generated, at his own costs;
- no financing is set up for the waste management of PV modules for the past, the present and the future;
- a landfill ban is introduced for PV modules;
- control and monitoring are done by the State Pollution Control Board (SPCB) through the reported data from waste treatment facilities;
- overall, the PV waste management situation is improved, but with limited results.

## C. EXTENDED PRODUCER RESPONSIBITLITY

This means the introduction of a Responsibility towards the "Producer", defined as the "first one putting the PV module on the territory of India", whereby:

- The producer is responsible for the waste management at the time the product is placed on the market; waste management is carried out collectively through the setup of one Producer Responsibility Organization (PRO) for PV modules managed and steered by the Indian PV industry; individual Extended Producer Responsibility is allowed as long as this is under the same conditions as for a PRO;
- financing is secured at the time of putting the PV module on the market, covering present and future PV waste management costs; moreover, financing for the past can be foreseen through a staggered approach;
- a landfill ban is introduced for PV modules;
- Control and monitoring are organized by the SPCB and/or Ministry of Environment/ Renewable Energy through the PRO or the Individual Producer; moreover, regular reporting on the sold amounts of PV modules and on the amounts of waste PV modules collected is carried out;
- Overall, the PV waste management is high.

A comparison of the three policy approaches is available in Table 17.

**Table 17 - Comparison of overall policy approaches for PV waste management in India. Source: own elaboration.**

| | BAU | BAU+ | EPR |
|---|---|---|---|
| Legal responsibility | End-owner | End-owner | Producer |
| Financing present waste management | no | no | yes |
| Financing future waste management | no | no | yes |
| Financing past waste management | no | no | possible |
| Landfill ban | no | yes | yes |
| Waste control and monitoring | no | SPCB | SPCB through PRO |
| Overall waste management | poor | intermediate | high |

Compared to a BAU scenario or to an improved BAU scenario whereby a landfill ban is introduced, the authors of this study recommend the Extended Producer Responsibility approach as the best one for the Indian context, as it constitutes the most effective means to perform sound PV waste management. It is advised to implement an EPR law for PV modules which sets the principle of a Producer Responsibility for PV modules and – where required – other products of a PV system, such as inverters and batteries.

## 4.2. Introduction to EPR business models for PV waste management

Over the last few decades, many countries have actively implemented policies and programmes to reduce pollution and waste generation. Yet, environmental pressures are still increasing. At the same time, the difficulty of siting new waste disposal facilities has increased. Regulations on landfills and incinerators have strengthened and the cost of waste management has risen. The NIMBY syndrome (Not In My Back Yard) reflects the growing concern of the public regarding waste as an aesthetic problem as well as a risk to human health and the environment. In addition, the tightening of disposal options has placed an emphasis on options for reducing waste and increasing reuse and recycling.

Faced with the increase of waste, many governments have reviewed available policy options and concluded that there was a need to apply new instruments to address this problem, including placing the responsibility for the post-consumer phase of certain goods on producers. Extended producer responsibility (EPR) is a policy approach in which producers accept significant responsibility (financial and/or physical) for the treatment or disposal of post-consumer products. Assigning such responsibility could provide incentives to prevent wastes at source, promote environmentally compatible product design and support the achievement of public recycling and materials management goals.

The OECD defines EPR as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. There are two related features of EPR policy: (1) the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, and (2) to provide incentives to producers to incorporate environmental considerations in the design of their products.

EPR programmes can be best understood as changing the traditional balance of responsibilities among the manufacturers and importers of consumer goods, consumers and governments with regard to waste management. Although they take many forms, these programmes are all characterized by the continued involvement of producers and importers with commercial goods at the post-consumer stage. EPR extends the traditional environmental responsibilities that producers and importers have previously been assigned (i.e. worker safety, prevention and treatment of environmental releases from production, financial and legal responsibility for the sound management of production wastes) to include the management of their products at the post-consumer stage.

Allocating responsibility and determining who is the producer are two of the most important policy design issues. This Chapter is intended to make information available to the Indian Government on EPR issues and benefits and on the actions required to establish effective EPR

policies and programmes. It examines various issues and framework conditions related to the design of EPR policies and programmes. Where possible, it draws on experience to date, as well as attempting to guide government policymakers with regard to relevant conceptual issues. It provides guiding principles and lists of questions for decision-makers to help them as they make their decisions about EPR. A list of policy recommendations is provided at the end of this Chapter.

## 4.3. EPR policies and considerations

### 4.3.1 Introduction

EPR has been recognized by most countries as a policy approach that can provide incentives to reduce the amount of post-consumer waste going to final disposal. However, in order to realize the benefits of EPR, a number of considerations should be taken into account to ensure that the policy yields the desired effect in the areas it addresses. Effective policy design will depend on the national circumstances, conditions, the market and priorities. Therefore, this Section discusses how the policy context and other factors can influence the design and outcome of EPR. It also provides a set of principles to guide policymakers when they establish EPR policy.

While the promotion of market-driven solutions is generally the preferred approach, this section attempts to provide government decision-makers with information that can help them decide on the direction and approach most appropriate for application in India. Product characteristics, markets, and intra-firm relations all affect the selection of an EPR instrument.

### 4.3.2 Guiding principles for EPR

The following guiding principles for the design and development of EPR policies and programmes emerged from assessing multiple EPR-programmes worldwide. These principles underline the development of effective EPR policies and programmes.

EPR policies and programmes should be designed to provide Producers[20] with incentives to incorporate changes upstream at the design phase in order to be more environmentally sound.

Policies should stimulate innovation by focusing more on results than on the means of achieving them, thus allowing producers flexibility with regard to implementation.

Policies should take into consideration a life cycle approach in order environmental impacts are not increased or transferred somewhere else in the product chain.

*[20]Under the European WEEE Directive a "Producer" is the natural or legal person established in the country and which manufactures and sells or which imports and distributes brands of products or which purchases OEM products and sells these under his own name or brand in the country; the Producer can also be established outside the country when the Producer is the owner of an online webshop which sells directly to residential or B2B-end customers in the country.*

Responsibilities should be well defined and not be diluted by the existence of multiple actors across the product chain.

The unique characteristics and properties of a product, product category or waste stream should be factored into policy design. Given the diversity of products and their different characteristics, one type of programme or measure is not applicable to all products, product categories or waste streams.

The policy instrument(s) selected should be flexible and chosen on a case-by-case basis, rather than setting one policy for all products and waste streams.

Extension of producer responsibilities for the product's life cycle should be done in a way to increase communication between actors across the product chain.

A communication strategy should be devised to inform all the actors in the product chain, including consumers, about the programme and to enlist their support and co-operation.

To enhance a programme's acceptability and effectiveness, a consultation of stakeholders should be conducted to discuss goals, objectives, costs and benefits.

Local governments should be consulted in order to clarify their role and to obtain their advice concerning the programme's operation.

Both voluntary and mandatory approaches should be considered with a view on how to best meet national environmental priorities, goals and objectives.

A comprehensive analysis of the EPR programme should be made (e.g. which products, product categories and waste streams are appropriate for EPR, whether historical products should be included, and the roles of the actors in the product chain).

EPR programmes should undergo periodic evaluations to ensure that they are functioning appropriately and are flexible enough to respond to these evaluations.

Programmes should be designed and implemented in a way that environmental benefits are obtained while domestic economic dislocations are avoided.

The process of developing and implementing EPR policy and programmes should be based on transparency.

It is relevant to highlight that under an EPR approach, it is not the government's role to control, monitor and regulate the producer or the PRO. If the EPR scheme is properly designed, these actors will have an incentive to achieve targets and goals set out in the waste legislation and will self-regulate themselves. Producers will take independently decisions around the design, implementation, execution, control and monitoring of the scheme. In contrast, the role of the government is to ensure that there is an effective legal framework in place for waste management and to set and review waste management targets and goals.

### 4.3.3 Goals and objectives

One of the most important steps in designing an effective EPR scheme is the establishment of clear policy goals and program objectives. Goals should be transparent and established in relation to specific environmental improvements, such as biodiversity, natural resource preservation or conservation, and energy conservation. The list below is not comprehensive.

There are four principal goals for EPR:

- Source reduction (natural resource conservation/materials conservation).
- Waste prevention.
- Design of more environmentally compatible products.
- Closure of materials use loops to promote sustainable development.

A good example of goals used in countries is Germany, where EPR is a cornerstone of the national goal of a closed loop economy. In the Netherlands, EPR is one of the policies used to help meet the national environmental goals of maintaining space (quality and quantity - referring to waste management issues), biodiversity and energy conservation.

A number of objectives for EPR policies can help meet stated policy goals. In this section an objective is viewed as a specific action or tactical step toward the policy goal. The objective(s) selected will vary depending on the type of product or product category, waste stream or sector to be addressed, as well as national priorities, conditions and circumstances.

Examples of possible objectives for EPR policies include, inter alia:

- reducing use of [particular] natural resources;
- reducing use of [specified] raw materials;
- reducing use of certain toxic substances and/or other potential hazardous components;
- reducing littering;
- reducing the spread of incinerators and their pollution;

- reducing the spread of landfills and their pollution;
- reducing the amount of waste going to final disposal (i.e. landfill);
- reducing energy use;
- financing a portion of waste management costs;
- internalizing costs of waste management (or other externalities) into the price of the product;
- increasing reuse and recycling of products;
- increasing the recycling of materials to retain their maximum value;
- creating an organized system for collecting specific products, product groups or waste streams;
- reducing waste management costs to taxpayers;
- reducing the costs of waste management borne by municipalities;
- developing cleaner production and products, which can include:
    - incentives for more environmentally compatible products;
    - products with less toxic and/or hazardous compounds;
    - developing new recycling techniques and capacity; or
    - improving materials management.

In setting goals and objectives, a number of issues affecting the nature, operation and results of EPR policies should be taken into account. These include defining the programme's terms and scope, setting targets or quotas, and identifying the roles and relationships of other laws and regulations already in place. The following sections address these points.

### 4.3.4 Defining terms

Terms such as producer, final product, recovery, recycling and distribution chain need to be clearly defined from the start. Therefore, the Government can rely on the knowledge at – inter alia – the Ministry of Environment.

### 4.3.5 Scope

The scope of an EPR programme should be considered in relation to stated goals and relative objectives. The types of products, product groups, waste streams and/or sectors to be addressed need to be determined since they can greatly affect how a programme should be

designed and developed. Without a clear and concise definition of scope, many issues, such as the complicated mix of product characteristics, can affect the allocation of responsibilities and the clarity of the roles of those affected by a policy.

### 4.3.6 Legal and administrative approaches

There is a continuum of approaches for implementing EPR – from fully voluntary to mandatory. Policymakers contemplating EPR will need to decide early on whether to make the programme voluntary or mandatory or to use a combination of the two (e.g. negotiated agreements or covenants). While particular EPR instruments and measures are discussed in Section 2, the following paragraphs provide an overview of approaches for decision-makers to bear in mind.

#### 4.3.6.1 Mandatory approaches

Many countries have used legal mechanisms (such as regulations and ordinances) for implementing EPR programmes. Decisions on whether to pursue a mandated programme should be made vis-à-vis the EPR policy, goals and national environmental priorities. Governments considering the establishment of a mandatory programme must first identify whether appropriate authority (e.g., waste agency) exists. If not, the enabling legislation, regulation or ordinance would need to be developed. Additionally, under a mandatory programme, a formal oversight role may be needed and provisions for sanctions would be necessary to ensure compliance. Also, the costs of implementing a mandatory programme could be significant and should be evaluated.

#### 4.3.6.2 Voluntary approaches

Voluntary approaches are a category of environmental policy instruments, covering a wide variety of arrangements. They range from industry-based to government-based initiatives and include:

- unilateral commitments by industry;
- agreements achieved through direct bargaining between polluters and pollutees;
- agreements negotiated between industry and public authorities;
- voluntary programmes developed by public authorities to which individual firms are invited to participate.

A pervasive use of voluntary approaches can be observed in several countries. Negotiated agreements like the Dutch Packaging Covenant or the Flat Glass Take-back programme are well known. Increasingly, company specific or sector-wide unilateral commitments are emerging in the area of EPR, especially with product take-back. The motivations behind these programmes can include economic drivers to recover high-value items, public relations gestures, means to avoid government intervention, or means to secure greater market share. Often such programmes result in reduced resource and energy consumption, reduced operational costs,

and increased credibility with shareholders and the public. The Responsible Care programme embodies the concept of product stewardship and is a well-known example of a multilateral (voluntary) commitment made by the chemical industry in many countries.

Recently, more and more industry-based initiatives like product stewardship (which often includes product take-back) and take-back have emerged. An evaluation of the drivers for these programmes and their expansion under certain product categories can provide valuable insights to decision-makers considering EPR.

### 4.3.7 Targets and quotas

Targets for recycling and quotas for the take-back of products are found in most currently operating EPR programmes. This mechanism can be critical when the objectives are, for example, to increase reuse or recycling rates or to reduce the amount of waste going to final disposal. Targets and quotas, which could be quantitative and/or qualitative, might include recycling or recovery rates, performance quotas or specific quality objectives. Consultations with affected and interested parties can help increase the acceptability of targets by the public, industry, and all levels of government.

Specific considerations to take into account when setting targets include:

- Who is involved in setting the target? (e.g. stakeholders).
- Will the target be voluntary or mandatory?
- What is the time for meeting the target? Will there be a phase-in period?
- What would happen if the target is not met in the established time period?
- Are baseline data available to measure the target against?
- What is the capacity of the market to meet set targets or quotas?

### 4.3.8 Matching supply and the capacity to manage the demand for recyclables

The public response to the German Packaging Ordinance was such that the initial targets were significantly overachieved. German secondary materials markets became saturated, and the excess material was “dumped” on the international market at below-market prices. The key issue was that the capacity and technical capability available to handle all the secondary materials did not fully exist when the Ordinance came into force. Over time, this market failure has corrected itself and decision-makers took away the lesson that national capacity and the capability to recycle secondary materials need to be scrutinized before setting targets and quotas.

The development of new recycling capacity requires time and investment, and governments may wish to introduce specific targets and quotas on an incremental basis to ensure that there is adequate time for the market to react to any unanticipated impacts. In order to avoid inhibiting innovation and perhaps stifling recycling capacity, care should be taken not to set

targets at arbitrary rates or shift the focus from longer-term changes to shorter-term fixes. In order to avoid such negative effects, one option could be to establish a phased-in schedule of targets or quotas to help build capacity and technical capability over time. Decision-makers might also want to establish a public awareness program concerning the targets and what they mean.

### 4.3.9 Roles and relationships of national and sub-national environmental goals, programmes and laws

In developing EPR policies, decision-makers should review how they would interact with and support national environmental priorities and objectives. As part of this review, it is necessary to assess environmental policies and laws to evaluate the current situation and to ensure that no conflicts exist with proposed EPR policies and programmes or with other national and sub-national laws (including trade and competition). At this stage, decision-makers may wish to take stock of current industry-based voluntary initiatives and local programmes as they consider whether intervention is necessary or where best to intervene. For those who are considering a mandatory approach, it would be prudent to assess the current legal structure to identify whether appropriate authority exists, whether a new law, regulation or ordinance would have to be created, or if adjustments to current regulations can be made.

### 4.3.10 Internalization of costs

A major obstacle in achieving sustainable economic development arises from the presence of external environmental costs. The OECD Council Recommendation on the Use of Economic Instruments in Environmental Policy from 1991 states that sustainable and economically efficient management of environmental resources requires the internalization of pollution prevention and control and damage costs. The importance of internalizing costs as clearly acknowledged in this Act, is a fundamental aspect of environmental policy design. Within the context of EPR, the extension of the producer's responsibility could explicitly lead to a substantial internalization of social costs for treatment and disposal. It could also implicitly correct other environmental impacts along the life cycle, not currently reflected in the final product price.

### 4.3.11 Participation of actors in the product chain - sharing responsibilities and setting targets

Part of the EPR debate concerns the concept of shared responsibility – or more explicitly, whether a producer should have primary responsibility under EPR. Sharing responsibilities across the product chain is an inherent part of EPR. While the policy mechanism is called Extended Producer Responsibility, it should be borne in mind that all actors in the product chain and in society must participate in order to optimize its effects. However, sharing responsibilities is a delicate aspect of EPR. All actors, including consumers, have an important role to play in effectuating EPR policy. Similarly, the co-operative nature implicit under EPR requires careful planning and communication among all affected and interested parties in the product chain.

Goals, objectives, and the type of policy instrument selected will dictate the allocation of responsibility (see also under Section 3 below). Regardless of the EPR mechanism selected, effective EPR implementation depends on the participation of all the actors in the product chain; they are all responsible in some way or other for the environmental externalities. The challenge for governments is to design their policies and programmes so that responsibility is appropriately shared without diminishing the incentives placed on producers to reduce the product's environmental impacts at the post-consumer phase.

### 4.3.12 The Polluter-Pays Principle

In 1972, the OECD enshrined the Polluter-Pays Principle (PPP) as the overarching economic and social principle with regard to promoting efficient resource allocation for environmental protection while avoiding distortions in international trade and investment.

The Polluter-Pays Principle states that the polluter should bear the expenses of preventing and controlling pollution to ensure that the environment is in an acceptable state, irrespective of whether these expenses are incurred through a charge on pollutant emissions or in response to direct regulation. Nearly 30 years of environmental regulations are based on the PPP.

Depending upon the nature of the market structure and inter-firm relationships, environmental policies applied at the level of the externality may not always achieve their environmental objective. Moreover, in the case of waste generation, the administration costs associated with targeting waste flows with different environmental impacts may be excessive due to the complex nature of household waste.

EPR, on the other hand, seeks to influence the reduction of life cycle impacts from products by creating such incentives explicitly. Rather than relying only upon price changes arising from policies applied at the point of waste generation to transmit the appropriate signals, EPR seeks to achieve this by integrating the appropriate incentives through responsibility. This is particularly important in cases where there is a very extended production-consumption chain, little vertical integration, and imperfect markets. With respect to EPR and PPP, there is nothing inconsistent about EPR insofar as the externalities are internalized within the product chain responsible for generating the externality.

## 4.4. Instruments and measures

**Key takeaways**

01 The EPR policy framework should be viewed in terms of both product and waste management policy. The policy option selected would depend on where in the product chain decision-makers wish to influence materials extraction, design or disposal.

02 **Several EPR policy instruments and measures are available to governments to help them meet their stated goals and objectives. They are product take-back, deposit/refund, advance disposal fees, product/material taxes, combined upstream tax and subsidy and minimum recycled content requirements. Policymakers should review these different instruments to identify which might best meet their particular needs. The point of intervention for the instrument selected depends on the point where the market fails to internalize the impacts from the disposal of products at their post-consumer stage. The instrument or mix of instruments that would best meet policy goals should be selected.**

03 **An instrument's applicability depends on policy goals, or the influence or pressure necessary to reduce environmental impacts of concern.**

04 **Several types of supportive measures can be used to enhance the effectiveness of an EPR policy. Such measures should be selected in light of the policy goals.**

05 **Environmental effectiveness and economic efficiency of EPR should be examined. If a less onerous alternative or measure could produce the same effects as the EPR policy instrument, there would be no point to introduce EPR-based policy.**

06 **Selection criteria can help policymakers select an EPR policy instrument that best suits their needs. These criteria are environmental effectiveness; economic efficiency; political acceptability; administrability (ease of administration); and innovative advancement.**

### 4.4.1 Introduction

This chapter describes a range of policy instruments for implementing EPR policy. Three basic categories of instruments exist: take-back requirements, economic instruments, and performance standards.

Take-back requirements can meet policy objectives by assigning responsibility for the end-of-life management of products e.g. product take-back.

Economic instruments can be used to meet the same objectives. These instruments are incentive-based and provide flexibility to the private sector to establish the means to accomplish the program requirement e.g. deposit/refund, advance disposal fees, material taxes and the upstream combined tax/subsidy.

In addition, performance standards like minimum recycled content can be set to specify a particular percentage of recycled materials to be used in the product.

Section 2.9 discusses the environmental effectiveness and economic efficiency of EPR and describes conditions under which EPR would be most efficient and effective. Criteria for selecting a policy instrument or measure are included in section 2.10. These criteria should help guide policymakers to select the most appropriate instrument in view of their particular environmental priorities, goals and objectives.

### 4.4.2 Policy drivers

National environmental priorities and other drivers need to be taken into account when considering EPR. To date, countries have used EPR to stimulate change in three key priority areas: resource efficiency, cleaner products and waste management. EPR can help realize objectives of sustainable development by helping to reduce wastes, reduce the release of potentially toxic chemicals in the environment, reduce use of virgin material inputs and lower energy consumption.

When resource efficiency is the primary concern, the policy emphasis would be on resources consumed in the production phase. Supporting instruments might include material taxes, take-back, combined upstream tax/subsidy and recycled content requirements. A specific focus would be on a life cycle approach. Measures should be designed to maximize overall environmental gains without limiting action to a particular phase of the life cycle.

In contrast, if improving the design of more environmentally compatible (or cleaner) products drives decision-making, the emphasis of EPR will centre on specific products or product categories that pose problems at the post-consumption phase of their life cycle. Increased attention to product design for better durability and recycling, as well as transparency of environmental impacts to the consumer, may also be expected. Supporting actions could include advance disposal fees, take-back and recycled content standards. Other supportive programmes would include those such as eco-labelling to identify preferable products for the consumer and for green government purchasing.

Waste management driven decisions are more likely to focus on the specific percentages of post-consumer materials to be diverted from final disposal. These activities would further support related research and development or commercialization activities for materials recovery technologies and capacities. Concerns about the internalization of costs may be more narrowly focused on internalizing costs for waste management. Instruments would include deposit/refund, take-back combined upstream tax/subsidy, and advance disposal fees.

### 4.4.3 EPR policy instruments and measures

While other environmental policy instruments tend to target a single point in the product chain, EPR seeks to vertically integrate signals related to the environmental characteristics of products and production processes throughout the chain. Several kinds of instruments and measures exist for implementing EPR. The following paragraphs outline some of the options available. The instruments discussed in this section are those that act to implement the basic principles of EPR. Therefore, programmes established using any of the instruments listed below would need to include the distribution of physical and economic responsibility (see Section 3) under the EPR policy.

It relevant to note that the decision about which of these options are the most suitable for PV waste management has to be taken by the PV industry itself, as the principle guiding EPR is self-organisation by the producers in order to achieve the goals set in the regulation. Therefore, this section won't provide recommendations on the most appropriate options, but will rather illustrate the full spectrum of the available instruments.

#### 4.4.3.1 Take-back requirements

Policies that require the producer and/or retailer to take back the product or its packaging after use are the clearest example of extending the producer's responsibility into the post-consumer phase of a product's life cycle.

**Product take-back**

The most active use of EPR, under both voluntary and mandatory schemes, is in product take-back. EPR is applied to specific products (e.g. automobiles), product categories (e.g. electric and electronic products) or waste streams (e.g. packaging) that are to be taken back or returned. This type of programme is often associated with targets for collection and recycling and/or reuse.

In most cases, the producer is given the responsibility (or as under voluntary systems, takes on the responsibility) of meeting the targets for reuse, recycling and collection through a law, ordinance or agreement unless other conditions such as participation in a Producer Responsibility Organisation (PRO) or in the initiation of an individual take-back scheme, have been met (PROs are industry-wide schemes that are set up to implement voluntary and regulatory EPR approaches, such as for example PV CYCLE).

Policy approaches range from legal requirements, to negotiated industry/government agreements, to completely voluntary industry-based programmes. Often take-back is regarded as the purest form of EPR.

While voluntary agreements fall under administrative approaches to EPR, it is important to note that there are certain industry-based initiatives that could serve as an option. Firms have taken action to redesign products for easier recycling and/or recovery of particular components deemed to have a positive value at their end-of-life stage. Some firms have redesigned products to reduce the amount of toxic materials or chemicals used - based on voluntary challenge initiatives such as the US EPA's 33/50 programme and the Canadian ARET programme. In other instances, a sector as a whole creates a programme - as was done in Australia through their packaging stewardship programme.

#### 4.4.3.2 Economic instruments

Whereas take-back requirements use the assignment of responsibility to the producer for the end-of-life management of their products to meet the policy objectives, economic instruments can also be used toward the same objectives. Listed below are economic instruments that can be used to effectuate EPR policy. These instruments provide a direct financial incentive for actors to implement EPR. Examples of economic instruments that can be targeted to meet EPR objectives include deposit- refund schemes, advance disposal fees, and taxes and/or subsidies. Under an economic-based scheme, producers make sure that the products return to them through a variety of measures – by having targets in place, by the obligation that the scheme must sensitize the market, by the condition that take-back collection network must be established.

When using economic instruments for EPR policy implementation, certain conditions should be established to ensure that a significant degree of the physical and/or financial responsibility of the producer is allocated. For instance, if the consumer is required to pay an advance disposal fee to cover the additional costs for treating their product at its post-consumer phase, then the physical responsibility should be extended to the producer. Another example would be the earmarking of a materials tax. Earmarking the tax would ensure that money paid by producers are used for the treatment of the products subject to the EPR programme. Moreover, this tax could be set so that it differentiates between those materials that are difficult to recycle or reuse (e.g. containing toxic chemicals or numerous types of materials) from those that are not.

**Deposit/refund schemes**

In a deposit/return system, a payment (the deposit) is made when the product is purchased and is fully or partially refunded when the product is returned to a dealer or specialized treatment facility. Traditionally, deposit/refund schemes have focused mainly on beverage containers. Despite the success rate of these schemes, little activity outside of beverage containers has evolved. Although they have been used in some countries to a limited degree for other product categories such as consumer batteries, fluorescent light bulbs, tyres, and shopping bags.

To encourage more environmentally sound choices of materials, charges are applied to specific products and are refunded when the product is returned.

Arrangements are usually made with retailers to accept same brand and type of product, which they sell. Distributors are often responsible for the pick-up of containers (or products) and delivery to a recycling or treatment centre. Deposit/refund schemes can also be organized through a recycling centre or through kerbside collection. However, studies indicate the return ratio is lower under these two methods. The physical responsibility for operating this scheme would be delegated to the producer (and perhaps the distributor).

Principally, the deposit should include the commercial costs of the container (or specific product), plus the environmental costs associated with the disposal or with littering. Refunds should equal the avoided environmental costs plus the scrap value of the container. Higher return rates can be achieved when the fee is set at a higher percentage of the price.

Administrative arrangements between the producers, retailers (and distributors) need to be made at the onset of the programme. To avoid dislocations, some programmes have set maximum numbers of returnables permitted per customer per retail establishment. Under a deposit/refund system, full or partial responsibility should be allocated to the producer.

Deposit/refund schemes are often introduced as a means to encourage reuse and the reduction of material inputs (e.g. beverage containers), and/or to ascertain a reliable flow of materials for recycling and recovery operations.

**Advance disposal fees**

An advance disposal fee (ADF), in the context of EPR, would be a fee levied on certain products or product groups based on estimated costs of collection and treatment methods. Fees are paid at the point of sale. Fees could be levied through the government or by an industry-based private sector organisation. Who collects the advance disposal fee (government or a private sector body) is an aspect that needs to be sorted out in the design of the system. The role of the retailer and distributor in this scheme needs to be arranged at the programme design stage.

Some countries with advance disposal fee programmes have set up a system to return a portion of the fee (paid by consumers) that was not used if recycling costs for the product have decreased. Similarly, lower fees or higher refunds could be paid for those products by which the waste management costs are reduced through actions such as redesigning the product for easier disassembly or with more homogeneous material composition. This scheme is similar in some respects to the deposit/refund scheme and is often used for longer-life products such as tyres, refrigerators or photovoltaic modules.

An ADF by itself would not constitute an EPR programme per se. The customer pays a fee for the recycling or treatment costs for the product, therefore, some portion of the physical organisation and treatment of the product at its post-consumer phase would need to be placed on the producers for the ADF scheme to be considered EPR. For example, producers (and importers) can organise an individual structure with retailers for product returns, or set up their own return depots. Another option is for producers and importers to form a private sector body (a PRO) to organise the collection and treatment of the products.

In efforts to enhance the communication about their EPR programme, one country requires that the advance disposal fee is placed on the customers sales receipt (and it is noted as a visible fee for the waste treatment of the product they are purchasing).

**Material taxes**

The aim of material taxes is to reduce the use of virgin materials (or materials that are difficult to recycle, contain toxic properties, etc.) in favour of secondary (recycled) or less toxic materials. Special taxes may be levied on particular materials used or on materials (or chemicals) deemed to cause pollution or create a particular hazard. This instrument can be used when source reduction is the principal goal.

Ideally, the tax should be set at a level where the marginal costs of the tax equal the marginal treatment costs. Taxes set at the optimal level can contribute to material reductions i.e. to a level that would address the externality. Establishing the appropriate tax level, and the administrative costs associated with collection and re-distribution of the revenues, would need to be factored into decision-making. The tax could be set in relation to the damage from production and/or costs of waste management and as a scarcity premium. The tax level also should take into account costs for recycling, reuse and/or recovery of the product to ensure that the appropriate signals are transmitted across the product chain.

The tax should be earmarked and used for the collection, sorting, and treatment of post-consumer products. Under a tax programme, the physical responsibility (full or partial) for post-consumer products should be allocated. A structure closer to the core of EPR would be to delegate physical responsibility to the producer or to establish a shared system of responsibility in which the producer responsible for the extra costs for the treatment of the post-consumer products, and as exemplified under the Japanese and French packaging laws, the municipality could retain responsibility (funded by the materials tax) to collect and sort the wastes.

**Upstream combination tax/subsidy**

An upstream combination tax/subsidy (UCTS) model is an alternative economic instrument to EPR, and not successful. However, the UCTS is consistent with EPR and it could be used as an instrument for EPR since it is a tax paid by producers, which is then used to subsidize waste treatment. An upstream combination tax/subsidy instrument signals the producer to alter their material inputs and product design and provides a financing mechanism to support recycling and treatment.

The upstream combination tax/subsidy combines a tax on produced intermediate goods, such as aluminium ingot or rolls of specific grade paper, with a subsidy to collectors of recyclables like used beverage cans and old newspapers sold for reprocessing. The upstream tax is levied by weight rather than per unit of a good because it is focused on materials and seeks to reduce the physical amount of material that ends up going to waste disposal. A subsidy is then provided to waste management firms or local governments to finance waste management.

The allocation of producer responsibility would be financial (through the tax). Producers can also be given physical responsibility (full or partial) for treatment of the post-consumer products. For instance, the producer might recycle their products while the local government

collects and sorts the waste through the subsidy. Tax schedules could be designed to deter the use of materials that might be difficult to recycle or have an impact on the environment (e.g. high toxicity). Establishing the correct tax and subsidy, as well as identifying who should be taxed and who should manage the system (level of government), are choices decision-makers will need to make.

#### 4.4.3.3 Standards (Minimum recycled content requirements)

A target of a minimum amount of recycled content (or secondary materials) per product can be set (like a performance standard). While minimum recycled content requirements are a performance standard per se, they will also encourage taking back of materials for recycling or re-use of the product. The producers and intermediaries generally take on the physical responsibility (or an agreed combination thereof).

Progressive standards can induce the potential for innovation. As stated by Kemp et al, 1991[21], the policy mix of a standard (minimum recycled content) and a levy, or tax, can enhance the potential for innovation. Minimum recycled content requirements are often used with paper products, glass containers and plastic beverage containers. Some industry sectors have strong voluntary programmes for paper products, aluminium and plastics. Partnerships with government have also been formed.

#### 4.4.3.4 Other industry-based measures

There are initiatives that firms may take that would meet similar objectives to EPR. Public policymakers would not be responsible for such policies per se, but could help create conditions to stimulate these activities. One measure is leasing where ownership of a product never terminates. Another measure is a concept based on the new economy in which there is a transition from selling a product to offering a service.

**Leasing**

With leasing, the producer would not terminate ownership. Many companies advocate leasing of their products because this gives producers control over their products" entire life cycle and allows them to repair and reuse components. This option can be impractical, or impossible, however, in the case of products with a very short life.

**Servicizing**

Servicizing is the notion that firms firmly rooted in product manufacturing evolve into being service providers (White and Feng, 1998)[22]. A servicized firm still makes a physical product, but subordinates such products within a new business strategy that sells their customers function

[21] *Kemp, R. P. M., A. A. Olsthoorn, F. H. Oosterhuis, and H. Verbruggen (1991), Policy Instruments of Stimulate Cleaner Technology, paper for the EAERE conference, Stockholm, June 11–14th, 1991.*

[22] *White, Allen and Linda Feng (1998). "Servicizing: The Quiet Transition to EPR," paper presented at the OECD Workshop on Extended and Shared Responsibility for Products: Economic Efficiency/Environmental Effectiveness. Washington, DC, 1–3 December.*

rather than physical input. The firm actually moves beyond extended warranties for longer-life products and leasing to redefine itself as a service provider, relegating its products to "service delivery agents" while rebuilding its cost and profit structure on the basis of function. Examples of this evolution from a product to a service company include firms such as Castrol, Henkel and Dow, who have established chemical management programmes. A package of services is provided with unit-based pricing structures, e.g. per door module coated or per wafer cleaned. Xerox has moved from a copy machine maker to being a "documents management" company where they now sell a service. Xerox finds this product stewardship programme provides them with better control over the product. The concept of servicizing clearly indicates an important trend for the future.

### 4.4.4 What is the primary response to an instrument?

The policy goals and specific programme objectives will influence decisions on which instrument(s) is selected and the point of intervention along the product chain. The following Table 1 depicts the EPR policy instrument and its primary response. While all instruments have secondary and indirect effects that could influence behaviour and changes across the product chain, Table 1 highlights the primary responses under EPR to the specific intervention.

**Table 18 – Primary response under EPR to specific intervention. Source: own elaboration.**

| | Source reduction | Environmentally Compatible Products | Waste Management |
|---|---|---|---|
| Deposit/refund | | • | • |
| Take-back | • | • | • |
| Materials tax | • | • | |
| Combined Tax/subsidy | • | | • |
| Advance disposal fee | | | • |
| Recycled content requirements | • | • | |

### 4.4.5 Applicability

The goals of the EPR policy will guide policymakers to select the most appropriate instrument. The application of an instrument to a particular product, product group or waste stream should take into account the feasibility of steering producer and consumer behaviour in a particular direction. Some of the policy instruments are more suitable or directly applicable to certain product groups, waste streams and sectors than others: that is, they can be directly aimed at product design and/or material choice stage in the product chain. Other EPR policy instruments target the waste management phase, but will create an indirect effect on the production and design phase of the product.

The allocation of physical and financial responsibility will affect the applicability of the instrument or mix of instruments.

### 4.4.6 Implementation components

The following table was developed to illustrate some of the implementation components for the EPR policy instruments listed in this section. While all of the instruments can have ancillary effects, the table below attempts to illustrate the direct effect or influence that could occur, the scope of the instrument (waste stream or product), and the body that could implement it.

**Table 19 - Implementation components of EPR policy instruments. Source: own elaboration.**

| | Product or waste stream | Stage in product chain | Direct response to intervention | Implementing body |
|---|---|---|---|---|
| Deposit/ refund | Specific products (e.g. beverage containers) | Disposal, with signals to design stage | Re-use and design | All levels of governments, industry based-firm level or private sector organisation |
| Take-back | Product and waste streams (and sectors) | Disposal with strong signals to resource extraction and design stages | Re-use, recycling some source reduction and design | All levels of governments, industry based -firm level or private sector organisation |
| Materials tax | Product (specific inputs) | Resource extraction and design stages | Reduced inputs of targeted materials and design | National and sub-national government |
| Advance disposal fee | Product | Disposal stage1 | Recycling and some reuse and recovery | All levels of governments, private sector organisation |
| Combined upstream tax/ subsidy | Product | Design and disposal stages | Reduced material input and recycling | National and sub-national government, private sector organisation (waste management) |
| Recycled content | Product (e.g. paper and plastics, etc.) | Design, signals to disposal stage | Design, reduced raw material input | All levels of governments, industry based-firm level or private sector organisation |

### 4.4.7 Other government measures

In addition to producer responsibility under EPR, other measures can be implemented, which complement and support the goals and objectives of EPR policy and programmes. These may be economic instruments that could help fund or reduce the cost of EPR, or they may be non-economic (often performance based) in nature. The latter include measures such as landfill bans, environmental labelling, and environmental or green procurement.

The following list of mechanisms have been explored or documented internationally.

Therefore, they are simply referenced here. It should be emphasized that the best mix of instruments would help bring about stated goals and objectives. Policy instruments and measures should be coordinated and not in conflict with other national or sub-national laws.

- unit based pricing (pay as you throw, waste volume charges);
- green government purchasing (especially of products with high recycled content where recycling quotas have been set);
- eco-labelling (energy consumption, environmental characteristics, etc.)
- landfill bans and taxes;
- removal of subsidies on virgin materials;
- disposal (landfill) bans and restrictions;
- materials bans and restrictions; and
- product bans and restrictions.

### 4.4.8 Other instruments

Additional economic instruments that are being, or have been, examined in many countries and could supplement or provide support to an EPR policy include:

- virgin material taxes;
- waste charges (levied on either collection or disposal of the waste after the point of sale);
- marketable permits (there is a potential application to products with respect to a legislation-driven level of recycling);
- recycling credits (payments made to those reusing containers or recycling materials, so that they do not go to final disposal).

### 4.4.9 Environmental effectiveness and economic efficiency of EPR

When is EPR likely to be more environmentally effective and economically efficient than alternative environmental policy instruments? This question can only be answered by distinguishing between the role of EPR-based instruments and other policy instruments in terms of the product [product-waste] chain. While other policy instruments tend to target a single point in the chain, EPR seeks to integrate vertically signals related to the environmental characteristics of products and production processes throughout the chain.

This is best understood if we compare the usual EPR-based instruments which tend to "bracket" the chain (e.g. deposit-refund, product take-back, materials taxes, advance disposal fees, recycled content standards) with a policy instrument that targets either the beginning (e.g. a virgin materials tax), the middle (e.g. a product tax) or the end (e.g. a unit-based waste fee) of the chain.

For the latter type of instrument (those applied to a particular point in the product chain) to be environmentally effective and economically efficient, information related to the environmental characteristics of products must be transmitted up and down the product-waste chain through the market.

Taking a unit-based waste fee as an example, such an instrument will be environmentally effective and economically efficient if it is able to transmit signals all the way back through consumption patterns, to manufacturing, and ultimately to product design.

For instance, a unit-based waste fee should encourage consumers to purchase products that generate less waste and to recycle as much waste as possible. However, it should also encourage producers to manufacture and market products that have these attributes, since

the market opportunities for such products will have improved relative to those products which do not. And finally, further upstream, there should be greater incentives to design products with such attributes relative to products that do not.

In some sense the broad acceptance for EPR is based upon a belief that such signals are not transmitted effectively through arms" length market transactions. Thus, there is a belief that a unit-based waste fee will not result in sufficient incentives for design for environment. Analogously, it is felt that a virgin materials tax will not sufficiently affect household decisions about the packaging content of the consumers goods they purchase. Thus, information about the environmental characteristics of products is not being transmitted effectively through the market. Even, if such signals are transmitted, it may be felt that the time-lags from one end of the chain to the other are excessive, slowing down the realization of the environmental objective. Thus, through EPR, governments have sought to integrate these incentives vertically throughout the chain by means of the policy instrument itself.

When would this government intervention be necessary? It would most often arise in cases where consumers had imperfect information about the environmental characteristics of products and thus did not base their consumption decisions on such information, even if they had clear preferences for less damaging goods. For instance, this would be the case if consumers did not recognize the relative waste burden of different products. It would also arise if product markets were imperfect at certain stages in the product chain. Illegal disposal is an obvious example of an important market imperfection, but even factors such as market power at particular stages of production can affect the transmission of signals. In such cases, signals concerning the environmental characteristics of products will not be effectively transmitted forward and backward.

It might also arise if there are technical constraints that prevent direct targeting of a given externality at individual points in the product chain. For instance, virgin materials taxes (or even product taxes) are often inefficient and ineffective means of targeting waste-related externalities in cases where there is considerable variation in environmental impacts depending upon the precise nature of downstream use and disposal. However, substituting them for waste fees may also be environmentally ineffective since such fees are usually calculated on the basis of characteristics (e.g. weight, volume, size of bags) which treat environmentally important attributes of waste (e.g. toxicity, leachability, biodegradability) in an undifferentiated manner due to the high costs of doing otherwise at the point of household generation when wastes are mixed.

However, there is often a trade-off since instruments based upon EPR can incur considerable administration costs (for consumers, firms and governments) due to the complexity of "bracketing" the product chain effectively. This is particularly true for long-lived and widely-dispersed goods produced in sectors which are not vertically-integrated and which are highly tradable. In such cases, there would not be reason to introduce EPR when less administratively costly instruments can achieve the same environmental goals and objectives more efficiently.

Thus, EPR is likely to be most effective and efficient in cases where other instruments are unable to provide the appropriate signals up and down the chain (due to imperfect information or other market imperfections), where it is difficult to target externalities precisely at individual points in the production chain (due to technical constraints), and where the administration

costs of EPR are not excessive relative to alternative policy instruments. However, it is important to remember that in many cases the effectiveness of EPR cannot be compared with individual policy instruments, but rather with a mix of instruments targeted at different points in the product chain. In many ways, the rise of EPR as a policy concept is attributable to the lack of coordination that often exists in the design and implementation of multiple policies at different points in the product chain.

### 4.4.10 Selection criteria

Where more than one type of instrument is being considered, the mix of instruments with the best performance should be chosen. The performance criteria can be a useful guide for policymakers for analysing the value and advantages of establishing EPR policy and selecting appropriate instruments. These performance measurements can also be viewed as criteria for use in evaluating the type of EPR programme that would best meet the stated goals and objectives:

- environmental effectiveness: the extent to which the instrument could be used to reduce or change environmental impacts in relation to the policy targets set. In the context of EPR, upstream changes in product design and composition (e.g. use of less toxic chemicals) and waste diversion could be two factors.

- economic efficiency: the extent to which the instrument saves (and expends) resources, i.e. capital, labour, materials and energy. This would involve an analysis of the costs of implementing the policy and ways to economize on or reduce capital, labour and administrative costs if need be;

- political acceptability: the extent to which the instrument is supported politically (at national, international and sub-national levels);

- administrability: the extent to which the programme is feasible to carry out. The capacity and capabilities of government and producers, as well as other factors such as free-riding, orphan and existing products, and trade and competition issues should be considered here;

- innovative advancement: the extent to which the programme can stimulate technological and managerial improvements.

When attempting to decide which instrument or mix of instruments to select, an analysis of costs of items such as production factors, costs of collection, sorting management of final residuals, secondary material prices and the operation of current recycling schemes ought to be carried out by the producer. Similarly, the environmental benefit of less pollution, less toxic material being treated, increase in landfills and incinerators and other intangibles such as lower risks from toxic waste, public health and well-being should be calculated into the decision.

These criteria could be helpful in determining whether the design of the policy and/or instrument would meet needs and desired outcomes before a programme is developed. Once an EPR programme has been in operation for a few years, these criteria can be used to evaluate it to ensure that the course and direction of the policy still meet government expectations. Mid-course adjustments could then be made accordingly.

## 4.5. Roles and responsibilities

**Key takeaways**

01 There are two responsibilities under EPR, physical and financial. These can be applied fully or partially (shared).

02 The producer is defined as the one with greatest control over the selection of materials and the design of the product. It can be the manufacturer, brand owner, or importer.

03 Governments need to select the responsibility model and assign precise responsibilities: ultimate, shared or apportioned.

04 Communication and coordination with all actors in the product chain are vitally important to the success of the EPR policy and program.

05 The level or degree of producer responsibility (full or partial for physical and/or financial activities) for the EPR program is a crucial decisional point in EPR policy design.

06 Decisions on the allocation of responsibility should be made in view of the policy goals, product characteristics, market dynamics, actors in the product chain and resources needed to implement the policy.

07 National government can set the framework for the policy and can contribute to the effectiveness of EPR by eliminating conflicting policies and by implementing policies to augment EPR.

08 State and local authorities play a crucial role under EPR. This includes their role and relationship to the producer, the producer responsibility organization (if one is to be formed) and in the co-ordination of their participatory role when the product is a classical consumer product. Roles and responsibilities for local government under the EPR programme should be precisely defined. When however, it is a more B2B-product such as photovoltaic modules, local authorities are a stakeholder with whom the producer or the PRO can then make arrangements for the limited amount of post-consumer waste which might end up at local authorities collection facilities.

09 The consumer and the final owner of the waste plays a dynamic role in most EPR programmes. For take-back programmes, it is imperative to inform the consumer and final owner on their role and help them understand the importance of their participation. The same is true under the deposit/refund, advance disposal fee and recycled content programs. Consumer and final owner convenience can be an important determinant of a program's success. Measures such as placement of return receptacles in easy to access locations, Internet sites listing the location of product return depots, and active information campaigns will help to ensure public participation.

10 The role of the retailer (distributor) within the context of the EPR programme should be established. The retailer can be a key conduit of information to the consumer and final customer and bridge the information gap between producers and consumers / final customers.

11 For take-back programmes, a producer responsibility organisation (PRO) could be a useful option for managing and collecting products in lieu of each producer establishing its own separate system. A PRO could also be created to manage a deposit/refund programme or an advance disposal fee scheme.

12 If a PRO is established, the role of local government and the PRO needs to be well defined when we deal with classical consumer products such as TV sets, washing machines.

### 4.5.1 Introduction

The objective of this Section is to summarize responsibilities under EPR and to define who is the producer. Also addressed are the roles of other actors and their potential interaction under an EPR scheme. Not all actors in the product chain are described in this Section since they can differ depending on the product, product group, sector or waste stream addressed. Actors common to most product chains, and involved in the implementation of EPR, are included. The distribution of responsibility and other considerations to factor in when allocating responsibilities, are also discussed.

### 4.5.2 Context

In reviewing the programmes in existence around the globe, take-back programmes appear to be a commonly used EPR instrument and the one most often selected for regulatory, voluntary or industry-based EPR initiatives. Given the extent of experience and on-going activity with take-back, the remainder of this document will focus primarily on conditions and issues associated with the take-back option. However, a majority of the conditions and issues related to take-back have similar applicability to other EPR policy instruments. Decision-makers will be able to draw on the information presented in this section and previous sections to evaluate the issues and needs when considering the application of take-back and other policy instruments.

### 4.5.3 The range of responsibilities

The core intent of EPR is to extend the responsibility for products at the post-consumer stage away from the taxpayer and municipalities and toward the producer of the product. The beginning of this section will address the range of responsibilities for governments to consider when developing an EPR programme, what is meant by responsibility, and how it is assigned. Paragraph 3.3.2. will address the identification of the producer and the shared responsibility options.

#### 4.5.3.1 What is meant by responsibility?

The first type of responsibility under EPR is physical responsibility. This refers to direct or indirect responsibility for the physical management of the products at the end of their useful life (post-consumer stage). Financial responsibility is the second type of responsibility, and it refers to the responsibility of the producer for paying all or part of the cost for managing the waste at the end of the product's useful life. This includes activities such as collection, sorting, and treatment.

Three other types of responsibility for EPR have been characterized by Thomas Lindhqvist (1998)[23]. They are informative, liability, and ownership of the product. Under a scheme for informative responsibility, a producer is required to provide information on the product and its effects during various stages of its life cycle (for example, eco-labelling, energy information, or

[23] *LINDHQVIST, Thomas (1998), What is Extended Producer Responsibility? In Extended Producer Responsibility as a Policy Instrument -What is the Knowledge of the Scientific Community? International Seminar, May, 1998, Lund.*

noise). Liability refers to a specific responsibility for proven environmental or safety damages caused by a product. With ownership, the manufacturer retains ownership throughout the life cycle of the product.

Since policymakers will need to make decisions on identifying producers and characterizing their responsibilities, the way the responsibility is allocated will help to explicitly define which responsibilities rest with various actors in the product chain.

#### 4.5.3.2 Who is the producer and for what is he responsible?

The role and nature of EPR necessitates an allocation of responsibility for implementing the policy instrument. A principal consideration is deciding who is responsible and for what? The responsibility and roles of actors in the product chain often differ depending on the product or category as well as the goals and objectives of the policy. Under EPR, leadership of the producer is critical to the success of the policy. The producer is in the position to influence a number of stakeholders to accept responsibility for their behaviour, including suppliers, businesses, consumers, educators, media, government and retailers (Fenton and Sinclair, 1997[24]). The producer is also in the position to influence the environmental impact(s) of their products -- or correct the market failure.

**Who is the producer?**

Studies in Finland and Sweden indicate that the actors in the product chain surprisingly agreed that it is the producer in the product chain who should be responsible for the environmental issues related to products (Timonen, 1997; and Ryden and Lindhqvist, 1998[25]). Both studies also noted that producers have in their hands product-related knowledge not available to others in the product chain. For example, usually the product producer has the greatest access to technological expertise, propriety information and product knowledge. Based on this knowledge and expertise, the product producer is in a better position than others in the product chain to make product changes, and it would be the producer who would accept physical and/or financial responsibility for the treatment of post-consumer disposal of the products they produce.

Producers are, therefore, in the best position to make changes to their products to meet the objectives of the EPR programme and to stimulate product innovation and redesign, promote less wasteful products (i.e. products where less waste enters the waste stream for final

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*[24]FENTON, Robert W and John Sinclair (1997), Roles and Structure of Producer Responsibility Organisations, Canada.*

*[25]TIMONEN, Paivi (1997), Consumers as Co-producers, paper presented at the OECD EPR Workshop, December, 1997, Ottawa.*

*Rydén, Erik. (1998) Extended Producer Responsibility - an emerging field for new economic actors. In K. Jönsson, & T. Lindhqvist,*

*Extended Producer Responsibility as a Policy Instrument – what is the Knowledge in the Scientific Community? (24-28). AFR-*

*Report 212. Stockholm: Swedish Environmental Protection Agency.*

disposal), or produce products that are easier to re-use or recycle. As such, an EPR scheme is most effective if the producer is designated as the entity with the greatest control over the decisions relating to materials selection and product design.

With longer-life products (such as photovoltaic modules), the producer is considered to be the firm whose brand name appears on the product itself or the importer. However, in the case of packaging, the filler of the packaging, rather than the firm that makes the product container or wrapping, would be considered the producer. In instances where the brand owner cannot be clearly identified, the manufacturer would be considered as the producer.

**Ultimate responsibility**

Given the diversity in product chains, actors and markets, there needs to be one actor assigned with the explicit responsibility under the EPR policy. The responsible party in the product chain would be the actor who has explicit or ultimate responsibility for meeting policy requirements. In most circumstances, the producer would be designated as the entity to which the ultimate responsibility is assigned. Assigning the ultimate responsibility to the producer, however, does not change the need for others to participate to ensure that the programme is carried out. A sharing of responsibility is an inherent part of EPR and is important for the success of the policy. For instance, under the German Packaging Ordinance the producer or fillers of the packaging are considered the ultimate producer and pay the fees for the Green Dot. Retailers are responsible for secondary packaging. Municipal governments, waste haulers, recyclers, and consumers and others in the product chain are all involved in the programme and have a role and responsibility for its implementation.

#### 4.5.3.3 Other responsibility combinations

**Shared responsibilities**

While close coordination with all actors in the product chain is an inherent part of EPR, responsibility may also be shared, in a more formal way, between the producer and the government or between one or more actors in the product chain. There are two basic models. The first model is shared responsibility between the municipal government and the producer. Under this model, the ultimate producer could be assessed a fee to pay for the physical management of the product at its post-consumer phase, although the municipality retains physical responsibility for a portion of the waste management. Many countries have used two options for implementation. One option is for the municipality to have physical responsibility (fully or partially) for the collection and sorting of the post-consumer waste while the producer (fully or partially) finances this activity and then physically takes the sorted waste back for treatment. The other possibility is for the municipality to continue operating as it had before, but with the producer paying for the extra costs associated with the treatment and disposal of their product. This applies for true products consumed by households. However, for products which are mainly consumed – installed with reference to photovoltaic modules – at large power plants and thus within a Business-to-Business environment, the shared responsibilities are spread amongst the producer and the other actors of the business value chain.

This shared method provides for partial cost internalization for the financial management of post-consumer products.

The second model of shared responsibility consists of an agreement (formal or informal) between the producer and one or more actors in the product chain. The producer would have the ultimate responsibility and the lead under the EPR programme. Specific responsibility combinations would depend on the policy instrument, product, distribution chain and other such factors. Two examples of this model would be the producer entering into an agreement with a recycling firm to collect products or the producer entering into an agreement with a retailer to collect deposits and issue refunds. Sometimes distributors and retailers are enlisted to collect the products and return them to the producer. Another example would be the case of advance disposal fees where the retailer would be responsible for collecting fees and distributing them to a government body or private sector organization (PRO).

**Apportioned responsibility**

Another form of shared responsibility would be to apportion responsibility between each actor in the product chain. Under this method, the role and degree of responsibility of each actor would be determined for the specific product, product group or sector. The distribution of responsibility is based on the role of the actor in the product chain. Often, industry-led initiatives are based on this concept. One advantage of this method is the increase of information about the EPR programme being disseminated to the actors in the product chain.

Determining (and ensuring) a fair and equitable distribution of responsibility could be a more challenging process than reaching an agreement among the actors on their specific roles and responsibilities. Under apportioned responsibility, assurance that all parties are equally participating in the programme is critical in order to limit those instances when only one or two of the actors along the product chain fulfil their role and responsibility. The programme might need to be designed with checks and balances to ensure full participation by all actors in the product chain and to limit free-riding. Incentives or rewards for participation can help improve participation. Or, other deterrents such as sanctions for non-participation (free-riding) may be necessary.

Given these issues and the complexity of some product chains, this method might be best served in situations where the length of the product chain is relatively short (few actors) and there are not a high number of producers involved.

Within the case of apportioned responsibility, the actors involved in the product chain should be given the opportunity to allocate roles and responsibility in the product chain. Under negotiated agreements and mandatory systems, the government could assign responsibility for products at their post consumption phase to the product chain itself. If this mode is selected, it would be very important to set a time schedule and due date for results. For mandatory or negotiated agreements, Governments may wish to incorporate a trigger clause that comes into force if the due dates are passed or other conditions are not met.

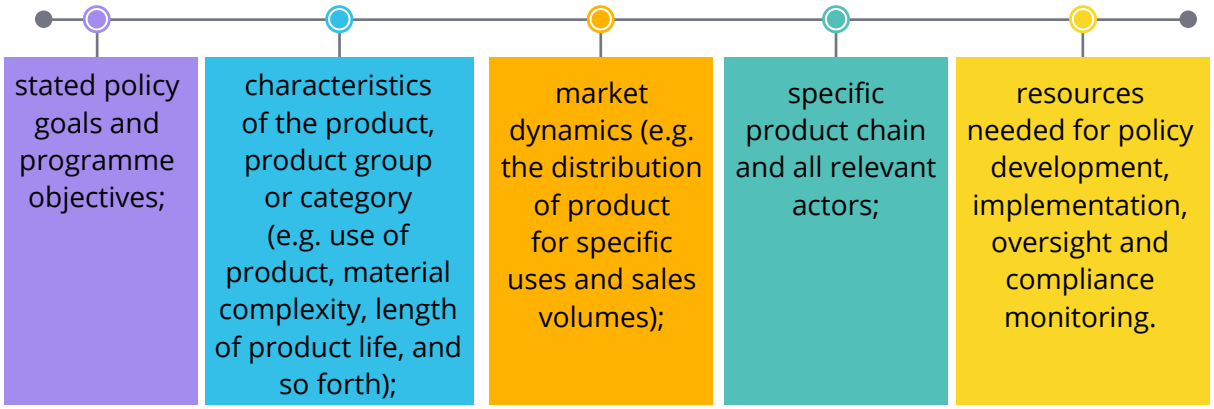
### 4.5.4 Distribution of responsibility

Once a responsibility model is selected, a decision on the extent of physical and financial responsibility placed on the producer (and others) is needed. There are several choices and combinations of physical and financial responsibility that can be initiated.

Combinations of these approaches to include full or partial responsibility are possible. Policymakers need to review the range of possibilities in the distribution of responsibility in relation to policy goals and the practicality of its implementation.

### 4.5.5 Considerations when allocating responsibility

When allocating responsibility for EPR, the following considerations should be taken into account:




### 4.5.6 Who pays?

A question often raised with EPR is who pays for, not who physically operates, the waste management system. Municipalities – financed by taxpayers - have traditionally undertaken treatment of municipal solid waste. Over time the sheer volume of per capita municipal waste has increased substantially and its composition has become much more complex. The rationale behind EPR is that the taxpayer burden of paying for that added pressure from increased waste could be reduced by shifting the financing to those who profit from the products. EPR recognizes that producers are most able to alter products to prevent waste, minimize waste management costs and reduce environmental pressures of a product at its post-consumer stage. Therefore, EPR policy should be designed to provide incentives to encourage producers to absorb social costs from the treatment of their products. Any unavoidable costs could therefore be incorporated into the product pricing. The producer and the consumer - in lieu of the taxpayer - would pay for the social costs (externalities).

#### 4.5.6.1 Funding mechanisms

As previously noted, an underlying issue with regard to EPR is how to fund the collection and treatment of post-consumer waste. Shifting what has traditionally been the responsibility of municipalities to the producer provides incentives for the producer to find ways to lower the costs they would pay.

The funding mechanism will depend on the particular instrument selected and product, product group or sector. Generally speaking, producers could pay through a tax or fee; consumers could pay through the product pricing or a fee, or through a combination of the above.

#### 4.5.6.2 Internalization of costs into the final price of the product

Related to the method of paying for the EPR scheme is determining the level of cost internalization. Internalization of social costs, or externalities, is possible when full financial responsibility is shifted from municipalities to producers and consumers - even if the municipalities still perform the same functions as before. The producers would incorporate additional costs for the treatment of the post-consumer product into the price of the product (in a proportion relative to the elasticity of demand). Substantial cost internalization gives producers incentives to change product design in order to reduce the costs associated with the treatment and/or disposal of post-consumer products.

In the case of partial-cost internalization, the costs of treating post-consumer products are partially paid by the producers. They contribute financially to the operation of the local waste management system, but the municipality still bears some of the costs of collecting, sorting or treating the post-consumer products.

### 4.5.7 National government role

National governments play a key role in establishing (through either law or negotiation) the legal policy framework for EPR and setting parameters for special agreements or voluntary programmes.

National governments can contribute to the effectiveness of EPR programs by: (i) raising awareness of program and requirements; (ii) eliminating policies that are inconsistent with EPR objectives (for example subsidy programs for raw material extraction); (iii) implementing supportive policies and measures such as green government purchasing or unit-based pricing of household waste; (iv) eliminating or removing barriers that are inconsistent with EPR policy; and (v) establishing mechanisms to help prevent free-riding and anti-competitive behaviour. In situations where policymakers wish to promote industry-based EPR initiatives, obstacles that would affect the initiation of voluntary efforts should be eliminated.

### 4.5.8 Local government role

Regardless of which EPR responsibility model is selected, local governments have a crucial role to play. Under some schemes the local authority retains responsibility for the collection and sorting of the waste. For other schemes, local authorities will have a role to ensure that the waste is properly dispatched to a parallel regime. Local government has an important role in stimulating the recycling market, assisting firms to build appropriate recycling capacity, and transferring information about new technologies for recycling, cleaner production processes and cleaner products to the public. They also can be instrumental in communicating information about the EPR programme to the public.

EPR policies generally place new and different responsibilities on local authorities – particularly with respect to the increased need to co-ordinate their activities with industry. For programmes designed to rely on, or contract directly with, the local authorities to continue to carry out

specific functions, responsibilities should be clearly defined and agreed. In instances where the EPR instrument results in the creation of a Producer Responsibility Organisation, it is critical that the relationship between the organisation and local authorities is precisely defined.

In countries where the local and regional authorities play a strong political role, they can help fulfil compliance and other oversight functions. Additionally, they can provide feedback to the national government on the effectiveness of the EPR programme at the local level.

### 4.5.9 Consumers

Consumer choices over which product to buy or how to dispose of it are critical factors to consider when designing an EPR programme. A communication plan, developed together with stakeholders, will help to strategically inform consumers of their roles and responsibilities under the programme. A well-conceived communication plan can help improve consumers" understanding and appreciation of the benefits of EPR and what is expected of them. This can instil a key sense of responsibility and increase environmental awareness. Maintaining active communication with the public by releasing data and information about the programme and its accomplishments, or by informing them of what they can do to contribute to the programme, helps keep the consumer engaged. Effective public communication can provide subsidiary benefits deriving from peer pressure to comply with the programme (e.g. returning products or placing them in the proper bin). Lack of a consistent or systematic communication plan can jeopardize the operation of the EPR programme.

### 4.5.10 Role of retailers (distributors)

Roles and functions of retailers (distributors) need to be clearly defined because their strategic position in the product chain can influence the operation of EPR programs. The retailer can be the one who takes back the product (new for old or like product returns), collects the charges or fees, provides the refund, or selects and stocks the products on the shelves. The retailer can be a vital component in an information dissemination strategy as they can furnish consumers with information about the EPR programme, products, and their role.

### 4.5.11 Producer Responsibility Organizations

Under take-back programs, it could be impractical and not particularly economically feasible for each producer to take back its own products. Therefore, third party organizations are often formed allowing producers to collectively manage the take-back (and most often arrange for the treatment) of products.

These organizations are often referred to as Producer Responsibility Organisations (PRO) and can be an effective structure for managing and collecting post-consumer products. The need to create a PRO depends on the policy instrument selected and other factors such as the product group, number of producers and importers, and secondary materials to be collected. The advantages of a PRO as a means to implement the EPR programme should be examined in the design stage of an EPR program.

Most PRO's in operation to date collect a fee directly from the producers based on a specific fee structure. Often a trademark is established for that organisation and the producer pays

a fee to carry the trademark on the product. Ideally, fee structures should be designed by the organization so as to reward those producers who move to achieve EPR policy goals and objectives. When a PRO's rates vary according to the cost of disposal, the resulting "competitive disadvantage" to firms whose products are more difficult to dispose of is not a problem under competition law or policy. For example, in a packaging take-back system a standard fee per package would not provide any incentive to reduce packaging weight or to use more recyclable materials because the producer would not benefit financially from doing so. When the fees are based on weight and type of material, a producer can benefit from design changes that reduce waste and facilitate recycling.

The PRO itself needs to be structured according to the policy goals, objectives and demands of the EPR programme.

PRO's can support both voluntary and mandatory take-back schemes, deposit/refund systems, and advance disposal fee programmes. PRO's can also have various functions extending beyond the management of take-back, such as for education and training of producers and consumers, collection of fees and other responsibilities as delegated under the EPR programme.

Through co-operation, individual producers can fulfil their extended producer responsibility much more cost-effectively. In fact, given that smaller companies will have relatively more difficulty organizing their own take-back systems than larger firms, the existence of an industry-wide PRO will remove what would otherwise be a tendency for EPR policies to impose relatively high burdens on smaller firms. To the extent that the existence of a PRO enables small firms to stay in business, the PRO may actually increase the level of competition in a market subject to an EPR program.

## 4.6. Free riders, orphan and existing products

**Key takeaways**

Free riders

01 It is plausible that complete removal of free rider behaviour – the one of actors in an EPR system who do not pay for the benefits they receive – may not generate sufficient environmental benefits to justify the administrative costs to minimize free riders.

02 An EPR programme's ability to deal with free riders is an important factor in considering alternative EPR systems and alternatives to EPR.

03 Peer group pressure and disclosure of free riders can help increase discourage free riding.

04 Reducing the costs of an EPR programme will encourage participation.

05 Policymakers and PROs need to analyse the incentives they create for the various actors operating in an EPR system through different pricing structures and legal liabilities, to ensure (as far as possible) that these are consistent with the ultimate goals and objectives of the EPR program and with overall economic efficiency.

06 Under mandatory EPR programs, government enforcement against free riders may be needed to assure fairness to producers that carry out their EPR responsibilities.

**Orphan and existing products**


## 4.6.1 Introduction

Three main issues that need to be addressed by any EPR program are "free riders', "orphan" and "existing" products. Free riders are the actors in an EPR system who do not pay for the benefits they receive. Orphan products are those which are subject to an EPR policy, but whose producer is non-existent due to bankruptcy or other reasons. "Existing" (pre-existing) products are those already on the market at the time the EPR policy is introduced. The ability to deal efficiently with these issues is an important consideration when different EPR programs and alternatives to EPR are analysed.

### 4.6.2 Free riders

Free riders benefit from the EPR system without contributing an appropriate share of the costs. There is scope for all kinds of participants (consumers, producers, importers, retailers, collectors and recyclers) to free ride one way or another. While there are various ways to reduce free riding, there is usually a trade-off between effectiveness and administrative cost. Achieving zero free riding, even if possible, would probably not be worth the cost.

The extent of the free rider problem depends on the design of the EPR system (policy instrument or mix of instruments selected) and the type of product involved. Take-back systems for products with thousands of producers/importers, for example, have a higher potential for free rider problems than those in more concentrated markets. The scope for free riding is greater and more complicated to deal with when a large number of producers (packaging material manufacturers, brand owners, wholesalers, retailers, etc.) are part of a long production chain.

In other product areas such as photovoltaic industry, electronics or motor oils, where the industry is more concentrated and/or vertically integrated, the number of producers affected by an EPR programme may be considerably smaller. Thus, there will be fewer free riders and the issue can be easier to deal with.

In some cases, the scale of free riding does not threaten the financial viability of an EPR system but does raise equity concerns, as the free riders obtain a competitive advantage. In others, however, even a small amount of free riding can compromise the entire system.

The following are examples of free riding in the context of take-back and recycling schemes:

- Producers/importers may under-declare the amount of products they put on the market that should be covered by the EPR scheme, or they may not be registered in the system at all.
- Producers/importers may free ride by paying EPR fees in a low-cost jurisdiction and selling their products in a higher-cost one.
- Collectors may mix products for which payments have been made within the EPR system with those for which payments have not been made.
- Consumers may use a designated collection receptacle provided by the EPR programme to dispose of materials not covered by the programme. The higher the charge for general waste disposal services, the greater the incentive to do so.
- Recyclers may illegally dispose of materials they are paid to recycle.

Existing EPR schemes have addressed free-rider problems in various ways. For example, the problem of consumer misuse of designated receptacles has been addressed by the German DSD through changing the incentive structure that applies to waste collectors, and by encouraging peer group pressure. While collectors were previously paid according to the

weight of the materials collected, they are now paid only for the portion of these materials that should have been collected (i.e. which DSD can recycle). This gives collectors an incentive to reject inappropriate materials that have been put out for collection.

Peer group pressure can be expected to play an important role in reducing free-riding by producers. There is an economic incentive to report competitors who cheat the system, to the extent that they can be identified. Reporting and monitoring systems are therefore very important. In theory, government enforcement against free riders would improve compliance, and should be possible both in mandatory EPR programmes and (perhaps to a lesser degree) when requested by participants in voluntary industry-based programmes. As it is impractical to physically monitor the amount of a product that ends up in an EPR collection system, random audits of the quantities placed on the market are an alternative compliance mechanism. In legislated schemes, authorities are likely to require reporting by producers that claim to be meeting their EPR obligations without resorting to a system such as a PRO.

Producers and their PRO's are able to deal with free-riding members by peer pressure, monitoring, self-reporting requirements, sanctions, and even expulsion from the PRO. But such methods are ineffectual against free riders who lurk outside of the EPR regime that applies to them.

When the PRO has done what it can to minimize free-riding, there might be instances where government help may be needed to obtain compliance by PRO non-members and other free riders. In addition to addressing free-riding producers, government (at the municipal level) could consider establishing compliance requirements for consumers whose participation is essential to EPR success. Wide dissemination of program information to consumers could help improve their understanding and increase compliance.

Public disclosure of producers who have been found to cheat the system may be an additional tool to encourage compliance. In addition, the lower the costs of being in the EPR system lowers the incentive to cheat. Finally, for mandatory programs the role of enforcement should help to minimize free riding.

### 4.6.3 Orphan and existing products

'Orphan" and "existing" products present challenges for EPR. Orphaned products are those subject to EPR requirements whose producer has disappeared due to bankruptcy or for other reasons. Existing products are those designed and/or introduced on the market before EPR requirements were established.

Existing products were not typically designed with the objectives of EPR in mind and, therefore, they may be more expensive to manage at end-of-life. With orphaned products, there is usually conflict related to who should bear the cost of end-of-life management. These problems, in turn, create concerns about the fairness of the allocation of costs.

The magnitude of these problems depends on the number of pre-existing products (for example in India already 35 GWAC of PV capacity is installed and will increase till the date

EPR is implemented), the cost of end-of-life management, the life span of the product (20+ years for PV), costs to treat orphan and existing products relative to their sales price, and the number of actors involved.

While the issue of existing products is not likely to be significant in the case of fast-moving consumer goods, it is likely to exist to some degree in the case of EPR systems for longer-life durables.

Decisions concerning how to deal with existing products depend on programme objectives. If the objective of an EPR scheme is primarily to encourage future design improvements with respect to end-of-life management, then it may unnecessary to attempt to deal with products already on the market. EPR could apply only to products put on the market after the introduction of the policy. If the over-riding objective is to deal as soon as possible with problems arising from disposal of the products, a decision will need to be made on whom is responsible for products already in the hands of consumers. Allocating responsibility for orphaned products is somewhat less complicated; it is essentially a political decision about who will bear the costs and responsibilities.

Product type and characteristics will affect the way orphan and existing products are addressed. Short life products like packaging and beverage containers would be dealt with differently than longer life products such as photovoltaic modules or white goods.

Different funding mechanisms can create different incentive structures and raise different issues with respect to orphan and existing products. The remainder of this section looks at the different funding mechanisms and their implications. These mechanisms are notably similar to those that can be used to fund EPR programmes for new products.

#### 4.6.3.1 Financing options for addressing orphan and existing products

**Advance disposal fees**

Under this method, a fee levied on a new product at the point of sale goes towards funding end-of-life management of similar products already at the post-consumer stage. In other words, current receipts finance current expenditures.

This method can be used to address both orphan and existing products if producers ignore the origin of products, which have already reached the post-consumer stage. Regardless of the brand, or the current status of the original producer, the sale of the new product provides funding for managing treatment of the used products.

One drawback is that it may be complicated to establish a direct link between the fee levied on the new product and the cost of dealing with that particular product when it is discarded. The pricing mechanism will therefore not send a signal to the market about the relative costs of end-of-life management for different brands of the same product, and cost internalization will be approximate. This is because the amount of the fee will be determined by current needs related to managing the stock of existing products, not that of future ones.

If authorities set a standard fee, different producers will not be able to compete on the basis of offering cheaper end-of-life management. Individual producers will not be able to offer lower prices on the basis of their lower end-of-life management costs. Economic incentives to improve the product's environmental design and recyclability will therefore be limited. The same situation would exist where a fee at the time of purchase system operated through a PRO that handled recycling and re-use collectively.

Whether this kind of system is administered by a PRO or individual producers, there are likely to be situations in which there is a mismatch between the generation of funding and the pattern of expenditure. Sometimes sales of new products may be relatively high, and the return of used products relatively low, generating a surplus. In other cases the reverse could occur, resulting in a deficit. There is a need to average out and adjust revenues and expenditures over time.

It will also be much easier to gain consumer acceptance of levying a fee on a new product to pay the costs of end-of-life management of existing products where there is a widespread agreement on the need to address the issue of disposing of these products.

**Fees paid at the time of purchase**

From an economic point of view, it is worth emphasizing that a fee paid at the time of purchase effectively uses the narrow tax base of new sales of a product to fund end-of-life management of products sold earlier. It is also open to governments to use a larger tax base (i.e. to use revenue from general taxation) to fund the same objective. However, where letting products such as new refrigerators and cars bear the cost distorts and depresses sales, the introduction of environmentally preferable technologies or more environmentally compatible products would likely be delayed.

A fee levied upfront for a product's eventual disposal could work in the case of products such as cars, where a system already exists to keep track of transfer and eventual disposal. Where producers take individual responsibility for end-of-life management, including keeping the proceeds of EPR fees to fund future end-of-life management, they will leave orphan products behind if they go out of business. Both the physical and financial responsibility for dealing with the orphan products would need to be assigned to the remaining producers or in some cases, the local authorities.

An EPR system needs to allow some tracing of "disappearing" companies, so that a simple name change, for example, is not sufficient to evade paying for end-of-life product management. That is, passing costs onto others too easily should not encourage the creation of orphan products.

Where fees are pooled at the industry level through a PRO, trust fund or government body, advance deposits are not lost when a company goes bankrupt or otherwise disappears. Nevertheless, the problem of averaging out the timing of receipts and expenditures remains, as does that of funding an eventual deficit.

**The last owner pays**

Rather than paying at the time of purchase, an EPR programme could mandate take-back and levy the fee for end-of-life management on the consumer when a product was returned to the retailer/manufacturer. This financing mechanism can address orphan products if remaining producers or a PRO agree to take back brands that no longer have a parent company. Additionally, affixed fee schedules at the time of purchase would inform the consumer of the actual fee they would pay at the end of life disposal at the point of sale. For example, when a consumer purchases a refrigerator, they would be informed of the actual fee that must be paid and their responsibility at the post-consumer stage.

It should be noted that having to pay a fee might deter consumers from returning products, which would increase illegal dumping or use of landfills. The likelihood of this happening depends on consumers" sense of responsibility, the level of fines (and level of regulation against placing waste in normal trash receptacles) for illegal dumping or landfill use, and the ease and cost of returning the used products. Regulatory action might be warranted to avoid illegal disposal of products and deter free riding of consumers by leaving products by the side of the road or illegally placing products in the municipal waste system. Moreover, consumer convenience will be an important determinant of the programme if the fee naturally prompts proper action by the last owner.

**Insurance**

One way to deal with the orphan product problem could be to take out insurance against the possibility of an underfunded end-of-life management liability. This could be envisaged where a PRO has collective industry-wide responsibility and is funded by payments from producers at the time their products are purchased. The PRO or a government authority could perhaps insure against the risk of having to pay for orphan products where a parent company had not contributed to the costs of EPR.

Alternatively, producers could be required to post a bond covering the cost of end-of-life management of products still on the market. The complicating factor here is that the consumer, rather than the producer, decides when products are at the end of their useful life. It would therefore be difficult to manage the terms of the bond and the pay-out stream.

**Phase-in**

If there are serious concerns about the fairness of levying fees on new products to pay for end-of-life management of existing products, and advance disposal fees are not considered viable, another option is to phase in EPR and associated costs to consumers gradually. For example, the proportion of existing products assigned to manufacturer end-of-life financing would increase over time.

Another option would be to announce a date when the EPR programme would become effective. This approach would be more suitable when the policy objective was concerned with influencing new product design rather than with disposal of existing products. Giving significant lead-time to the implementation of an EPR programme allows time for existing products to be

handled in the traditional "pre-EPR" way, thus avoiding a situation in which new sales include the costs of handling existing products. Using such an approach, the amount of notice given would be significantly influenced by the probable lifetime of the product in question.

## 4.7. Costs

### 4.7.1 Introduction

Defining costs that should be covered by EPR is a relevant issue. Most EPR schemes clearly cover partly or fully the net costs for the management of waste that has been separately collected (e.g. costs for collection and treatment, minus revenues from the sales of recovered materials), as well as administrative, reporting and communication costs relative to the operation of collective schemes.

'Full-costs" theoretically include (in addition to those aforementioned):

- Collection, transport and treatment costs for non-separately collected waste (waste covered by EPR but not entering the separate collection channel, e.g. waste collected together with mixed municipal or industrial waste);
- Costs for public information and awareness raising (in addition to a PRO's own communication initiatives), to ensure participation of consumers and final owners of the discarding products (waste) within the scheme (i.e. through separate collection);
- Costs related to waste prevention actions;
- Costs for litter prevention and management;
- Costs related to the enforcement and surveillance of the EPR system (including, auditing, measures against free riders, etc.).

In addition, for those costs explicitly covered by the EPR system, the level of coverage (full or partial) by the producers varies. This level of coverage is closely linked to the share of responsibilities between stakeholders (see also Section 3 above).

### 4.7.2 Costs

The costs within an EPR-environment are usually divided into two big chapters: administration (overhead) and operations whereby the overhead costs are relatively stable and the operations costs might fluctuate depending on the amount of collected waste versus the costs for treatment and the negative or positive prices of the recovered materials.

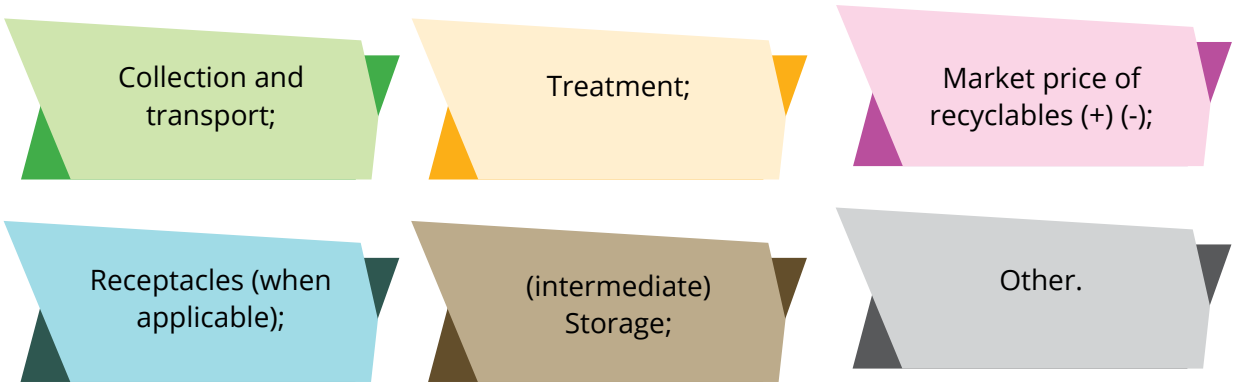
**Administration costs**

The administrative costs consist mainly of the following ledgers and might differ a bit when the EPR is more focused on household waste or industrial waste:

- Costs for Data management and reporting from Producers to the PRO and from the PRO to the public authorities;
- Costs for public information and awareness raising (usually when households needs to be reached);
- Marketing and Communication costs;
- Costs related to waste prevention actions (more for one-way and fast-consuming products than for long life products such as photovoltaic modules);
- Costs for litter prevention and management (usually within household waste);
- Costs related to the enforcement and surveillance of the EPR system (including, auditing on the POM (Put-On-the-Market data) and on the treatment performance of waste treatment plants, measures against free riders, feasibility studies, etc.);
- Staff costs;
- Office costs;
- Financial costs (banking, interests, financial auditing, etc);
- Legal advice and support;

**Operations costs**

The operations costs consist mainly of the following ledgers and might differ a bit when the EPR is more focused on household waste or industrial waste:



In most of the cases, net operational costs (i.e. collection, transportation and treatment costs) for the management of separately collected waste are covered by the EPR system.

The extent to which net operational costs are assumed by PRO's (and therefore covered by producers" fees) is highly variable and depends notably on the share of organizational and financial responsibilities of the various stakeholders, as well as on the national framework for EPR.

For example, in most cases for battery waste, the financial responsibility assumed by battery producers covers 100% of collection and treatment costs.

For WEEE, PRO's can cover 100% of transportation (pick-up from public amenity centres) and treatment costs. However, in a number of cases, PROs also cover 100% of the collection costs, through reimbursement to local public authorities.

For some streams, operations are self-financed. This means that revenues from the recycling materials' sales fully cover the costs for collection, transport and treatment. In these cases, producers' fees (if any) are mainly used to fund data management, auditing activities, communication efforts and administrative costs (staff etc). This applies commonly to End-of-Life Vehicles and waste oils and for some flows of electronic waste. However, the situation may also vary from one country to another.

**Photovoltaic modules versus costs and revenues under EPR**

For photovoltaic module[26], the administrative costs shall be similar as in each EPR-environment. The challenge is the operational costs where – the good and bad news – almost no waste occurs whilst the fixed administrative costs exist.

The long lifetime of these products is a huge contribution to the prevention of waste and thus to the delay of costs whilst at the other hand the very low amounts of discarded photovoltaic

modules result today easily in a spread of the costs by 90% administrative costs versus 10% operations costs. Within 20 years, this spread will change into relatively low administrative costs versus the amount of operations costs.

On the other hand, the volatile solar market is a risk factor within EPR.

Therefore, the creation of provisions or funding for future waste management is crucial in order to be able as solar industry to manage the upcoming waste environmentally sound in the (near) future.

A draft financing model for an Advanced and Visible Disposal Fee is therefore very recommendable.

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*[26]As stated in the introduction to this Chapter, this section explores EPR costs of PV modules only. Other products within a PV system such as inverters and batteries can easily be added to the programme, since these are attractive products in the waste phase due to the value of the materials in these products, whereas the value of end-of-life PV modules is lower as they are mainly composed of glass.*

## 4.8. Recommendations

The following list contains key recommendations for policymakers. While these recommendations are applicable to all government interventions, they are based on experience with the design and implementation of mandatory and voluntary EPR policy approaches for PV modules in several European countries.

### 1. Set up a five-year Management plan.

The PV industry shall introduce a five-year Management plan which defines the strategical vision and, which contains at least with the following main features:

- A forecast of the amount of collectable used PV modules;
- Measures about prevention (prevention plan);
- The strategy related to information campaigns (communication plan);
- The actions towards the owners, the installers and wholesales companies related to collection, reuse and treatment of used PV modules (sensitize plan);
- A five-year financial plan;
- A plan containing the provisions spread over 35 years which is annually monitored and – when required – updated;
- A method, which allows to follow-up the collected and treated used PV modules, including annual reporting;
- The actions related to the collection of PV modules;
- The actions related to the treatment of PV modules.

### 2. Do not set any collection target in the first phase of the EPR system.

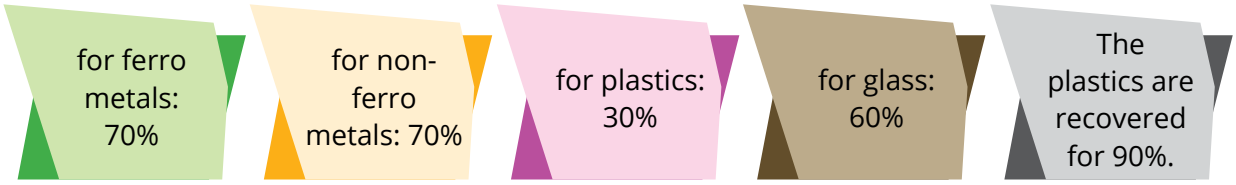
The first 35 GW in India is from very recent date whilst the lifetime of PV modules is easily 20+ years and PV modules are an investment product instead of a consumer product. Once the first five-year Management Plan is expired, the PV industry and the policy makers can foresee for example a “waste generated” target based upon the installed amounts and the experience in collection of the past 5 years.

### 3. Set clear, realistic and appropriate treatment targets.

Treatment targets shall be appropriately described in the five-year Management Plan. They should be ambitious, yet realistic based on the analysis of the current context. As for the treatment targets, the following values are recommended:

| Recovery[27]: 70% (of which) | Preparation for reuse and Recycling: 55% |
|---|---|

The treatment of discarded PV modules must lead to achieve the following – tentative – percentages with regard to the preparation for reuse, and recycling of components and materials:




The targets established need to be transparent and acceptable to all stakeholders (industry, consumers, environmental citizens" organizations, consumers, public interest groups and others.

Periodically review the targets of EPR policies and adjust their ambition in line with waste management and resource policy objectives; take account of the costs and benefits of proposed targets and establish them in consultation with stakeholders.

### 4. There is no single "right" approach.

There is a continuum of EPR approaches from voluntary (industry-based initiatives, such as PV CYCLE from 2008-2013) to mandatory (such as PV CYCLE as from 2014). The approach used depends on differences in products, market structure, targets, prices of secondary materials and other factors.

### 5. The visible fee approach seems the best fit to the Indian context.

There are two financing options:

**a) Internalization of waste management costs**

Today, there is no clear evidence of a strong positive impact of internalizing the management costs in the sales price of PV modules. A PV module is relatively new product and thus the industry is still in a full swing of producing more efficient PV modules whilst at the same time the very long lifetime of these products allows these to add a huge value in preventing waste for 20+ years.

The manufacturer can have the largest influence on product design. However, the manufacturer shifted the past ten years from manufacturers around the globe to currently 90% of the manufactured PV modules are produced in Asia.

[27] *"Recovery" is a legal term in the waste law and means "preparation for reuse, recycling and energy recovery".*

**b) Visible fee**

The visible fee approach drastically limits the free riders, saves the cash of the Producers/ Importers – the economy drivers – and put the financial responsibility on at the Polluter (Pays) whilst the legal responsibility is and remains at the Producer/Importer.

For a PV module, starting with a visible fee approach is the best way to start an EPR-program in India because:

- Avoiding Free riders: during the first 5 years in India, it is much more important to focus on a market where all producers and importers are compliant with the EPR regulations;
- It is a powerful mechanism to create a level playing field and at the same time to build a reasonable Fund for future waste management for a product with a very long lifetime of 20+ years;
- The manufacturing of PV modules is mainly done outside India and the manufacturers producing their products for a global market where currently no Ecodesign requirements exist for PV modules.
- There is no country nor a region in the world which has an existing Ecodesign framework in place for PV modules; even for other products the Ecodesign or Design for recycling requirements only exist on paper and have no proven record; even the European Union strives to have its Ecodesign requirements for PV modules implemented only by the earliest in 2024;

### 6. Ensure neutrality to competition.

The framework of the EPR program should be designed to have as neutral effect as possible on competition.

A. In general, more competitive markets for collection, recovery and re-use of products will yield lower costs and higher production of these services. It is important to avoid creating monopoly or monopsony power through regulatory barriers to entry in post-consumer materials markets. However, this can be easily organized when the PRO invites the complete downstream market to bid for logistics, treatment and other supplies the PRO requests – see also F.

B. EPR policies create a powerful incentive for companies to co-operate to jointly meet the individual responsibilities. Policymakers should seek to eliminate artificial regulatory barriers to efficient co-operation, including regulatory provisions that seek to dictate particular forms of co-operation.

C. Where possible, competition authorities should be included in the EPR policy-making process to provide advice on the likely impact on competition and consumers of alternative EPR approaches. Competition authorities should carefully examine the extent to which co-operation is necessary for EPR purposes and should focus their

analysis on how EPR goals can be reached without the policy instruments or the subsequent private conduct creating unnecessary harm to consumers. Competition authorities may also be useful sources of analysis of free-rider problems.

D. Fair and transparent pricing by the PRO is critical. Competition law enforcement can play an important role in ensuring that EPR systems are not used as a vehicle for anti-competitive conduct that "unfairly" increases prices (i.e. beyond that justified by the costs of EPR) for disposal services or in product markets.

E. Competition in the market of the PRO services is critical - either through allowing more than one PRO or through allowing individual collection systems and having in both options the same conditions for each PRO and individual collection system. Even if there is only one actor in the market at any given time, competitive outcomes could still be achieved if there are no barriers to entry for new competitors.

F. Similarly, the PRO should contract out collection and recycling services on a competitive basis. Contracts should not be unduly long term; bidding should be open, competitive and fair.

G. PROs should not abuse any market power they may have through monopoly pricing or other anti-competitive practices.

H. International "dumping" of collected materials can cause unfair competition, undermine recycling efforts of the importing country, and may constitute a case for anti-dumping action.

### 7. One solution for all photovoltaic modules.

In general, the most obvious distinctions are between short-life and long-life products, and between waste from industrial production and that from private households. There are different influences and aspects within each product group that need to be factored into the decision–making process.

More specifically, for PV modules this generic lesson is not recommended because at the time of putting for the first time a PV module on the territory of India, nobody knows where this PV module will be installed: a residential rooftop, a commercial or industrial rooftop, an utility solar farm or any other large PV power plant?

PV modules have a long lifetime irrespective in which application they are installed; moreover, the objective of EPR legislation is providing a producer responsibility for the post-consuming/ using phase and not the manufacturing phase of the product.

The scope of the EPR for PV modules must be each PV module sold on the Indian territory whereby the funding of the EPR system must be equal for each purchaser, irrespective where the PV module is installed (residential or large power plant).

Only the collection of PV modules can be organised as such to enable collection of residential rooftop PV modules through municipal collection or drop off points whilst all PV modules originating from PV installations lower than, e.g., 5 kW must be collected through a B2B-collection network; the latter can consist of a number of fixed collection points throughout the country taking into the installed PV capacity per state and on-site pick-up for large amount of PV modules.

### 8. Promote R&D on product design and material substitution.

In designing an EPR program, incentives should be given to change the product design and materials used (secondary in lieu of raw materials). This should be done in concert with national or state policy goals and program objectives related to the prevention, reuse and waste management of products in general and taking into account what has been described under point 3 "Financial incentives".

One way forward to stimulate this is through R&D funding programs towards the industry and the academic world. R&D funding programmes and their objectives are the unique responsibility of the country of India or the Indian states.

In Europe, the Horizon 2020 programme for example pursued its objective through three distinct, yet mutually reinforcing, priorities, each containing a set of specific objectives: Priority "Excellent science', Priority "Industrial leadership" and Priority "Societal challenges'.

In the latter, funding is focused on the following specific objectives:

- Health, demographic change and well-being;
- Food security, sustainable agriculture, marine and maritime research, and the bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, resource efficiency and raw materials;
- Inclusive, innovative and secure societies.

Most of the R&D funding in Europe related to recycling and waste management for any product or industry are under the scope of number e) "Climate action, resource efficiency and raw materials". This could also be foreseen for India.

The liability towards the funding is mostly 50% by the private industry and 50% by the European Union, except for non-for-profit organizations, which benefit from a 100% funding.

### 9. Encourage competition in the waste management sector.

Competition is necessary to control waste treatment costs. Lack of competition can lead to high costs for collection, sorting and treatment. This becomes a problem when a firm must negotiate removal, sorting and treatment of its collected products. Without appropriate competition, there is the potential for a producer to be placed at an unfair advantage with respect to the costs it is required to pay for the removal, sorting and treatment of post-consumer wastes.

The establishment of an EPR program will have an impact on the size and structure of the industry that is involved in the collection, recovery and disposal of the products in question. Some products and materials already have market-driven recovery operations before EPR is instituted (e.g. glass recycling or car scrappers). Other products and materials would have been primarily the responsibility of municipal authorities prior to any EPR system. Products such as PV modules constitute currently in Indian of a virgin market where local and voluntarily initiatives exist but nothing is structured. The industrial structure of these businesses will change when an EPR program is introduced, and policymakers need to be aware of some potential competition issues that may arise as a consequence.

**a) Waste Collection services**

As the recycling and waste treatment industry grows in size, partly driven by EPR and recycling policies, it is not surprising that more investment would be attracted to this sector and larger companies would emerge to reap economies of scale. The important point from a competition point of view is that producers and consumers would get better value for their EPR money if the process for awarding the collection contracts are open, competitive and fair. If the large collectors start charging excessively high prices, then smaller companies should have the opportunity to undercut them. The longer the contract term, the less opportunity there is for exposing the collection part of the chain to competitive forces. Once again, competition for the market rather than in the market should still generate competitive outcomes.

There have been examples reported of municipal authorities and/or existing contractors having received preferential treatment or being shielded from competitive tendering pressures - largely in the context of PROs having to set up EPR systems in very short time frames to meet regulatory deadlines. This meant they were in a weak bargaining situation vis-a-vis existing municipal or private collecting businesses.

Indian EPR policymakers should therefore consider that providing adequate time frames for phasing in EPR requirements will allow for more competitive, cost effective arrangements to be made by PRO's with their collection contractors. However, policymakers may also not be surprised if only one or a few collection contractors are willing to invest in collecting (very) low amount of discarded PV modules because this is today the main challenge in Europe and across the globe: there are no PV modules waste in that sense that in general the collection contractors are not attracted by the very low number of shipments and tonnes. A waste collector prefers guaranteed daily or weekly collection services instead of the unpredictable collection request today for PV modules.

**b) Concentration of recyclable/secondary materials markets**

The risk of concentration of one PRO buying and selling collected PV modules is very low in the start-up phase because:

The very low amount of PV modules waste generated;

- The specifications and the composition of a PV module: in weight 80-85% flat glass, 10% aluminium, 5% other metals and plastics encapsulated in a laminated product.

  Not an attractive appetizer for recyclers and waste treatment companies.

- Reuse might ease this pain, however there is no clear framework to define under which conditions a PV module – irrespective the technology – is a reusable

- product and there is no guarantee that each brand of the PV module manufacturers allows "reuse" of their electro-technical and semi-conductor products.

Therefore, and based upon the experience of PV CYCLE, we are not afraid that one PRO will generate a concentrated or monopolist market condition. The situation will rather be if the PRO will find one or more suppliers at a reasonable price in India.

**c) The Waste Pickers**

In India, the informal economy by the waste pickers plays an important role in decentralized waste management, composting, paper recycling, waste water treatment, biogas and afforestation.

When setting a take-back program for PV modules and other products of PV Systems, the PRO shall need to analyse if and how waste pickers can or cannot be inserted within the waste management of waste generated from PV Systems.

### 10. Boost consumer participation.

EPR programs for household waste (e.g. packaging, glass bottles, Household WEEE and batteries) strongly depend on consumer participation. Environmental awareness and information dissemination are vital components of any EPR program. Consumer convenience, in terms of easy access to collection and recycling centres, is an imperative (e.g. through well-placed receptacles, kerbside collection, etc.). Barriers to consumer participation should be minimized.

Consumer or - in this case of PV modules – rather owners of PV modules and PV systems or electricity generators choices over which PV module to buy or how to dispose of, are critical factors to consider when designing an EPR program.

A communication plan, developed together with stakeholders, will help to inform the purchasers of PV modules and PV systems of their roles and responsibilities under the program. A well-conceived communication plan can help improve the owners of PV systems' understanding and appreciation of the benefits of EPR and what is expected of them.

This can install a key sense of responsibility and increase environmental awareness. Maintaining active communication with the PV system owners by releasing data and information (e.g. annual report, newsletter) about the program and its accomplishments, or by informing them of what they can do to contribute to the program through the PV value chain (installers, whole sales and utilities), helps keep the owner of a PV system engaged.

Effective business-to-business communication which ends up at the owners of PV systems (residential, commercial, utilities and large-scale) can provide subsidiary benefits deriving from peer pressure to comply with the program (e.g. returning products or placing them in the proper bin). Lack of a consistent or systematic communication plan can jeopardize the operation of the EPR program.

Roles and functions of installers (and EPC Contractors) need clearly to be defined because their strategic position in the PV value chain can influence the operation of EPR programs. The installer can be the one who takes back the product (new for old or like product returns), collects the charges or fees, or selects the PV modules in his warehouse or business. The installer can be a vital component in an information dissemination strategy as they can furnish owners of PV systems with information about the EPR programme, the PV modules, and their role.

### 11. Use life cycle analysis.

Life cycle analysis can help increase the acceptance of a program and lead to products' environmental optimisation.

However, take into account the comment under point 3. b) above.

### 12. Establish monitoring systems.

Exerting pressure to meet targets through compliance monitoring is necessary in order to realize the desired benefits. The experience in Germany is that there are limited results when no monitoring mechanism exists. This was demonstrated in cases of purely voluntary programs.

Governments and industry should cooperate to establish effective, adequately-resourced monitoring systems; in some circumstances, they may consider establishing an independent monitoring body financed by the industries involved in EPR.

### 13. Take into account the operational waste management infrastructure.

This is of basic importance when designing an EPR program. Often the municipality has a system that could continue operating and carrying out the additional functions (funded through the EPR program). Similarly, the EPR program should not hinder the operation of efficient recycling programs.

### 14. Ensure dialogue among stakeholders.

In order to clearly define the main objectives of EPR and the systems in place and to delineate sufficiently the roles and responsibilities of key stakeholders, a specific dialogue mechanism must be established which shall result in contentious relationships among stakeholders.

### 15. Implement measures to enhance environmental effectiveness.

Target setting is an approach to enhance the effectiveness of EPR's. The establishment of binding targets should be informed by an assessment of costs and benefits as well as consultation with stakeholders.

Environmental effectiveness of EPR systems could also be enhanced by better enforcement. In some EU Member States enforcement capacity is lacking and unauthorized facilities and collection points are in operation. Inadequate enforcement can undermine not only the effectiveness but also the financial viability of EPR/PRO systems. It also fosters the export of hazardous waste.

### 16. Ensure strong transparency.

The governance of EPR systems require transparency. This shall provide a more effective means for assessing their performance and holding them accountable for their activities. Presenting technical and financial data is in this perspective important. The reasons for the shortcoming of this, vary among EPR's but may be due to unclear reporting requirements, the commercial sensitivity of some information, and/or anti- competitive behaviour on the part of the Producers concerned. The European Commission suggests that, at a minimum, EPR systems/ PROs should be obliged to provide information on:

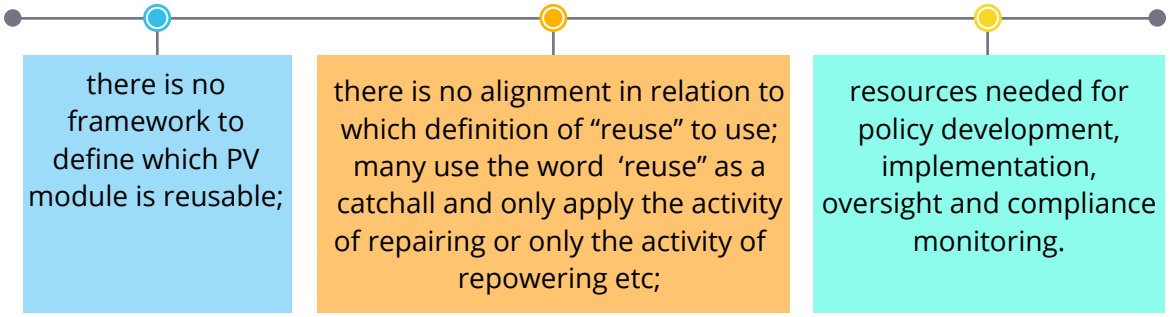
- their fees;
- the amount of products put on the market by their members;
- the amount of waste collected and treated (reused, recycled, recovered (including energy recovery) and disposed of), so that the final destination of all collected waste is identified.

Mandatory EPR systems should be required to report regularly on the technical and financial aspects of their operations; their performance should be regularly audited, preferably independently; to the extent possible, definitions and reporting modalities for EPR systems

operating in the same jurisdiction should be harmonized, and a means for checking the quality and comparability of data established; voluntary EPR systems should be encouraged to be as transparent as possible and periodically to undergo independent evaluations of their operations.

### 17. Define a clear framework for possibility of reuse.

In the area of "reuse" of PV modules, there is no experience in Europe. There is a limited number of companies claiming to reuse, repurpose, repair, repower PV modules but the main points are the following:




PV CYCLE BELGIUM has contracted a consultant for a Study related to the item "reuse of PV modules". The study has been requested by the Belgian authorities as part of the Environmental Agreement, PV CYCLE BELGIUM has concluded with the public Belgian waste authorities.

The scope of the Reuse Study is a feasibility study regarding re-use of PV modules to evaluate the options of re-use of PV modules. The different options are analysed on an economical, an environmental, a technical and a social perspective. The countries under the scope of this study are Belgium, Germany, France, Italy, the Netherlands and United Kingdom.

The study shall provide regional or national authorities an independent and solid answer towards their request about Reuse.

Even though the Study has not been finalized, we share with you – confidentially – an extract of the summary of the study. In this study the waste classification, end-of-waste criteria and reuse and repair recommendations are elaborated for the module types with the highest market shares (crystalline silicon (c-Si), cadmium telluride (CdTe) and copper indium diselenide (CI(G)S)).

Major findings are:

- In Europe the national transpositions of the European WEEE directive have to be ap- plied, which may set different rules in the EU member states. This leads to a fragmentation of the collection and recycling in Europe.

- At the decommissioning of a PV Power plant, disassembled PV modules might enter a secondary market as a product; others might enter the waste regime first and will be forwarded to a pre-treatment site where the PV modules are sorted into classes a) repair/reuse, b) recycling.

  In this case the end-of-waste criteria of the European waste framework directive have to be applied to bring the modules back to the product regime. Member States may have passed additional regulations. Exports are in principal covered by the Basel convention. There are hardly any regulations and guidelines for End-of-Waste criteria for PV modules available.

A proposal is presented in this report.

- When a PV power plant is dismantled several percentages of the PV modules still might be intact and can be potentially reused after a quality inspection and some refurbishment. A small market for used modules is already present today. The modules may be used as replacements in other PV installations or exported into other markets.

- The staff involved in the dismantling, collection, transport and waste treatment should be trained regularly to obtain optimum results and minimize resource losses and potential environmental and health risks.

- The documentation of PV systems should give clear advice on dismantling and final treatment supported by web-based information, local authorities and waste treatment service providers. Due to the increasing number of varieties of PV modules on the market, the manufacturers should provide information on hazardous materials and safety instructions.

- PV modules should be collected separately and not mixed with other wastes. It is recommended to distinguish at least PV modules made with crystalline silicon cells and thin film cells because they might require different waste treatment processes.

- The components of PV systems should be recycled separately: PV modules, metals, electrical equipment, batteries, cables and mounting materials.

Most PV systems in Europe were installed during the last 6 years, having just passed up to 20% of the expected average lifetime. In the case of any potential early defects, customers may try to claim warranties or guaranties, as long as the contract partner still exists. Insurance companies may be involved to compensate for the repair costs or at least part of it within the agreements of the contracts. The ownership of the PV modules can change in such a case to the insurance company. Therefore, mostly a defective module may be returned to the contract partner, to a service partner of the manufacturer for inspection, repair or to an insurance partner. The PV modules might be repaired and can be resold as replacement PV modules or on the world market as used PV modules. With growing installed PV capacities, the number of such cases may increase as well. Therefore, a small used PV module market has been established already supported e.g. by internet platforms such as www.secondsol.de or www.pvXchange.com. There are also several companies buying used or repaired PV modules for a secondary market,

domestic or abroad. Prior to the remarketing of used PV modules some quality checks have to be made with a focus on electrical safety and power output. Sometimes the products get a new label with new guarantees (in compliance with national laws) and sometimes not at all with all the accompanying risks, also for the original manufacturer or the original brand owner. The refurbished PV modules will have to be sold at a reduced price (e.g. up to 70% of an initial new module price) what is limiting the efforts for inspection and repair for cost reasons. Typical repair work is applying a new frame, a new junction box, a diode replacement, new plugs and sockets etc. Even solar cell replacements and re-lamination may take place in some cases.

The reuse market of PV modules is hardly documented, but reuse and export of the PV modules to other countries (e.g. Africa, Pakistan, Afghanistan, etc.) takes place by manufacturer takeback and by some decommissioning or companies which claim that they "reuse" PV modules.

There are no repair and quality standards for second-hand PV modules yet.

Two cases can be distinguished:

1. The module shall be sold as a used product

2. The module was collected as waste and has to become a product again.

In both cases the product should at least be fully functional or proved to be functional. A visual inspection and cleaning should be carried out and an IV-curve should be recorded. For product and electrical safety reasons a ground continuity and an electrical isolation test should be performed and the system voltage of future applications limited according to the test results. The results shall be documented and a new label with the results should be placed on the back of the module. A warranty of 6 months or 12 months should be foreseen at minimum.

In case 1, the used PV module is still a product and can be sold as a product.

In case 2, the PV module is considered to be waste and the waste legislation applies. The company claiming to be able to "prepare PV modules for reuse" must proof that the waste PV module can become a "reused" product again by adequate quality testing and documentation. Important end-of-waste criteria as set e.g. by the European Waste Framework Directive are (non-exhaustive):

- The module is functional;
- Quality inspection documents can be shown;
- A market and a price exist for the module. A purchase contract can be shown;
- It is packed like a product.

The exact number on how many PV modules can be “prepared for reuse” depend on the history of the PV module and the detected damages.

The biggest issue today is that there are no special standards for End-of-Waste criteria for PV modules, nor for the tests a “prepared for reuse PV module” must undergo before it is fit again for sales as a second-hand PV module and there is no inspection from the authorities on this currently small market which operates in general in a grey area.

An example of an Inspection operation in Italy in January 2020 under the name “Black Sun” and which has been reported by local media of the region of Umbria.

The reports noted that the Prosecutor responsible for the Anti-mafia together with the Police estimated that the scam of the reused PV modules generated around €40 million EUR.

Italian media reported seven arrests have been made after an investigation which already started at the end of 2016 whereby a huge number of PV modules were classified as “recycled and treated as waste” whilst in reality the PV modules were sold to some unspecified African countries, Pakistan and Afghanistan.

Several treatment plants active in treating PV modules have been closed by the Prosecutor and are still closed today.

The reports also state that around about 3,000 metric tonnes of PV modules had been seized in the raids by the police.


Therefore, we recommend to first define a clear framework in order that each potential operator knows upfront when and how a PV module can be “prepared for reuse” and under which conditions such a “prepared for reuse PV module” can be sold again as a second-hand PV module.

CHAPTER 05

# CONCLUSIONS AND RECOMMENDATIONS

## Key recommendations

**Short-term (2020-2025) recommendations:**

- Impose an immediate landfill ban for all equipment originating from a PV system;
- Develop a separate piece of Indian legislation for the end-of-life management of PV modules under an EPR approach;
- Allow the Indian PV industry to propose a sustainable and long-term solution for PV waste.

**Medium and long-term (2025-2030) recommendations:**

- Develop sustainable product policies for PV modules, inverters and systems, such as Ecodesign and Ecolabel, based on globally recognised standards and a methodology that take into account the full product lifecycle;
- Consider including sustainability criteria in national renewable energy auctions, based on a point-based system, to reward products with the lowest environmental impact;
- Periodically re-assess rules on PV waste recycling to keep pace with the evolution of the sector;
- Set up joint EU-India Horizon 2020 calls for R&D projects on PV recycling technology or innovative equipment.

## 5.1. Regulation framework in the EU and in India – main conclusions

There are important similarities and differences between both regions for waste treatment regulations relevant for waste generated from PV systems.

In both regions, PV modules are considered as "one product, one equipment" – one does not apply a waste law to "components" of an equipment.

Whereas PV modules and inverters are under the scope of the EU WEEE Directive, the Indian E-Waste (Management and Handling) Rules are not applicable to PV modules and inverters because these E-Waste Rules only apply to two categories of electrical and electronic equipment that do not include PV products. In contrast, in the EU there is a so-called "open scope" whereby each electrical and electronic equipment falls under the scope of the WEEE Directive since August 2018.

Both the European WEEE Directive and the Indian E-Waste Rules are based on the Extended Producer Responsibility (EPR) principle, foresee mandatory collection targets and are mainly focused on "consumer electronic waste'.

There are comprehensive Industrial Solid Waste Rules in place in India, but they do not include solar PV within their scope, whilst the European Union has its Waste Framework Directive which settles the basis requirements for each waste type irrespective of Extended Producer Responsibility legislation or other specific legislation which might come on top.

C-si PV modules are not considered as hazardous waste under the Indian Hazardous and Other Waste Rules. While in 2019 MNRE issued a draft blueprint addressing the potential issue of antimony leaching from landfilled solar glass, leaching of antimony from solar glass would occur only in a worst-case end-of-life management scenario in which modules are dumped in an uncontrolled landfill and the solar glass is completely crushed. However, even in this scenario antimony concentration would be significantly below the threshold set by the Hazardous and Other Waste Rules. A ban on landfilling PV modules would virtually eliminate the risk of leaching of antimony and other substances.

Looking at the current policy framework around end-of-life PV products in India, preliminary findings show that the following measures should be explored:

Impose a landfill ban for all equipment originating from a PV system;

Implement a legislative framework for voluntary or mandatory Extended Producer Responsibility for equipment coming from the Renewable Energy Industry whereby the industry proposes through a five-year management plan its objectives and how to achieve these under supervision if the MNRE and/or MOEF.

Create a self-standing EPR legislation for PV modules separately from the E-Waste Rules. As PV technology, which is outside the scope of the E-Waste Rules, will become the cornerstone of the energy transition, it is recommended to set out a separate legislation instead of adapting rules from the E-Waste Rules legislation.

Allow the Indian PV industry to propose a sustainable and long-term solution for the waste generated by a PV system taking into account that PV modules have a very long lifetime and today's generated waste is by far not attractive to enable big industrial waste treatment capacity for PV modules.

The development of such a piece of legislation can supported by the current study taking into economic, technological, social and environmental characteristics of India, including technologies of material recovery, market price of recyclables, collection and recycling business models (deposit systems, subsidy systems etc), recycling fees and cost implications for electricity costs and Indian solar businesses, and an implementation roadmap.

Once this preparatory study has been conducted, a separate piece of Indian legislation for the end-of-life management of PV modules should be developed. The new legislative framework should include in the scope inverters and other PV system components. While it is too early to determine whether inverters and other PV components should be part of the same legislation for PV modules or rather be part of the E-Waste Rules, it will be key to ensure synergies across the different pieces of legislation and to optimise the economic, social and environmental dimensions in waste collection and treatment.

The Indian PV recycling legislation could be inspired by lessons learned in Europe. Therefore, it is important to remember that the European WEEE Directive (similar to its Indian counterpart) is legislation, which was originally established for purely household appliances and consumer electronics. The WEEE legislation is not specifically designed for PV appliances or commercial or industrial electrical and electronic equipment. Therefore, it is recommended to invite first the Indian PV Industry to propose a management plan for the end-of-life phase of their products such as PV modules, inverters and batteries, to allow its assessment by the MNRE and to conclude based upon the accompanying discussions if and how legislative support would benefit for the Indian society.

## 5.2. PV waste scenarios in India – main conclusions

Looking at the PV capacity annually installed in India from 2010 to 2020, it can be noted that the PV market effectively started in 2012, and boomed only in 2017. Compared to current installation levels, the annual PV market is expected to grow significantly across all three scenarios investigated in the study. By 2030, cumulative installed capacity experiences a multi-fold growth across all scenarios. Under the Low and Medium scenarios cumulative capacity reaches 187 and 287 GW respectively, up from 40 GW in 2020. The High scenario capacity reaches 400 GW by 2030, in line with government ambition. Assuming that PV systems installed in 2020-2030 have a lifetime of at least 30 years, any capacity installed during this period will reach the end-of-life stage not before 2050.

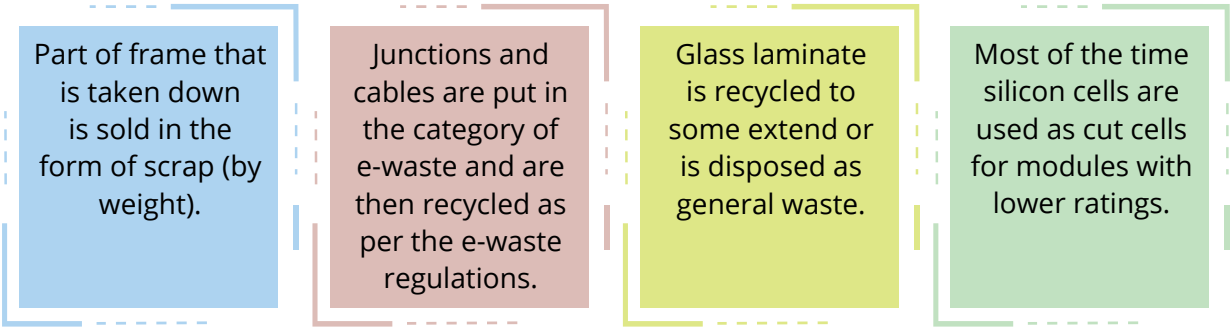
Given that ground-mounted solar constitutes the vast majority of PV capacity, and that the residential segment is only a fraction of rooftop installations, it can be concluded that the greatest bulk of end-of-life PV waste will be deriving from B2B relations.

According to the analysis carried out in the context of this study, by the year 2030 India will generate a cumulative mass of PV module waste of 11 kilo tonnes (kt) in the Low scenario,

21 kt in the Medium scenario, and 34 kt in the High scenario. The waste generated due to the end of life of the PV modules would start accumulating only around after the year 2040 and will become rapidly the most relevant waste source.

## 5.3. PV practices in India – main conclusions

In India there is no policy in respect to dealing with the waste generated by PV modules as they are neither included in e-waste, nor in hazardous waste regulations. Presently the module waste is treated in the following ways: -




In this process approximately 50% of the total material is revived back today from recycling.

The treatment facilities classify the PV module waste (or its components) as hazardous waste or e-waste in India. In general, around 20% of the waste is recovered and the remaining part is treated by TSDFs upon payment of disposal fees. This results in cost implications to the owner or holder of the PV modules waste. A few holders or owners of PV modules waste having their internal environment management system, follow an informal practice to manage the PV modules waste.

However, the fee for dumping and disposing the waste in India is not properly defined and due to the lack of rules and inspection, the PV modules waste have a risk ending up in uncontrolled landfills or in open land.

## 5.4. Possible business models for PV waste management in India – main conclusions

### 1. Preferred approach for PV waste management and possible EPR business models

As described in Chapter 5, compared to a BAU scenario or to an improved BAU scenario whereby a landfill ban is introduced, the authors of this study recommend the Extended Producer Responsibility approach as the best one for the Indian context, as it constitutes the most effective means to perform sound PV waste management. It is advised to implement an EPR law for PV modules which sets the principle of a Producer Responsibility for PV modules and – where required – other products of a PV system, such as inverters and batteries.

Several EPR policy instruments and measures are available to governments to help them meet their stated goals and objectives: product take-back, deposit/refund, advanced disposal fees, product/material taxes, combined upstream tax and subsidy and minimum recycling requirements. Policymakers should review these different instruments to identify which might best meet their particular needs. An instrument's applicability depends on policy goals, or the influence or pressure necessary to reduce environmental impacts of concern. Several types of supportive measures can be used to enhance the effectiveness of an EPR policy. Such measures should be selected in light of the policy goals. Selection criteria can help policymakers select an EPR policy instrument that best suits their needs. These criteria are environmental effectiveness; economic efficiency; political acceptability; administrability (ease of administration); and innovative advancement.

Governments need to select the responsibility model and assign precise responsibilities to both physical and financial responsibility. The level or degree of producer responsibility (full or partial for physical and/or financial activities) for the EPR program is a crucial decisional point in EPR policy design. Decisions on the allocation of responsibility should be made in view of the policy goals, product characteristics, market dynamics, actors in the product chain and resources needed to implement the policy. The national government, state and local authorities, the retailer, the consumer and the final owner of the waste all play important roles under EPR – measures should take into account all these stakeholders. In several cases, a producer responsibility organisation (PRO) could be a useful option for managing and collecting products in lieu of each producer establishing its own separate system.

It is plausible that complete removal of free rider behaviour – the one of actors in an EPR system who do not pay for the benefits they receive – may not generate sufficient environmental benefits to justify the administrative costs to minimize free riders. Policymakers and PROs need to analyse the incentives they create for the various actors operating in an EPR system through different pricing structures and legal liabilities, to ensure (as far as possible) that these are consistent with the ultimate goals and objectives of the EPR program and with overall economic efficiency. Under mandatory EPR programs, government enforcement against free riders may be needed to assure fairness to producers that carry out their EPR responsibilities. Decisions with regard to orphan and existing products must be also taken.

Most EPR schemes cover partly or fully the net costs for the management of waste that has been separately collected, as well as administrative, reporting and communication costs relative to the operation of collective schemes. For photovoltaic modules, the administrative costs shall be similar as in each EPR-environment. The challenge is the operational costs, where almost no waste occurs whilst the fixed administrative costs exist. The creation of provisions or funding for future waste management is crucial in order to be able as solar industry to manage the upcoming waste environmentally sound in the (near) future. A draft financing model for an Advanced and Visible Disposal Fee is therefore very recommendable.

## 2. Recommendations for the setting of an EPR system

a. Set up a five-year Management plan. The Plan should define the strategical vision and contain information including prevention, communication, sensitize and financial plans.

b. Do not set any collection target in the first phase of the EPR system. As PV modules are an investment product instead of a consumer product, a collection target can be set later on.

c. Set clear, realistic and appropriate treatment targets. We recommend to recover target of 70%, of which preparation for reuse and recycling of 55%. Material-specific targets are included in paragraph 5.8.

d. There is no single "right" approach. Both voluntary and mandatory approaches have been used in the past.

e. The visible fee approach seems the best fit to the Indian context. It drastically limits free riders, saves the cash of the Producers/Importers and put the financial responsibility on at the Polluter whilst the legal responsibility is and remains at the Producer/Importer.

f. Ensure neutrality to competition. Lifting regulatory barriers to entry will decrease costs.

g. One solution for all photovoltaic modules. All PV modules sold on the Indian market should be within the scope of the EPR, irrespective of the size of the PV system.

h. Promote R&D on product design and material substitution. One way forward to stimulate this is through R&D funding programs towards the industry and the academic world, under the responsibility of the Indian government.

i. Encourage competition in the waste management sector. Lack of competition can lead to high costs for collection, sorting and treatment.

j. Boost consumer participation. A communication plan will help to inform the purchasers of PV modules and PV systems of their roles and responsibilities under the program.

k. Use life cycle analysis. LCA can help increase the acceptance of a program and lead to products' environmental optimisation.

l. Establish monitoring systems. Governments and industry should cooperate to establish an effective, adequately resourced monitoring system, possibly through an independent body

m. Take into account the operational waste management infrastructure. The EPR program should not hinder the operation of existing efficient recycling programs.

n. Ensure dialogue among stakeholders. A specific dialogue mechanism must be established which shall result in contentious relationships among stakeholders.

o. Implement measures to enhance environmental effectiveness. Target setting and proper enforcement are among the approaches to do so.

p. Ensure strong transparency. Mandatory EPR systems should be required to report regularly on the technical and financial aspects of their operations, audits should be regularly conducted, while reporting should be harmonised.

q. Define a clear framework for possibility of reuse. Stakeholders should know upfront when and how a PV module can be "prepared for reuse" and under which conditions such a "prepared for reuse PV module" can be sold again as a second-hand product.

## 3. Proposal for a mechanism of fee calculation

A draft of financing model for an Advanced and Visible Disposal Fee for PV modules is provided below.

The following assumptions are taken into account at the end of the year 2019:

- Managed by an industry-led PRO
- 50% of market share in Year 1
- A 10 GW Market forecast per year for the first five years (2020 – 2024)
- Weight per module of 18 kg
- Average Watt per module of 375 W
- Average transport and treatment costs of 9,825 INR/ton or 115 EUR/t
- Foresee costs for Historical Waste or PV capacity installed until end of 2019: 34 GW
- Return rate of 0,01% + only 80% of total returns
- Waste to collect during Year 1: 1262 tons
- Potential waste installed during Year 1 to return the next 30 years: 227,000 tons (rounded)
- Unknown today: profit of the materials? Which materials?
- Recycling fee: 3.95 INR/piece (0,05 EUR/piece)

The following cost structure is taken into account (in EUR):

1. **Administration (total: 20,022k INR (236,000 EUR))**

    a) Marcom: 6,957k INR (82,000 EUR)

    b) Staff: 8,484 k INR (100,000 EUR)

c) Office

d) Financial

e) Data management and reporting

f) Other

**2. Operations (total):**

a) Transport: 7,635 INR (90 EUR/ton)

Treatment: 2,120 INR (25 EUR/ton) (note: landfill cost in India: 5,344 INR (63 EUR/t)

The following revenues are generated through the advanced and visible recycling fee of 0,0110 INR/W or 3,95 INR/piece (0,00014 EUR/W or 0.05 EUR/piece): 53,704k INR (633k EUR)

Result end of Year 1: 21,125k INR (249k EUR)

Provisions for future costs at the end of the year 2024 for sold PV modules since start of 2020: 5,8%

No provisions for historical waste are yet built up.

## 4. Proposal for the organisational structure

The organizational structure for a collective system which implements and executes the Extended Producer Responsibility could have the following components, represented by two legal entities with their powers and responsibilities.

1) Not for profit association “PRO Circular”

Owners are the PV Companies putting PV modules, inverters and batteries on the Indian market.

- Responsibilities:
  - Define the Strategy
  - Define the Financial plan
  - Define the fee
  - Management financial assets

- Tasks:
    - Communicating and Informing about PV Energy and the Circular Solar Economy of a Take-Back and Recycling Programme for the PV System" waste (modules, inverters, batteries, BOS products);
    - Advisor to the national and State Authorities;

2) Purchase of services through private company "PRO INDIA"

- Responsibility:
    - Executes the strategy and the decisions in the name of, on behalf of and under control of the Management Organization

- Tasks:
    - Purchases the services of collection, shipment and treatment (re-use, recycling and final treatment) in order to achieve a zero-cost service for PRO CIRCULAR.
    - Services for all PV systems, residential and B2B PV Power plant

## 5.5. Key takeaways from stakeholder survey on PV waste management in India

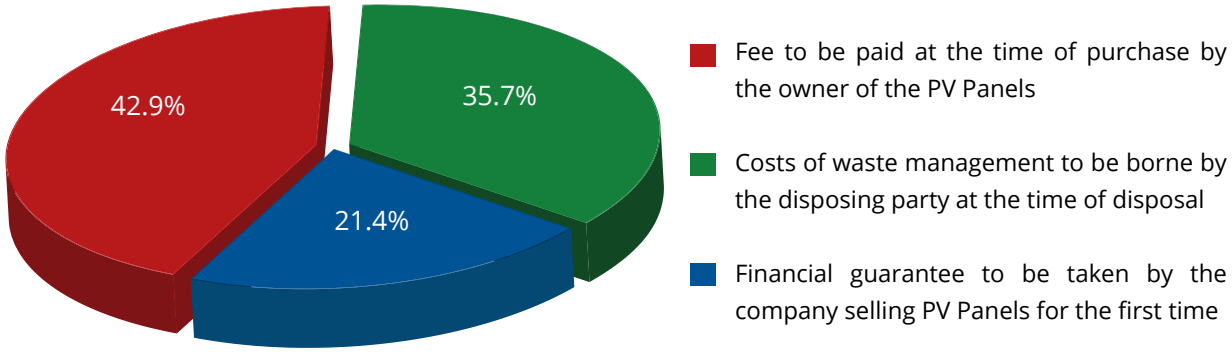
EU India TCP, NSEFI, SolarPower Europe and PV cycle designed a questionnaire to understand the notion of Indian stakeholders (especially manufacturers and developers) on different aspects of PV waste management mechanism. 13 key questions were posed to the stakeholders to seek their inputs. Around 71% of the stakeholders were willing to take the responsibility for the end-of-life phase of PV modules, inverters and batteries sold into the Indian market. Among the manufacturers who participated in this survey almost 80% of them were willing to take this responsibility.

When asked about the ideal method to finance the end-of-life phase of PV modules around 43% of the stakeholders preferred that the Fee to be paid at the time of purchase by the owner of the PV Modules while around 36% of the respondents felt that these costs should be borne by the disposing party(in this case mostly developers) at the time of disposal. The rest of them expressed that they would prefer a financial guarantee to be taken by the manufacturer of PV modules.

**Figure 6 – Response to stakeholder survey – question 1: Who should bear the costs of waste management?**

2) What will be the ideal method to finance the end of-life phase of PV Panesl sold as - for example - from 1 January 2021?

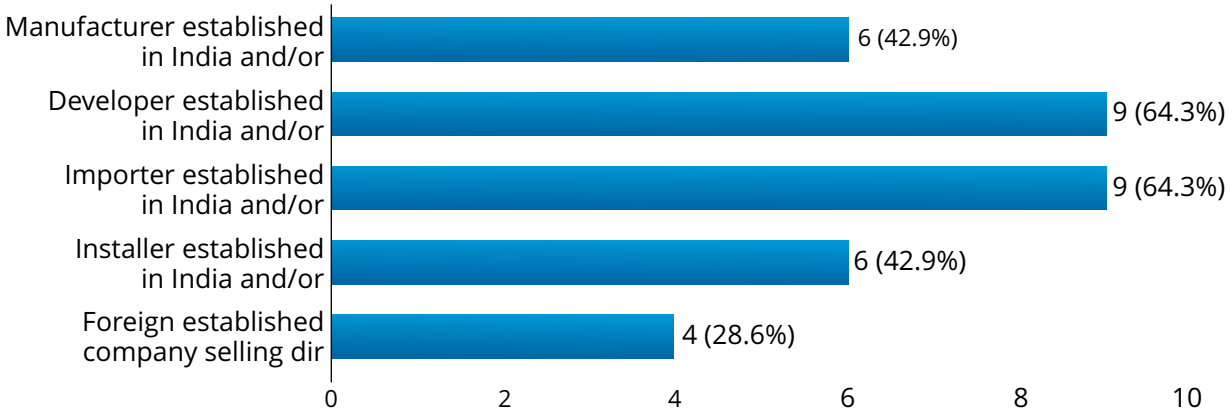
14 responses




Majority of the respondents felt that both the developer and the manufacturer/importer are equally responsible for producer responsibility related to the end-of-life phase of modules in India. A resounding majority of around 93% of the respondents were willing to accept a recycling to be paid by the final customer. 92.9% of the stakeholders agree with setting up a limited fund for future waste management of PV modules sold in India and they recommend this fund as an important solution to address the challenge of the future waste management of PV modules that are already installed in India before 2021 (or before a comprehensive policy evolves) and the same percentage of stakeholders believed a Management Organization steered by the PV industry itself is the best way to handle this fund.

**Figure 7 – Response to stakeholder survey – question 2: Who should be legally responsible for Producer Responsibility related to the end-of-life phase of PV modules sold on the Indian territory?**

3) According to you, who is the legally responsible for Producer Responsibility related to the end-of-life phase of PV Panels sold on the Indian ter...urerestablished in India and selling in India, etc)?



100% of the respondents accepted the notion of a recycling fee which takes into account the level of recyclability of a PV module.

Only half of the stakeholders questioned believed that PV recycling will be profitable in the coming years. Most of them cited the scale, market for the recycled materials, and incentives for recycling, diversity of PV modules and collection cost as the possible reasons of non-profitability.

According to 50% of the stakeholders, the cost of technology in the initial years may be high until an optimum size and efficiency is established and In a country of India's size, transport costs are also significant if materials have to be moved from one corner of the country to another. Until PV dismantling and recycling units are set up in different corners (or hotspots) of the country, it is difficult to bring financial efficiency to the PV recycling model. In the long run, this has a definite potential to be profitable.

Stakeholders expressed that profitability of recycling of PV modules will depend on a lot of different factors. The decommissioning of large-scale PV power systems today offers the possibility for a positive return from salvage values of recovered materials as well as the value of the land, hence the overall business case for high-value recycling according to them is positive. When it comes to the collection and recycling of distributed installations at small scale, the logistic costs for the reverse logistic chain play an important role, as well as the amount of waste becoming available for central processing in treatment facilities. They felt that the economies of scale will most likely improve over the next couple of years and lead to the possibility to also generate a profit from high-value recycling of PV modules. Advance techniques required for dedicated PV recycling facilities focusing on high value recovery and supply chain will play a critical role.

Around 71% of the stakeholders interviewed felt that recycling inverters is economically viable in India while only 35% felt recycling Lithium Ion batteries is viable in India. Imposing Landfill ban and taxes on it along with enforcing stricter Extended Producer Responsibilities are the two main factors the stakeholders felt should be enforced by the government to push the market for a circular economy. Finally, a majority (86%) of the respondents felt that setting targets for a minimum amount of recycled content to be included while manufacturing of new modules will help in realizing recycling goals.

**Figure 8 – Response to stakeholder survey – question 3: What practices of government do you think will push the market for a circular economy?**

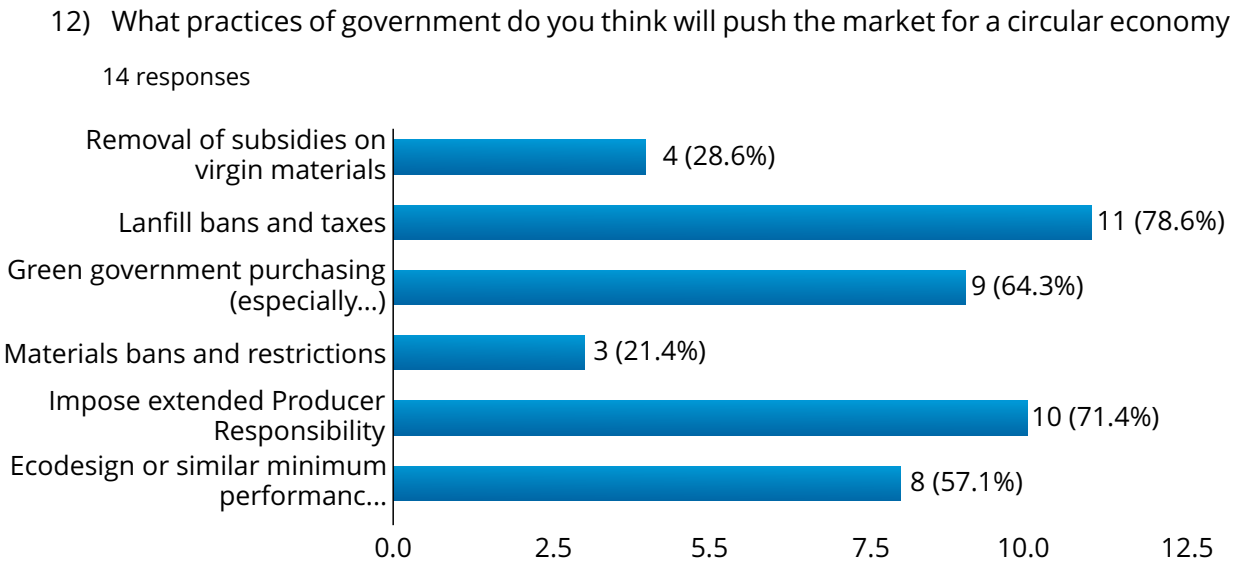
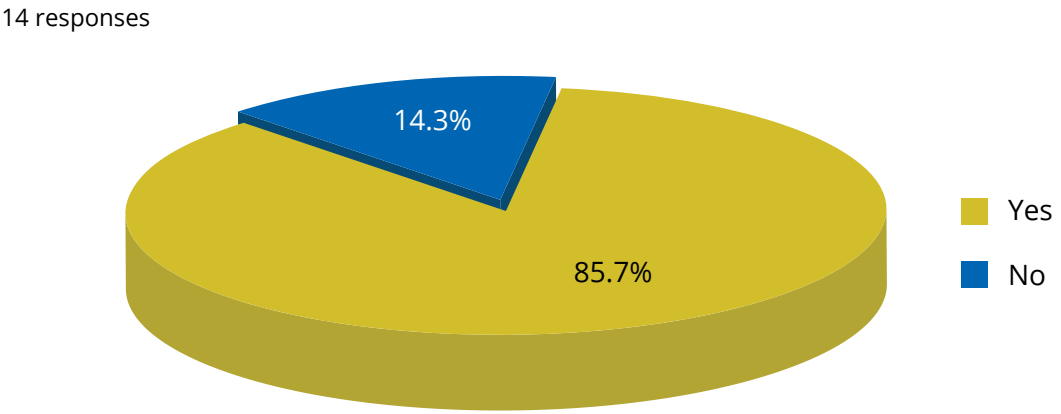



**Figure 9 – Response to stakeholder survey – question 4: Would setting up a standard, i.e., a target of a minimum amount of recycled content to be included while manufacturing of new modules, improve PV waste management in India? (Blue: yes; red: no)**




Overall, from the survey it can be concluded that stakeholders in India are concerned about the PV waste and it's management in the country in coming years and are willing to consider a fee to create a fund which is managed by an industry body to facilitate this process and manage India's PV waste. This report encompasses the measures and strategies that have been proposed or suggested by majority of stakeholders in terms of Landfill ban, EPR enforcement and centralized fund.