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:

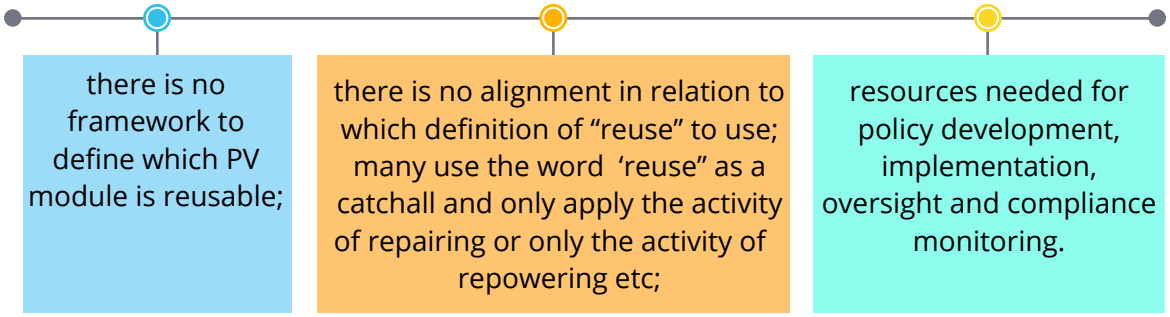
- their fees;
- the amount of products put on the market by their members;
- the amount of waste collected and treated (reused, recycled, recovered (including energy recovery) and disposed of), so that the final destination of all collected waste is identified.

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.