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TRADE AND ENVIRONMENTAL SUSTAINABILITY STRUCTURED DISCUSSIONS

COMMUNICATION FROM THE UNITED KINGDOM

The following communication, dated 23 March 2023, is being circulated at the request of the delegation of the United Kingdom.

BUILDING OUR EVIDENCE BASE AROUND ENVIRONMENTAL GOODS

Technical paper from the United Kingdom

Introduction

TESSD can be used to collaborate on, and develop, a shared evidence base for environmental goods, helping us understand barriers to trade in key technologies that will help achieve environmental objectives – and what can be done about them. Value chain analysis is a good way to explore these questions.

1. The 2022 TESSD work programme proved effective at convening a broad base of WTO members to discuss urgent environmental challenges posed by climate change, pollution and biodiversity loss, and the role that trade plays in combatting them. Environmental goods and services (EGS) remained one of the highest priority areas for members, and various presentations shared through our meetings have shone a light on issues holding back trade, particularly in environmental goods. There is broad support for the idea that moving forward, shared environmental objectives should form the foundation of EGS discussions, with deep dive discussions into the various sectors supporting these objectives.

2. Furthermore, as set out in the World Trade Report 2022, global coordination around government measures will be required to ensure trade and climate policies are mutually supportive and play a full role in helping countries meet their environment objectives.

3. In this context, EGS deep dive discussions in 2023 provide an important opportunity to build a shared understanding of:

    a. which goods will be most important to help us achieve environmental objectives and what services enable them;
    b. what barriers are limiting trade in these goods; and
    c. what steps can be taken to alleviate these barriers.

4. In our view, a powerful way to build up an evidence base is through value chain analyses, identifying and then analysing the full range of goods and services associated with various key technologies. Not only do value chain diagrams provide an accessible way to visualise the link between goods and services, product lifecycles as well as the nature of production and trade, they provide an important launching point for further analysis into relevant barriers to trade.

5. The remainder of this paper is devoted to explaining the concept of value chain analysis and how it can contribute to building the proposed evidence base. The examples we have developed in this paper are focussed on renewable electricity generation[1], aligned with the first proposed deep dive into renewable energy under the objective of climate mitigation. In developing these examples, we have reviewed the extensive literature relating to two types of solar photovoltaic (PV) modules: monocrystalline and multicrystalline.

Climate mitigation, renewable energy, and electricity generation – cases for solar

Solar PV modules will be important in achieving climate mitigation objectives, reducing greenhouse gas emissions and operational costs compared with fossil-fuel based electricity generation.

6. That solar PV modules make a significant positive impact towards meeting environmental objectives is well understood.

7. The **International Renewable Energy Agency (IRENA)** in their report on the Future of Solar PV[2] indicate that scaling up capacity of Solar PV over the next three decades could bring capacity up to 8,519 GW by 2050. Furthermore, they outline that enabling market conditions are essential to prepare the future energy system and that the cost competitiveness of Solar PV drives reductions in system prices. If accompanied by sound policies, the transformation can bring socio-economic benefits associated with greater employment, education, and skills – in short, "unleashing the massive potential of solar PV is crucial to achieve climate targets" (IRENA, 2019, p. 9).

8. The **International Energy Agency (IEA)** have estimated in their roadmap for the global energy sector[3] that distributed solar PV generation, which represents around 40% of the solar PV market in 2050, could be 7,500 TWh by 2050 in their sectoral pathway to Net Zero. They indicate that low-cost renewable energy technologies will make a significant difference in the race to Net Zero, outlining a pathway that calls for scaling up solar rapidly this decade, reading annual additions of 630GW of Solar PV by 2030.

9. **Project drawdown** also documents the impact that solar photovoltaics have according to growth in energy output and avoidance of GHG emissions worldwide:

> *"We assume that distributed solar photovoltaics can grow from 180 terawatt-hours of electricity generation to 6,010.21–9,786.80 terawatt-hours by 2050. This large range is due to the many possibilities for future renewable technologies and the extent of electrification. That growth can avoid 26.65–64.86 gigatons of greenhouse gas emissions."*[4]

10. The **UN Climate Technology Centre and Network (CTCN)** clearly sets out that under the objective of climate mitigation, Solar PV[5] responds to three key needs: diversification of energy sources, cleaner energy sources, and reduced GHG emissions. An indication is also provided of the applications Solar PV is best suited for: areas with high solar irradiation, residential as well as commercial buildings, small off-grid systems, and grid connected systems. Extensive information is also provided regarding the feasibility of the technology and its operational necessities.

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[1] Although the scope of technologies considered in this paper is limited, we are aware of and recognise a wide range of other solar solutions which have not been addressed here. There are similarly a wide variety of other renewable energy technologies that have not been addressed. We are interested in exploring a wider variety of solar solutions in future, but beyond solar we recognise and are interested in exploring several other types of renewable electricity generation that may be of interest to members such as: wind, hydroelectric solutions (of various scales), geothermal solutions, ocean or marine energy solutions, and other nascent technologies.

[2] https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic.

[3] https://www.iea.org/reports/net-zero-by-2050, p. 147.

[4] https://drawdown.org/solutions/distributed-solar-photovoltaics n.b. figures from 2017/2018.

[5] https://www.ctc-n.org/technologies/solar-pv.

11. The **UNIDO ITPO Tokyo STePP platform**[6] describes the major features and advantages of a variety of solar solutions[7,8], which are attributed to the stability of power supply, the effectiveness of solar in many applications, the adaptability in a wider array of climates, and the durability and reliability of solar systems. The platform also includes engineering schematics for these technologies, which can be useful for HS classifiers when evaluating the essential characteristics of solar PV technologies.

12. The **World Intellectual Property Organization's (WIPO) Marketplace for Sustainable technologies**[9] is a large and ambitious resource that can be used to identify opportunities for voluntary technology transfer on mutually agreed terms. In this database, companies holding intellectual property rights for sustainable technology can provide an indication to firms elsewhere in the world regarding the type of commercial relationship under which they would be willing to facilitate voluntary technology transfer. Each entry in the database has also been rated according to its technology readiness level (TRL)[10,11,12,13], a measurement system used to assess the maturity level of a technology, which is widely applicable across all sectors.

13. Reviewing the WIPO resource, a variety of database entries exist for different types and applications of solar PV technologies along with details of the intellectual property owners and benefit descriptions for each solution. A selection of examples from this resource for solar PV technologies can be found in the table in ANNEX II.

14. Reflecting on these frameworks, examples of aspects which could demonstrate the positive environmental impact of a good might include: their effectiveness at achieving environmental outcomes; the nascence of technologies; how easy it is to deploy the solution; the state of commercialisation of the solution; and wider instructive frameworks for qualifying the environmental credentials of goods and services. These impact considerations have been elaborated on in ANNEX III.

15. Having reviewed the case for solar technologies found in these resources, we have developed example value chain diagrams for the production of Solar PV modules. We are conscious that the examples we have used may be incomplete or require correction. **They should be seen as illustrative**. Our intention is to refine the underlying examples and to submit these in due course as substantive contributions to an evidence base. However, we welcome views on the nature of this analysis, how it may be refined and whether others are interested in partnering or conducting similar work.

Value Chain Mapping

Value chain diagrams provide a powerful tool for organising key information relating to goods.

16. Trade has evolved into 'Global value chains' through which the production and distribution of environmental goods and services have spread around the world. Value chain analysis is the *means of describing and evaluating* the activities and products involved in any given value chain for an environmental good.

17. Value chain diagrams visualise and describe a range of manufacturing activities or production processes that are applied to raw material inputs and intermediate products as these are transformed into final goods, that combine to form technological solutions to environmental challenges.

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[6] http://www.unido.or.jp/en/activities/technology_transfer/technology_db/.
[7] http://www.unido.or.jp/en/technology_db/2883/.
[8] http://www.unido.or.jp/en/technology_db/2978/.
[9] https://wipogreen.wipo.int/wipogreen-database/.
[10] Mankins, J.C. (2009). Technology readiness assessments: A retrospective. Acta Astronautica, 65(9-10), 1216-1223.
[11] https://innovolo-group.com/innovation-en/innovation-terminology-en/what-is-a-technology-readiness-level-trl/.
[12] https://www.gov.uk/government/news/guidance-on-technology-readiness-levels.
[13] https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level.

18. We draw a distinction here between supply chain and value chain analyses; the former focusing on *which* firms are trading goods and *where* they are trading them; the latter focusing on precisely *what* is being traded and *how* traded input and intermediate goods are transformed into final goods. We have not calculated the value-added at stages of each value chain in this paper, though this type of analysis could be informed by the value chain diagrams in future.

19. These diagrams describe both goods and services, production and trade. They can therefore serve as a unifying conceptual framework on which we can 'hang' information relevant to environmental goods and services using annotations which speak to various policy challenges. Such diagrams can be used to organise information to improve our collective understanding of trade and production in the relationship between goods and services, and the environment. In this way, they also tie together policy information needed to develop better and more coordinated trade, industrial, and environmental policies.

20. The diagrams shown below are for illustrative purposes only and are not yet finalised. The classifications have not been quality assured and should not be assumed accurate. The codes appearing in these diagrams should *not* be read as a complete 'list of products' as have previously been developed for environmental goods policy.

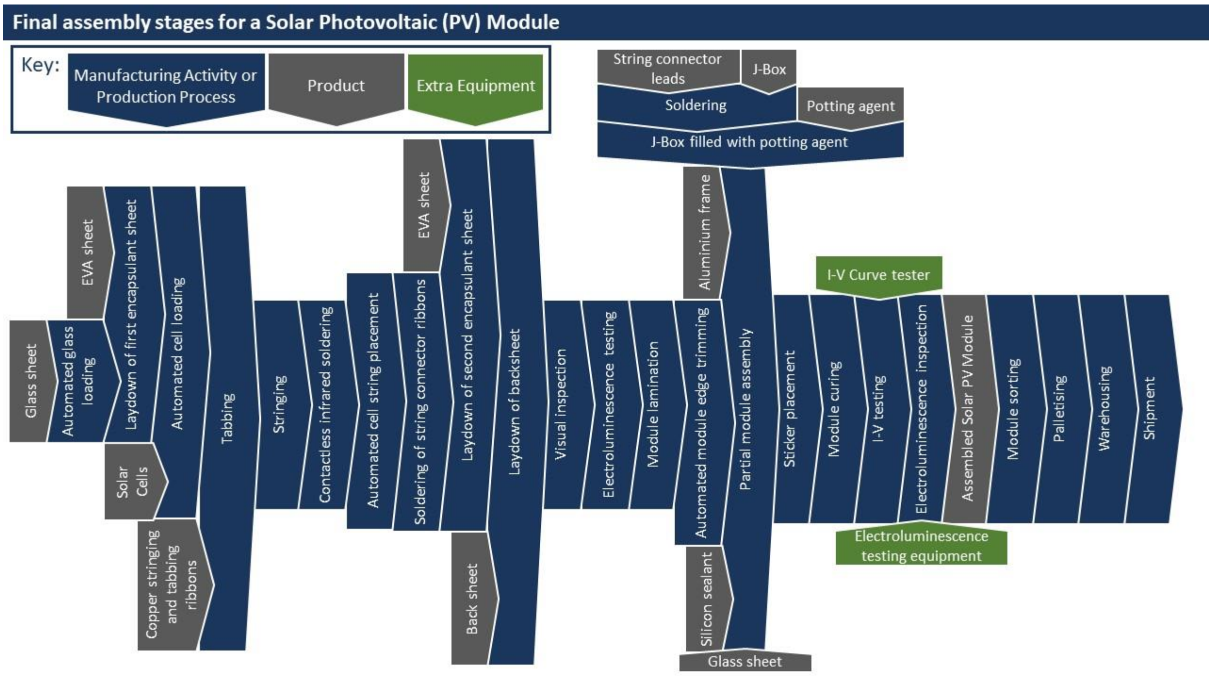


Figure 1: Value chain diagram showing the final assembly stages for a solar PV cell. See ANNEX I.VIII for an enlarged version.

21. We have worked through various publications in the public domain to produce value chain diagrams for the manufacture of solar PV cells, including a report from the US Energy department into the supply chain for photovoltaics.[14] Reports such as these often contain relatively simple explanations or diagrams showcasing the value chain activities that sit behind a certain portion of the supply chain. We have built from these diagrams by reformatting the existing information into the value chain diagram shown in Figure 1 and consulting with academic publications, industry publications, and (where possible) sector experts to incorporate further details.

[14] https://www.energy.gov/eere/solar/solar-photovoltaics-supply-chain-review-report.

Benefits of using value chain diagrams

22. Value chain diagrams organise complex information (often contained in lengthy academic and industry publications) in an accessible way and can be used to visualise a wider set of issues than simple lists of goods historically have contained. Such information can support better decision making around policy intervention and implementation.

23. The elements of a value chain diagram describe the productive capabilities that a country needs to participate in the global value chain for the final good; illustrating these capabilities provides a roadmap for economies on all development pathways. It shows exactly where governments need to support industrial development to participate in the emergent global environmental economy. As a result, trade and industrial policymakers across the world can use these diagrams to assess their national or firm-level productive capability in these technologies and improve their understanding of the relationship between production and the environment. Doing so could then lead to greater participation in the global value chains for the associated environmental goods, or their inputs and intermediate products. Value chain diagrams are not only useful in understanding where countries currently possess relevant productive capabilities in the environmental economy, but also where countries can work towards building capabilities oriented towards improving the environmental compatibility of industrialised production.

24. Value chain diagrams themselves could be used to identify where voluntary and mutually agreed tech transfer is possible and where it will be most valuable. A more developed annotative layer of analysis could seek to explicitly link technologies found in these value chain diagrams with entries in the World Intellectual Property Organisation's (WIPO's) Marketplace for Sustainable Technologies[15], a potential area of future refinement discussed further in ANNEX I.II.

25. Value chain diagrams can also be used as 'skeletons' upon which further relevant information can be added. This could include further information to aid classification. It could also include information on broader environmental impacts across the lifecycle or more specific issues around barriers to trade.

Constraints around value chain diagrams

26. The depth of information about production processes can vary significantly across source publications. For example, we may only have a basic 'assembly' step, rather than a full description for the processes involved in assembly. As further evidence is gathered through expert engagement, we hope to elaborate on these parts of the diagrams to fill in the gaps.

27. Often, the processes represented in these diagrams may not be the only way to do things. Further research may reveal alternative processes which can be captured in future diagrams. Similarly, we are aware that some processes are currently missing entirely from these diagrams. There may be multiple routes to get to the same final product, but there may also be differing final products that utilise the same technology. For example, the predominant type of solar module is the conventional, mature crystalline silicon module, but there are other, more innovative types of solar panels, which are yet to be scaled up but which may share cross-cutting inputs, manufacturing processes, embedded learning and so on.

28. Moreover, we have made no assessment of respective national productive capabilities or participation in different elements or portions of these value chains. We have also not completed analysis of where specialist expertise or equipment may be required or made any assessment of the degree of specialisation required at any stage of each value chain.

[15] https://wipogreen.wipo.int/wipogreen-database/database.

29. These diagrams contain no analysis of the market structures or power dynamics in global value chains[16,17] among participants. Power dynamics can shape the emergence and development of barriers to trade but can also be an influential force in overcoming these. By exploring this in greater depth as we develop our understanding of value chains for environmental goods further, we can proactively identify those dynamics least conducive to environmentally preferable outcomes in trade.

Using value chain diagrams to organise key information

Having illustrated the activities and products involved in the development of environmental technologies, we can add layers of annotations describing various issues relating to trade.

30. As described above, value chain diagrams can be annotated with further information in support of policy decisions relating to goods. Below, we explore a number of areas where hanging additional information can support prioritisation and planning for policy intervention, these cover: classification, links between goods and services, lifecycle considerations and barriers to trade.

Classification annotations

31. Constraints around commodity codes are well understood. The most specific level of goods classification on which all WCO Members are harmonised is at the 6-digit level, at which codes represent broad categories of goods. Only rarely can HS6 codes be used to pin down specific goods which policy makers may wish to target, and they often contain a wide range of goods that are not connected with environmental outcomes. Historically, goods have been identified using HS6 codes and ex outs (more detailed specifications / exclusions) which have then been interpreted at national level to achieve specificity. This often leads to divergences of implementation among members who do or do not maintain national classification systems beneath the HS6 level.

32. Important efforts at HS reform at the WCO have introduced greater harmonisation around specific goods which might be labelled 'environmental' over recent years; efforts which continue as part of the HS27 reform and revision process. But a pre-requisite to the development of HS reform proposals is a detailed understanding of the essential characteristics of environmental goods and how these differ from other products classifiable under a shared subheading. The 'Ex-Out' descriptions found in past lists of environmental goods do not offer sufficient specificity to assess these characteristics.

33. Our starting point for understanding these goods should be the proper identification of relevant commodity codes. In the diagram below, we have sought to capture the most specific commodity codes available within the Combined Nomenclature (CN) system used in the UK and EU, together with CAS numbers[18] where appropriate.[19] The first 6 digits of a CN code is common to all WCO members as an HS6 commodity code.

[16] Dallas, M.P., Ponte, S. and Sturgeon, T.J., 2019. Power in global value chains. *Review of International Political Economy*, *26*(4), pp. 666-694.

[17] Dallas, M.P., Ponte, S. and Sturgeon, T.J., 2017. *A typology of power in global value chains* (pp. 1-35). Frederiksberg, Denmark: Copenhagen Business School, Department of Business and Politics.

[18] https://www.cas.org/support/documentation/chemical-substances/faqs.

[19] Where chemical elements are clearly named, labelled, or otherwise identifiable, they have typically been assigned a CAS Number. The ECICS consultation database can be used to look up the CN codes associated with CAS numbers: https://ec.europa.eu/taxation_customs/dds2/ecics/chemicalsubstance_consultation.jsp?Lang=en.

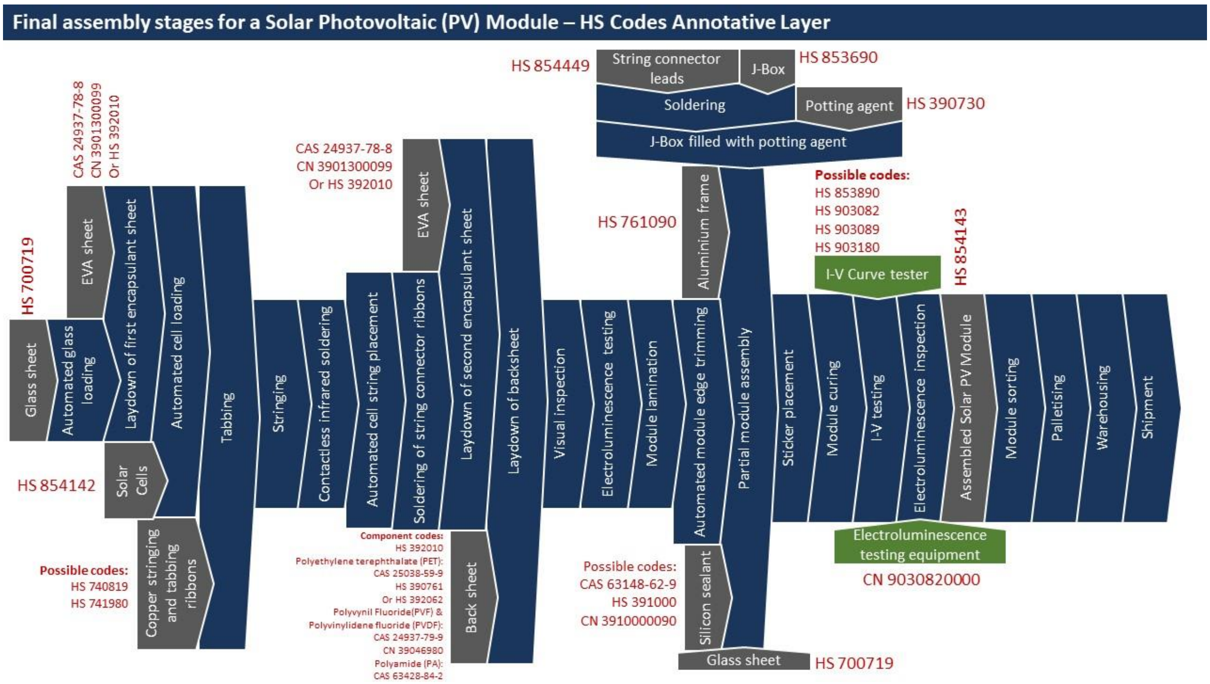


Figure 2: Value chain diagram with commodity code annotations. See ANNEX I.IX for enlarged version.

34. It is important to stress that this is *not* a 'list of environmental goods' to which we envision future provisions might apply. This illustration simply shows how a product which appears on many past lists of environmental goods, i.e. Assembled Solar PV Modules (that have recently been allocated a dedicated HS6 commodity code in the HS2022 nomenclature), can be placed within its full value chain context in a way which links it to input and intermediate products.

35. As described above, these classifications are illustrative. They are based on short descriptions of products and would need further research into product specifics together with more extensive discussions with classification experts to confirm their essential characteristics and place within the nomenclature. For this reason, we welcome active collaboration with the WCO as we develop the evidence base around environmental goods.

36. A collaborative process to identify commodity codes is likely to highlight specific areas where divergences are most marked or problematic, and thus where HS reform may be most suitable. However, it is unlikely that HS reform will isolate all relevant goods, and collaboration between members to harmonise approaches to national classification may become the best approach to simplify trade across key global value chains.

Links between goods and services

37. The separate challenges around goods and services have led to a separation of effort in these areas. However, as reflected in these 'goods and services' working groups, there is a growing recognition of their close relationship to one another. While the question remains open on combining goods and services, value chain diagrams highlight their close relationship. Fundamentally, services are used in the production of goods, goods are used in the delivery of services and services can be used to ensure that environmental benefits are realised in the use of goods (particularly important when dual-use concerns persist).

38. Value chain diagrams already show the combination of processes and goods that form technologies. Some of the processes described in the diagrams can be provided by a value chain participant or by a third-party firm as a service. In addition to annotating value chains with commodity codes, annotating them with CPC codes shows which services might be involved in different stages of the value chain.

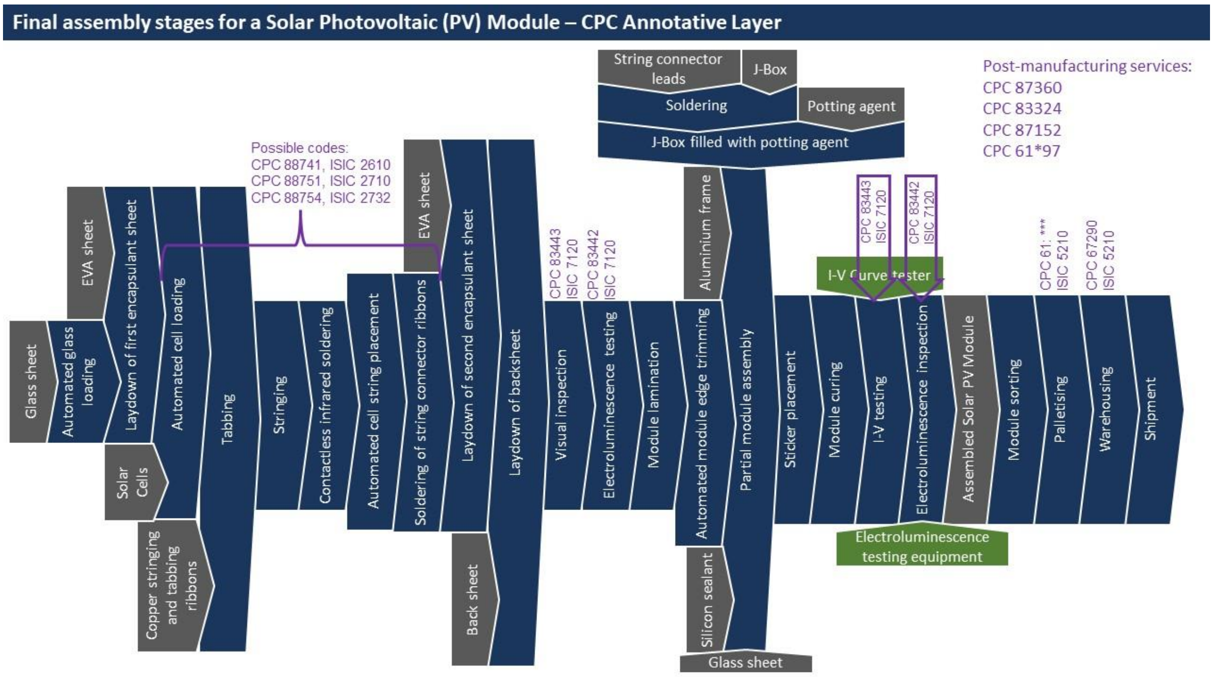


Figure 3: Value chain diagram showing some CPC code annotations.[20] See ANNEX I.X for enlarged version.

39. Services experts note that in general, it is more challenging to list services that specifically contribute to environmental outcomes compared to environmental goods. Much like how HS codes represent *categories* of goods, CPC codes represent a wide array of services. Traditionally, the definition of 'environmental services' has been constrained to the very narrow 'core list' under CPC section 94, covering areas such as sewage, sanitation and refuse disposal services.

40. The classification difficulties for services stem from the breadth of the CPC system compared to the Harmonised System, as well as general difficulties in categorising and tracking services trade. There are therefore more technical challenges associated with dual-use, as noted in the recent WEF paper on accelerating decarbonisation through trade.[21] The available trade data for environmental services is also more limited, making it more difficult to prioritise those of interest according to trade volumes and environmental impacts. Value chain analysis therefore offers an opportunity to explore the processes which sit behind the delivery of an environmental service in greater depth, whilst directly linking them to goods.

Lifecycle considerations

41. Reviewing previous work on potential environmental goods, a disproportionate emphasis is often placed on the end use of goods, with relatively little consideration given to relevant environmental issues around other lifecycle stages. However, it is important that a balanced view should be taken regarding a product's relationship to the environment, covering both benefits *and risks* to the environment.

42. We recognise it is entirely possible, for example, that the processes associated with the extraction of raw materials and production of a good may outweigh the environmental benefits associated with its end-use. It is therefore imperative that we find a meaningful way of accounting for the balance of positive and negative impacts that might arise at different lifecycle stages when describing the relationship between products and the environment. This does not

[20] These are *very* rough and purely illustrative examples. The classifications used here have not been quality assured.

[21] WEF's (2022) paper noted the issues with liberalisation of dual use services, and offers suggestions for possible solutions, including potentially specifying services in more detail than the CPC code. https://www.weforum.org/reports/accelerating-decarbonization-through-trade-in-climate-goods-and-services/.

prevent us from describing how goods can support environmental outcomes. This allows us to scope out opportunities for collaboration to improve the environmental compatibility of different lifecycle stages across the value chain.

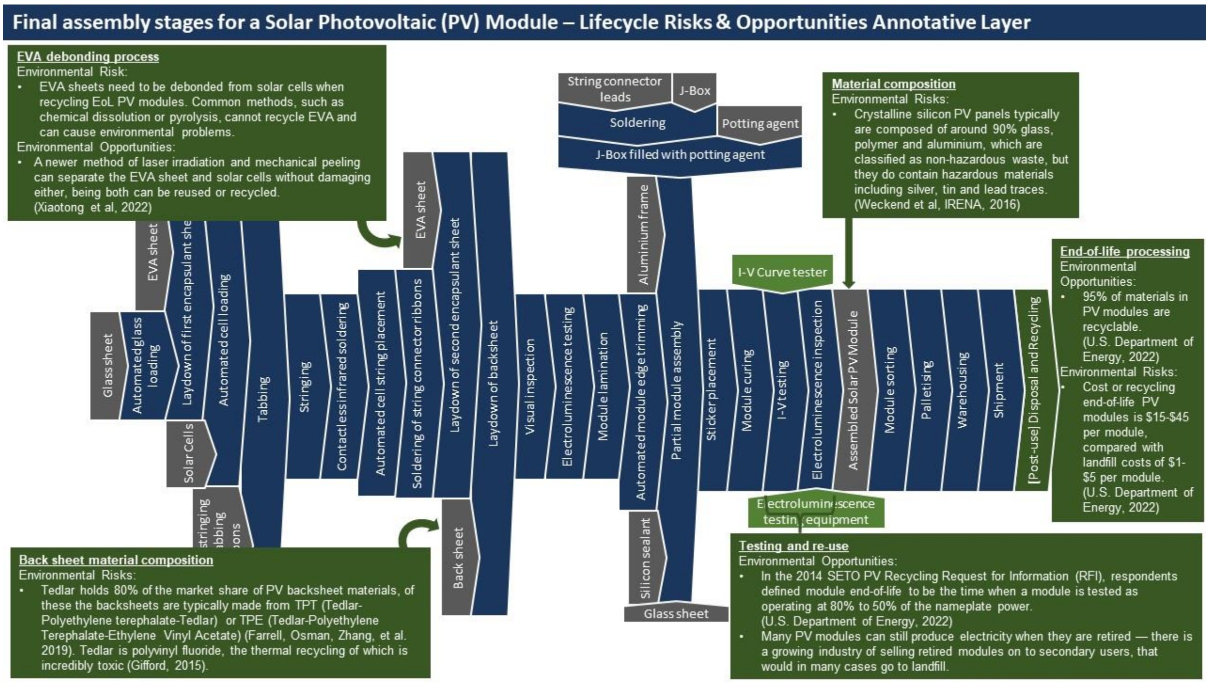


Figure 4:[22] Value chain showing lifecycle considerations. References in footnotes and enlarged diagram in Annex I.XI.

43. Figure 4 shows how a value chain diagram might be annotated to account for both risks and opportunities to environmental outcomes. Here we have reviewed the literature on the relationship between the production of solar PV cells and environmental outcomes. Conclusions on the environmental benefits of solar electricity can be reasonably balanced against the risks of its lifecycle stages. A holistic understanding of the risks can support coordinated efforts to improve the environmental compatibility of production over time using new techniques, such as the new process for using laser irradiation in debonding EVA sheets.

44. By representing a sequence of activities, value chain diagrams often align with the lifecycle of technology. It is therefore possible to annotate lifecycle issues directly onto the value chain diagram, reflecting specifically on:

a. Raw material extraction.
b. Production or manufacturing.
c. Transportation.
d. End-use or consumption.
e. Re-use, recycling, other recovery, disposal, waste prevention & reduction etc.

[22] References from Figure 4: Farrell, C., Osman, A.I., Zhang, X. *et al.* Assessment of the energy recovery potential of waste Photovoltaic (PV) modules. *Sci Rep* 9, 5267, 2019. https://doi.org/10.1038/s41598-019-41762-5; Gifford, J. Recycling the whole module, PV-magazine, 2015. https://www.pv-magazine.com/magazine-archive/recycling-the-whole-module_100018150/; US Department of Energy. Solar Energy Technologies Office Photovoltaics End-of-Life Action Plan. Office of Energy Efficiency & Renewable Energy, US Department of Energy, 2022; Weckend, S., Wade, A., Heath, G. End-of-Life Management Solar Photovoltaic Panels. Irena.org, 2016; https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels; Xiaotong Li, Huan Liu, Jiachuan You, Hongwei Diao, Lei Zhao, Wenjing Wang, Back EVA recycling from c-Si photovoltaic module without damaging solar cell via laser irradiation followed by mechanical peeling, Waste Management, Volume 137, 2022, pp. 312-318, ISSN 0956-053X, https://doi.org/10.1016/j.wasman.2021.11.024.

45. Mapping environmental issues across the lifecycle onto the value chain is a good way to enable alignment between environmental and trade policies. While trade policy can remove barriers to trade, wider environmental policies may be needed to mitigate the risk of an associated potential increase in environmental harm. This can allow more holistic thinking about goods and policy actions we take.

46. There is no agreed methodology for conducting lifecycle analysis, though several frameworks exist.[23,24] However, simply working to annotate issues identified by businesses and other experts across the lifecycle onto value cains can greatly enhance our understanding and enable us to take more holistic decisions, more confidently. Our aim here is not to prescribe an approach to firms regarding how such analysis should be conducted, simply to highlight those risks and opportunities for environmental outcomes across a lifecycle that we can see from a policymakers' perspective. The intention is that these resources can act as a signpost to manufacturers and traders in these goods for how they can align the valuable work they are already doing to improve the environmental compatibility of production with the wider environmental objectives we are pursuing.

47. Ultimately, with appropriate citation and referencing, a list of opportunities and risks at each lifecycle phase need not be any longer than the environmental benefit descriptions found in past environmental goods lists. Indeed, many of the benefit descriptions in past lists already make reference to more than one lifecycle phase, despite their scope often being limited to end-use, so there is a base of evidence for goods in this format which can be built on – taking the value chain approach to describing environmental goods does not mean starting from scratch.

Barriers to trade: Tariffs and Non-Tariff Measures (NTMs)

Technical Barriers to Trade (TBTs): standards and regulation

48. While much previous discussion has been devoted to MFN tariff rates on potential environmental goods, businesses and stakeholders tend to flag non-tariff measures as posing barriers to trade in environmental goods. Indeed, the WTO Secretariat described a wide range of possible NTMs affecting goods trade in their presentation in October 2022. This paper delves briefly into TBTs because of their importance and relevance to the products in question and to build on the UK's presentation on TBTs from July 2022.[25] The research behind the presentation found that TBTs account for 34% of the 89,421 non-tariff measures recorded in UNCTAD's database.[26]

49. When exploring NTMs for environmental goods, it is important to note that regulations and standards are often employed to achieve legitimate domestic policy purposes, including improvements in sustainability and environmental protection. UNCTAD (2021) reports that about 10% of all measures notified under the WTO SPS Agreement and the TBT Agreement cite environmental protection as one of their objectives.[27] Very often international, regional or domestic standards are used as a basis for mandatory technical regulations and conformity assessment procedures which businesses have to meet. Where these don't exist or are not appropriate, countries can use domestic and regional standards.

50. TBTs, as per the WTO TBT Agreement, cover technical regulations, standards and conformity assessment procedures, As a starting point, we can analyse TBTs associated with certain commodity codes for final 'environmental' products/goods. However, this faces challenges associated with classification and risks excluding TBTs which affect production processes, inputs and intermediate products. Identifying how different TBT aspects are relevant to elements of the value chain helps improve our understanding of their impacts at different production stages. This analysis can be performed at the value chain level for each of the areas covered under TBT's.

[23] In 2011, Defra, the Carbon Trust, and the British Standards Institute published the Guide to PAS2050, which explains how to perform lifecycle analysis on goods using five overarching lifecycle phases. This framework built on ISO 14040:2006, which describes the principles for lifecycle assessment and impact assessment, focusing on similar overarching phases.

[24] https://www.iso.org/standard/37456.html.

[25] https://www.wto.org/english/tratop_e/tessd_e/uk_presentation_190722.pdf.

[26] https://trainsonline.unctad.org/home.

[27] UNCTAD (2021), Better Trade for Sustainable Development: The role of voluntary sustainability standards.

We have begun this exercise by exploring which standards might apply across the final assembly stages for a solar PV module in Figure 5.

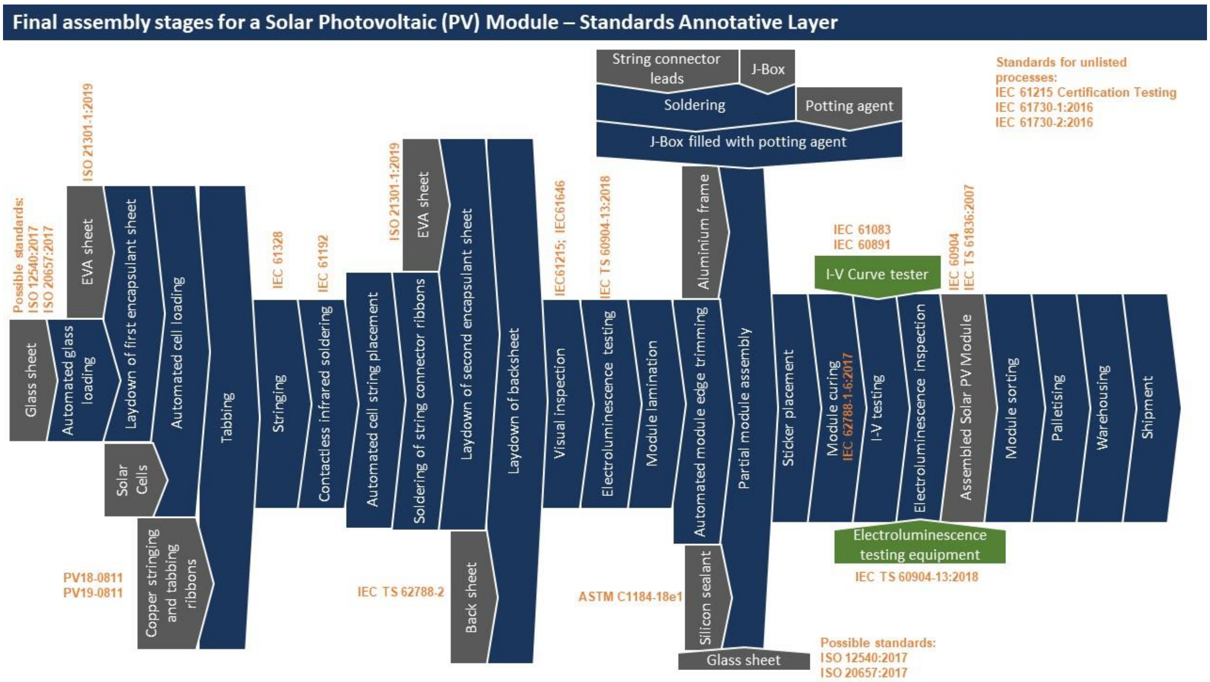


Figure 5: Value chain diagram with standards annotations. See ANNEX I.XII for enlarged version.

Table I: Classification of different types of standards

Classification of Standards	Standard included in Figure 5 annotation	Examples	Nature of Document
International Standards	ISO, IEC	Developed by global standards development organisations (SDOs) such as International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) for countries to adopt for national use	Voluntary
Regional Standards	BS EN	Prepared by a specific region e.g., BS ENs are British standard implementations of English language versions of European standards (ENs)	Voluntary
National Standards		Developed either by a national SDO/body or other accreditation bodies e.g., Bureau of Indian Standards (BIS) for India, Standards Australia for Australia	Voluntary
Industry Standards	PV, ASTM	Criteria developed within an industry relating to the standard functioning and carrying out of operations in their respective fields of production[28] e.g. Photovoltaic Standards (PV) and American Society for Testing and Materials Standards (ASTM)	Voluntary

[28] https://www.directives.doe.gov/terms_definitions/industry-standard#:~:text=A%20set%20of%20criteria%20within,the%20members%20of%20an%20industry.

51. Table I provides detail on the types of standards we have included in the annotation of the value chain diagram (Figure 5), and whilst standards are voluntary, they can become mandatory when used or incorporated in domestic regulation.

52. Figure 5 illustrates several important points simultaneously. Firstly, it documents how standards might apply to or affect a final product by showing where they apply across various production stages. Secondly, it shows that standards which affect the supply of environmental goods, and therefore potentially affect trade, may not always apply directly to the finished product.[29] Thirdly, it reveals where multiple standards could apply to a product or input, giving rise to potential divergence among standards that might apply in different markets.

53. Producers conforming to regulations and standards across the value chain can incur significant compliance costs and technical difficulties understanding which standards to adhere with and where, especially SMEs and producers in developing countries.

54. Working in a value chain format is the first step in understanding and addressing these issues, through a) identifying the relevant international standards so it is more clear what kinds of best practice exist, which is useful for technology transfer, b) encouraging the practice of basing technical regulations on international standards and c) identifying where there is significant divergence in standards and encouraging the development of new standards. The increased alignment and in some cases harmonisation of standards and other regulatory practices will facilitate better quality trade and therefore facilitate better deployment of environmental technologies that have the capacity to reduce carbon emissions.

MFN Tariffs

55. As well documented, efforts over the last 30 years to promote trade in environmental goods have primarily been focused on the reduction of import tariffs.[30] However, the debate regarding tariff reductions on environmental goods requires more nuance. Identifying tariff rates across global value chains helps to identify not only where tariffs may be high on finished goods, but also where tariffs may be high on inputs to production, forming potential bottlenecks. This framework allows us to explore where tariffs exist, why they are in place, whether they ultimately pose a barrier to the uptake of these technologies, and explore more creative solutions to resolve these challenges.

56. The simple average applied MFN tariff rates across G20 and TESSD members for the commodity codes highlighted in Figure 6 have been analysed in Graphs 1-4, compared with an illustrative 5% tariff cap (the tariff cap agreed as part of the APEC environmental goods initiative in 2012). Average tariff rates on final environmental goods are often low, demonstrated by Graph 1 for Assembled PV Modules. Whilst TESSD members maintain low average applied tariffs on some key inputs to the production of these technologies compared to the G20, as shown by Graph 2, higher average tariffs remain on some inputs to the production of these technologies, as shown by Graph 3. Tariffs on inputs to the production of renewable electricity technologies and on components of utility scale renewable electricity generation facilities can directly increase the cost of energy provision.[31,32] Further analysis could replicate the kind of bottleneck analysis conducted by the WTO Secretariat looking at COVID-19 goods during the pandemic.[33]

[29] The codes we have matched to goods should not be seen as definitive, and more investigation will be needed to identify the specifics.

[30] https://www.wto.org/english/tratop_e/tessd_e/secretariat_presentation_experiences_with_egs_promotion.pdf.

[31] Feedback from industry gathered in 2021 highlighted that tariffs can directly affect the calculation of the levelized cost of electricity (LCOE) by adding to capital costs. LCOE can act as a proxy indicator for the total cost of electricity provision.

[32] https://www.marathoncapital.com/news/impact-of-section-201-import-tariffs-on-utility-scale-solar-lcoe.

[33] https://www.wto.org/english/tratop_e/covid19_e/vaccine_inputs_report_e.pdf.

57. In the European Commission's 2014 impact assessment on the Environmental Goods Agreement[34], elimination of tariffs on environmental goods considered as part of the EGA was estimated to, relative to the baseline, reduce global carbon emissions by almost 10 million tonnes by 2030 and prices in these goods by 0.8% on average.[35] There are different examples of how tariff reductions can be achieved. Under the APEC initiative, members agreed to steadily reduce their tariffs to below 5%. Such examples can give inspiration for how we can tackle tariff barriers in the future. Beyond this, there are a variety of flexible options for addressing tariff barriers, particularly where they are creating bottlenecks to the supply of environmental goods.

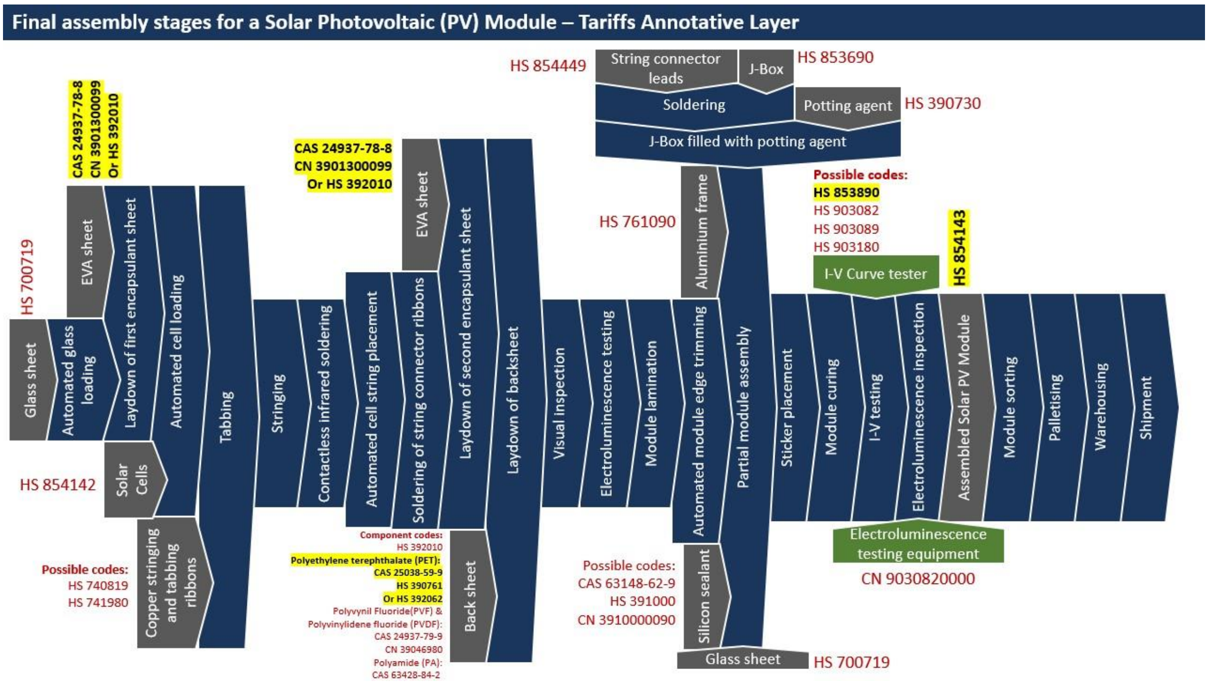
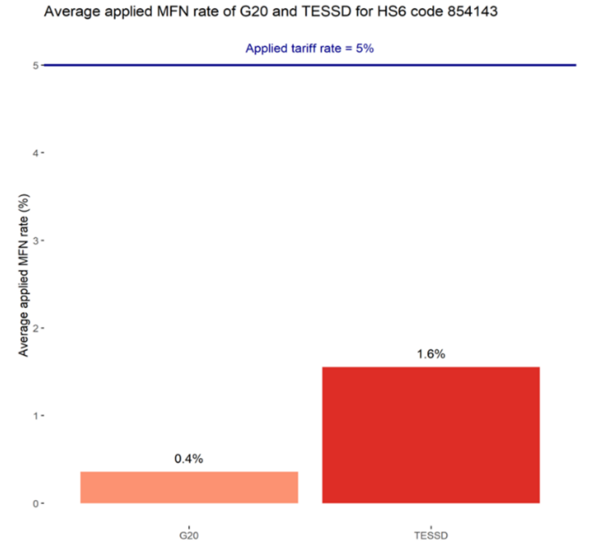


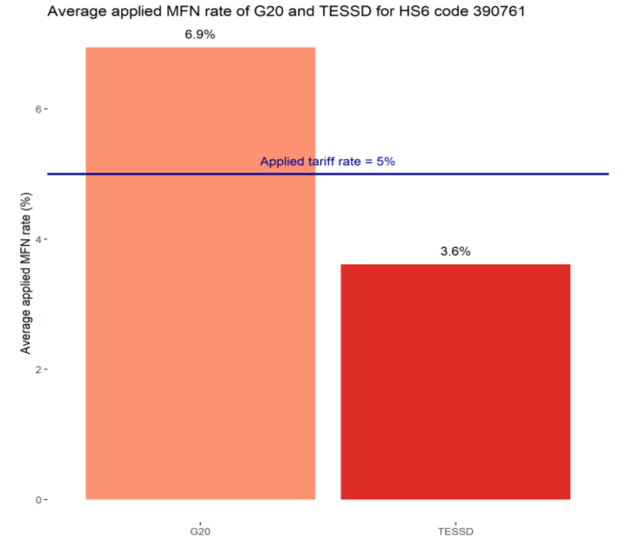
Figure 6: Value chain diagram highlighting simple average tariff rates for G20 and TESSD members studied below.

[34] https://op.europa.eu/en/publication-detail/-/publication/f256d8d8-067c-4f3c-9a21-c3601816c2cf.
[35] The results of the study should be interpreted as relative to the baseline scenario (without EGA) rather than as absolute reductions.

Graph 1: Assembled Solar PV Module

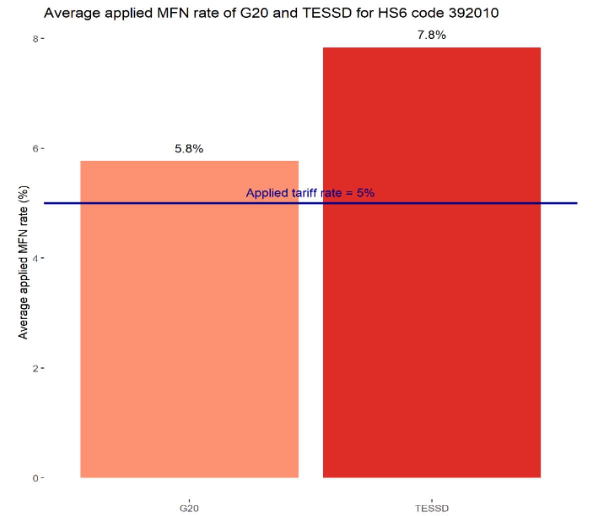


Graph 2: Component of Back Sheet - PET

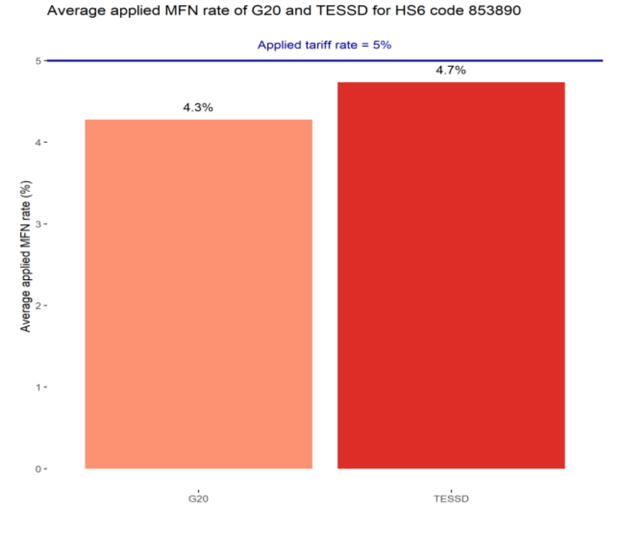


Graph 3: EVA Sheet

s



Graph 4: I-V Curve Tester



Source: Tariff data sourced from ITC MacMap (Market Access Map, International Trade Centre, https://www.macmap.org/) for all countries except UK where tariff data is from national sources.[36]

[36] The latest year available in MacMap for each country was used in the tariff analysis (2021 for the majority of countries but in some cases data has been sourced from earlier years and in rare cases tariff data was missing altogether). Analysis was carried out using HS2017 nomenclature. Where data for individual countries was reported in a different HS nomenclature it was concorded into HS2017. For HS codes that are new in HS2022 we have assumed that the tariff data for the corresponding HS2017 code(s) also applies to the new HS2022 code(s). For example, we have assumed that the average tariff for HS2017 code 854140 applies equally to HS2022 codes 854142 and 854143. For the purposes of the analysis, EU members have been included as one EU group rather than as individual countries due to the EU's Common External Tariff.

Countermeasure tariffs and disputes

58. In addition to MFN tariffs, in some instances goods can be affected by retaliatory tariffs, which are selected both for their trade value and ability to incentivise a country which has breached international agreements or obligations to redress issues which have been subject to trade disputes. The Swedish National Board of Trade[37] has suggested that significant proportions of renewable energy products under discussion as part of the EGA have been subject to retaliatory tariffs arising from trade disputes over the last 20 years.

59. We can annotate the value chains noting those goods which are subject to these additional tariffs and highlighting the specific impact they may have on global value chain participation, and thus on trade.

60. Identifying products subject to such tariffs could lead to greater consideration of environmental issues when selecting products to target and in reviewing them. We note that often, environmental considerations do not feature within criteria used for applying retaliatory tariffs.

Next steps

Working together to build and collate an evidence base around environmental goods

61. The development of an evidence base built upon value chain analysis is an effective way to organise information related to environmental technologies, to support an assessment about the best way to implement policies that promote sustainable trade and increased deployment.

62. As described, the UK will be refining the examples in this paper to be shared in due course. Examples in this paper remain illustrative.

63. We also intend to undertake similar work into other technologies, including those supporting the development and installation of offshore wind turbines. Exploration of other forms of renewable electricity generation, low-carbon electricity generation, transmission and distribution of electricity, and electricity storage could form the basis of future research. We also recognise the importance of expanding the scope of solutions under consideration in future to cover renewable energy more holistically, such as by exploring clean heat technologies, hybrid electricity and heat generation, heat management, and broader energy storage solutions. Future research in the energy sector could also explore sector-specific applications of Carbon Capture, Use and Storage (CCUS), as well as hydrogen production, distribution, and storage.

64. We strongly encourage members to undertake similar work, to help understand the scope of goods and services, barriers to trade, as well as to identify potential policies that support sustainable trade. Alternatively, we encourage members to review the evidence base being brought forward by others.

65. We welcome reflections on the ideas shared in this paper, and welcome engagement from interested members with questions, views or interest in collaboration.

66. Ultimately, the planned TESSD deep dive discussions can be used to present and share research. Such contributions, if well organised through a living report or similar document, can ultimately support discussions between members about actions we can take.

[37] https://www.kommerskollegium.se/globalassets/publikationer/rapporter/2020/trade-barriers-to-goods-and-services-important-for-climate-action_webb.pdf.

ANNEX I – EXAMPLE SOLAR PV MODULE VALUE CHAIN DIAGRAMS

I.I Methodological notes

When contemplating how to approach the development of value chain diagrams, we were inspired by the work of the Advanced Propulsion Centre (APC) to document the value chain associated with hydrogen fuel cells.[1] The contents of our diagrams are based on publicly available sources of information. Our starting point for documenting the different stages of the Solar PV value chain was one report in a series of supply chain deep dive assessments from the US Energy Department into different renewable energy technologies.[2] This report contained process diagrams explaining the intermediate production steps that take place at different points in the supply chain. We converted the contents of this publication into the value chain format found in the APC report and added to this using further desk-based research.

The value chain diagrams we have produced relate to conventional, silicon crystalline solar cells as opposed to other, more innovative cells being developed such as thin-film, BIPV, etc. In future, with further input from experts, traders, and TESSD participants, we would like to expand this analysis to cover other solar solutions as well.

Astute observers may note that the set of value chain diagrams developed here does not yet cover the products or processes entailed in and arising from the safe disposal or recycling of materials at the end of a Solar PV Module's lifecycle. We are aware of some of the work that has been done to explore this lifecycle stage[3,4,5] and wish to incorporate these stages into future value chain diagrams.

I.II Classification notes

The commodity codes in these diagrams have not been verified by classification experts and therefore should be treated as illustrative. Traders should not cite this material as reference for how products should be classified.

Whilst the diagrams themselves assist in answering some classification questions needed to ascertain the essential characteristics of the final product (What components does the product have? What are the raw material inputs?), they do not contain answers to other important classification questions (What does it look like when presented at the border? How is it packaged? Is there any accompanying paperwork which might assist in the identification of the product? etc.). In future, we would like to work directly with traders, experts, and classifiers to seek more accurate classifications for the products appearing in these diagrams.

CAS numbers have been used to support the classification of chemicals and metallurgical materials because we can cross-reference these with the Combined Nomenclature classifications found in the ECICS consultation database.[6] We then use the first six digits of the CN code as the HS code in the diagram – noting that classification divergence is possible among members beneath the HS6 level.

[1] See page 3 of the report: https://www.apcuk.co.uk/automotive-fuel-cell-system-and-hydrogen-tank-value-chains/.

[2] https://www.energy.gov/eere/solar/solar-photovoltaics-supply-chain-review-report.

[3] https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.

[4] Komoto, K. (2014), "Developments on PV Recycling in Japan", *Proceedings 24th European Photovoltaic Solar Energy Conference*, Hamburg.

[5] Komoto, K., Oyama, S., Sato, T. and Uchida, H., 2018, June. Recycling of PV modules and its environmental impacts. In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC) (A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)* (pp. 2590-2593). IEEE.

[6] https://ec.europa.eu/taxation_customs/dds2/ecics/chemicalsubstance_consultation.jsp.

Future improvements under consideration

Diversifying the colours to represent more. Other prototype diagrams we have developed apply a wider selection of colours to these diagrams to indicate the differences between raw materials, worked materials, processed goods, and final goods; processing versus assembly stages; specific technologies; and machinery or tools required in each step.

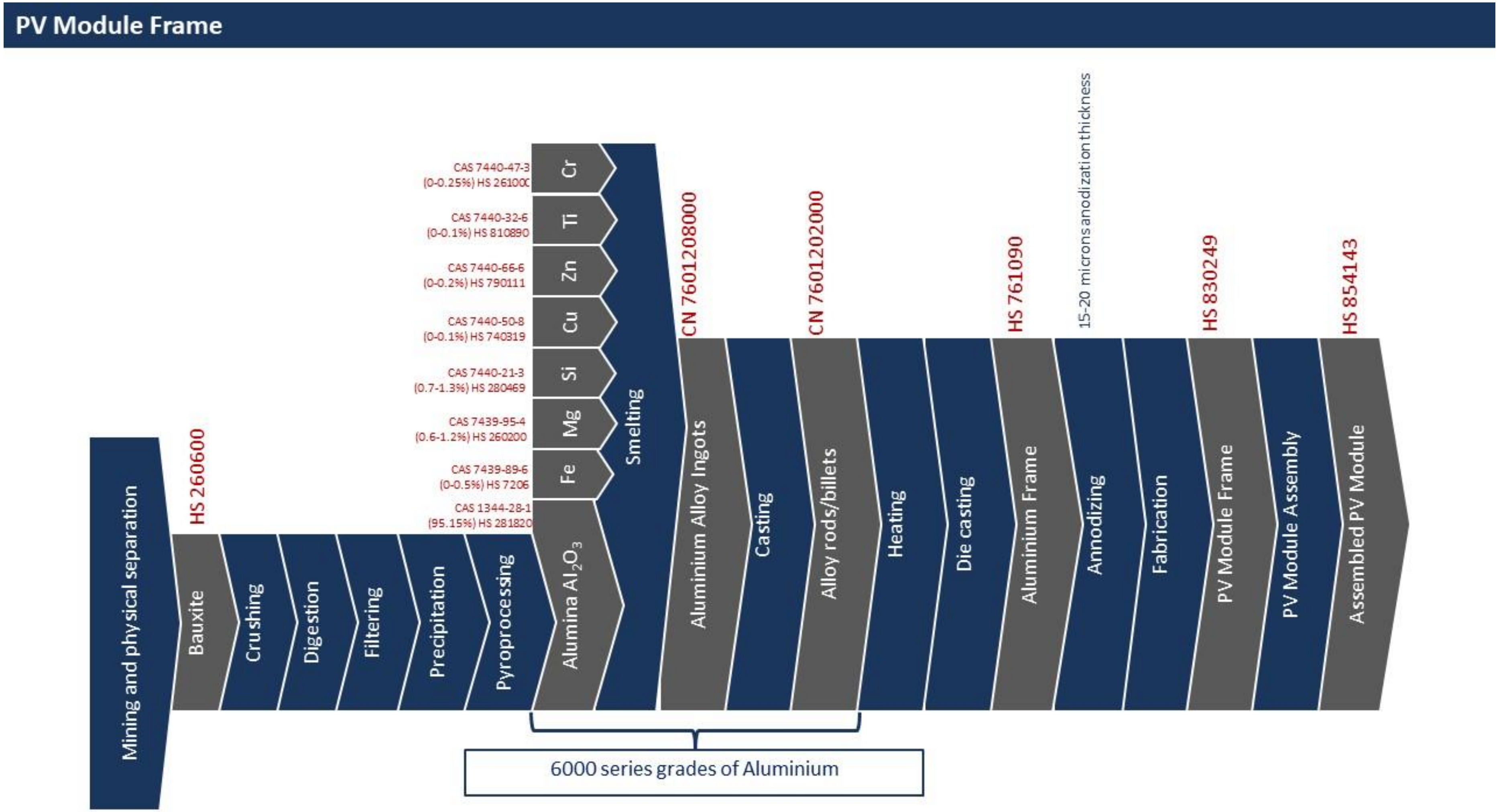
WIPO Green database entries layer. This layer of annotations could show which of the products or technologies appearing on the diagram are available through the marketplace for sustainable technologies. Each product or technology could be annotate with the database ID for the relevant entry. We could also experiment with different colour coding systems for different layers of analysis, such as a shaded risk and opportunities assessment on the lifecycles layer.

*Adding economic metrics***.** This could potentially span multiple new layers. As suggested in the paper, these resources could be used to perform value-added analysis, which could be conducted at the level of entire diagrams, portions of a diagram, or individual products. We might also be able to explore the addition of product complexity indicators[7], Revealed Comparative Advantage (RCA) values for specific economies or groups of economies, and other product-specific economic assessments.

Assessments of National Productive Capabilities. Products and processes appearing in the value chain diagrams could be coloured differently according to where any given country does or does not host firms capable of making or using these. This could be modelled on the value chain analysis contained within the APC's Automotive Batteries Chemical Supply Chain Report[8] (see page 6).

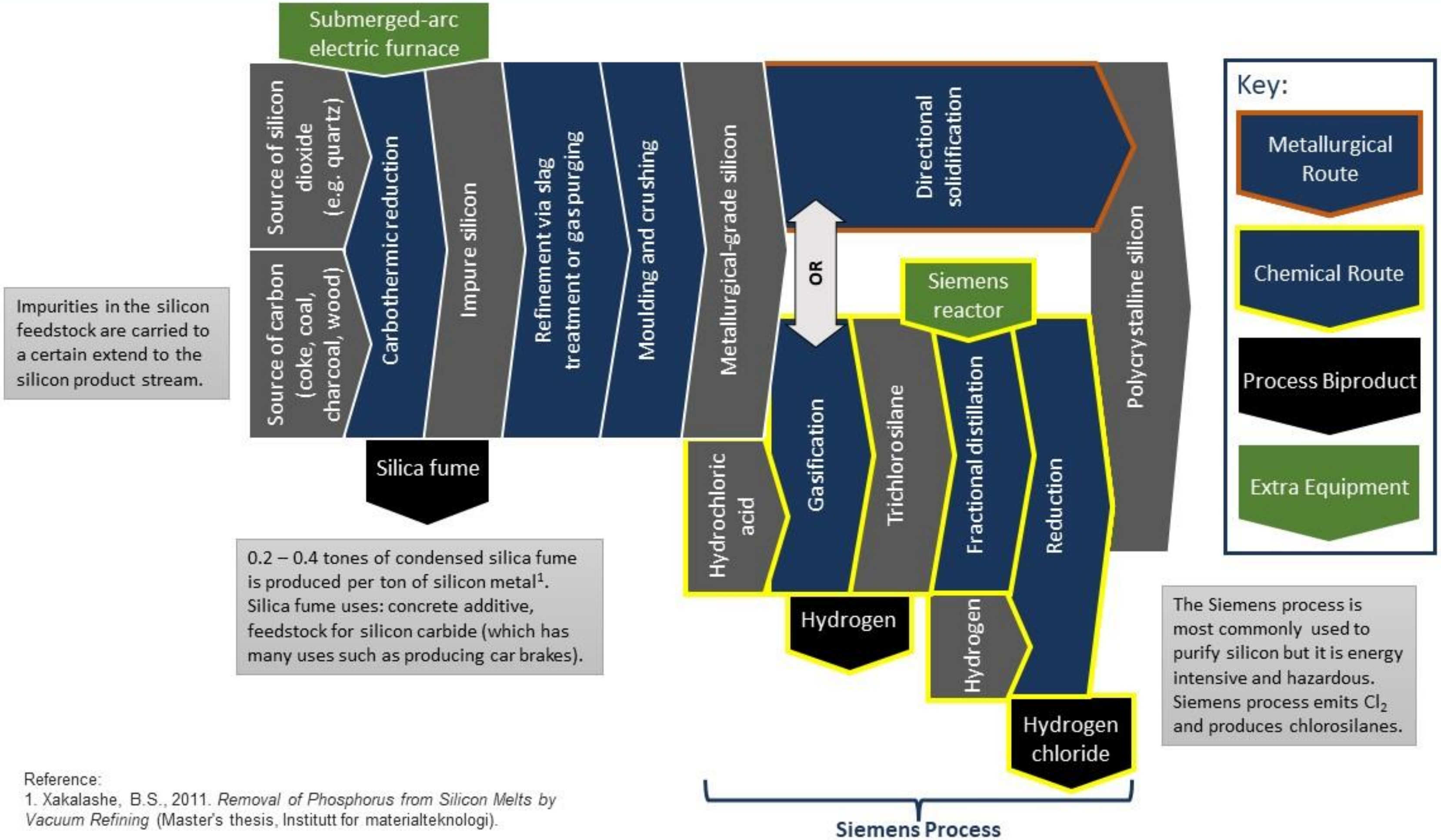
[7] https://atlas.cid.harvard.edu/rankings/product#:~:text=The%20Product%20Complexity%20Index%20(PCI,produce)%20include%20electronics%20and%20chemicals.
[8] https://www.apcuk.co.uk/automotive-battery-chemical-supply-chain-report-summary/.

I.III PV Module Frame

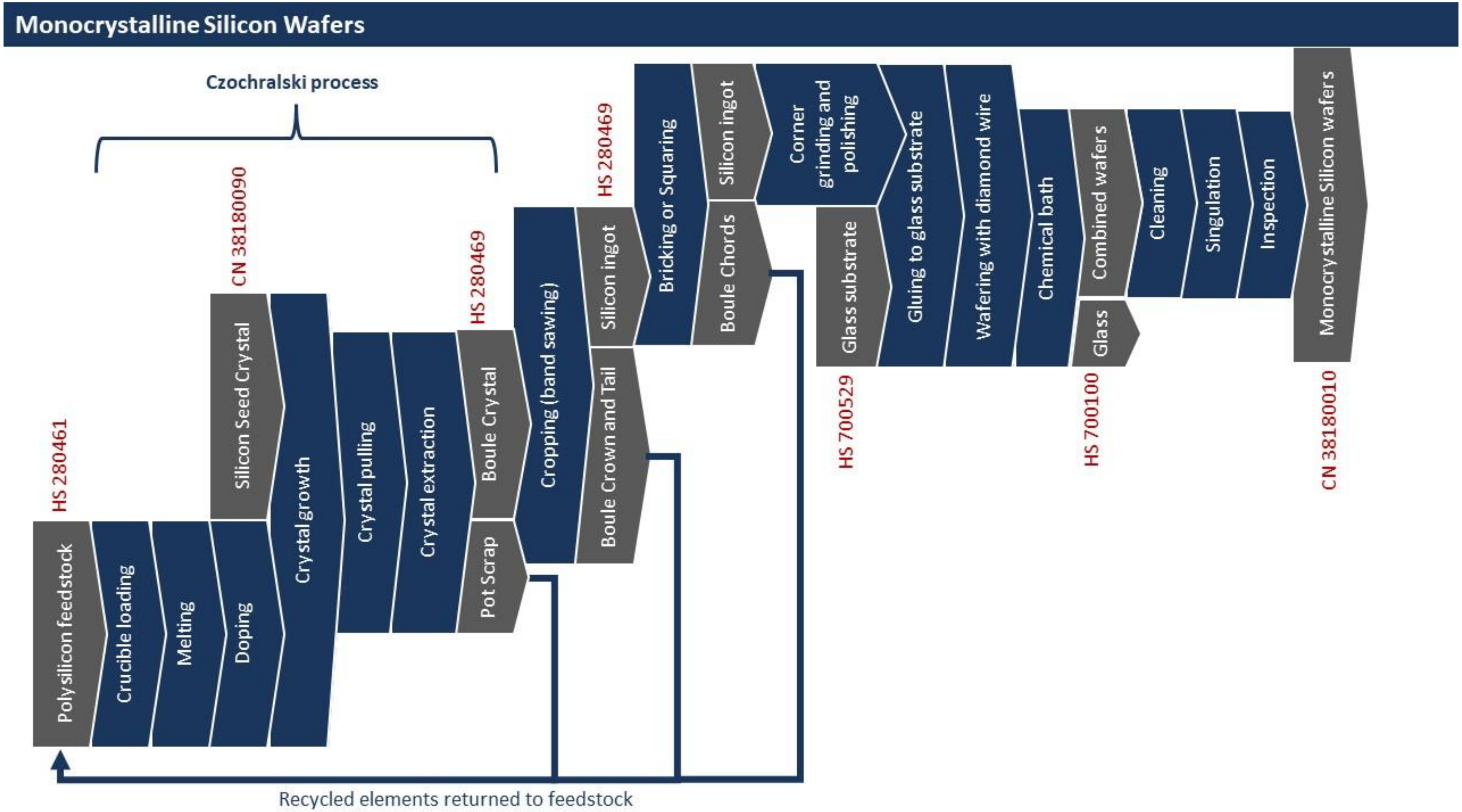


I.IV Raw Silicon Refining

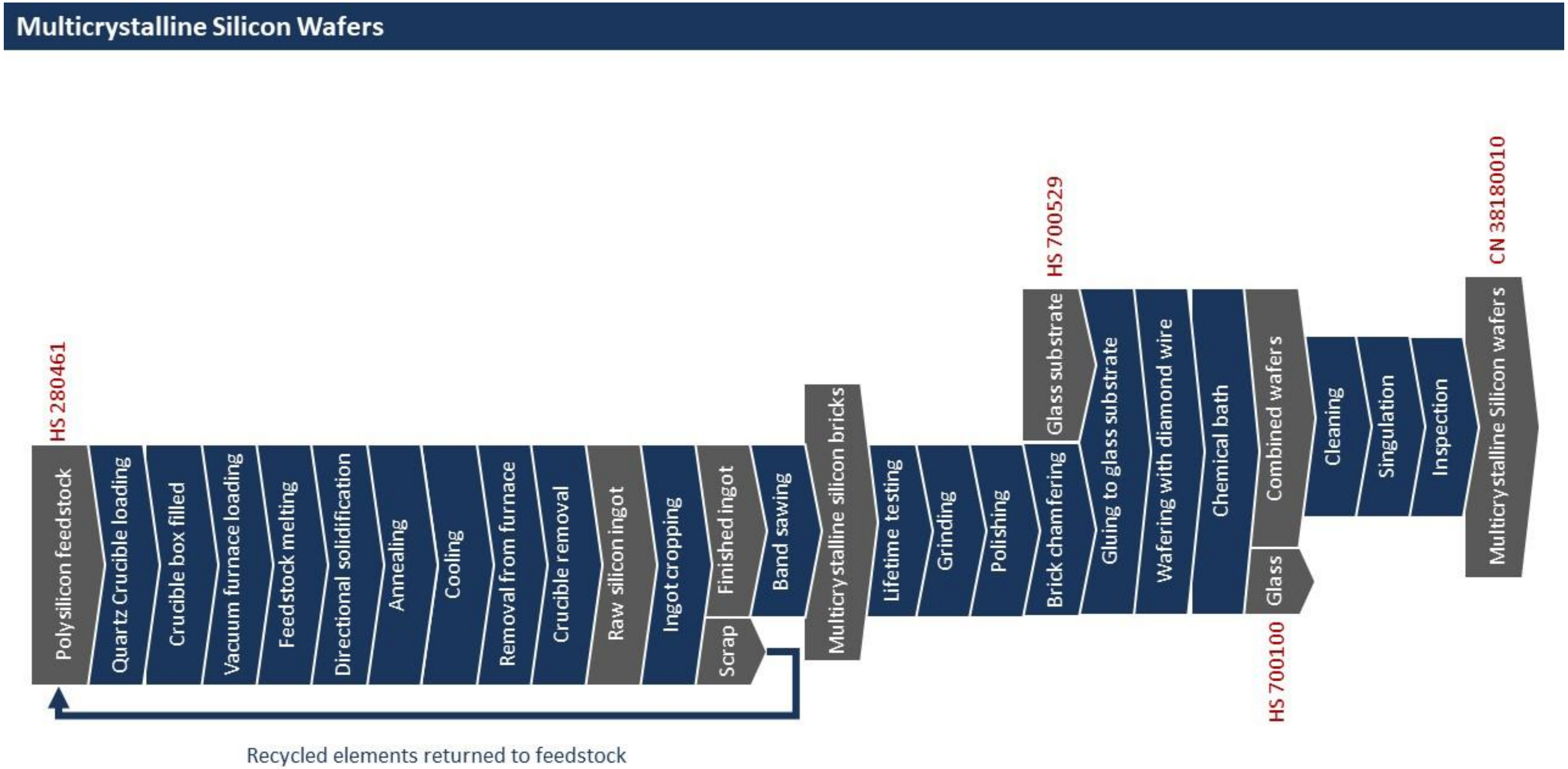
Raw Silicon Refining



I.V Monocrystalline Silicon Wafers

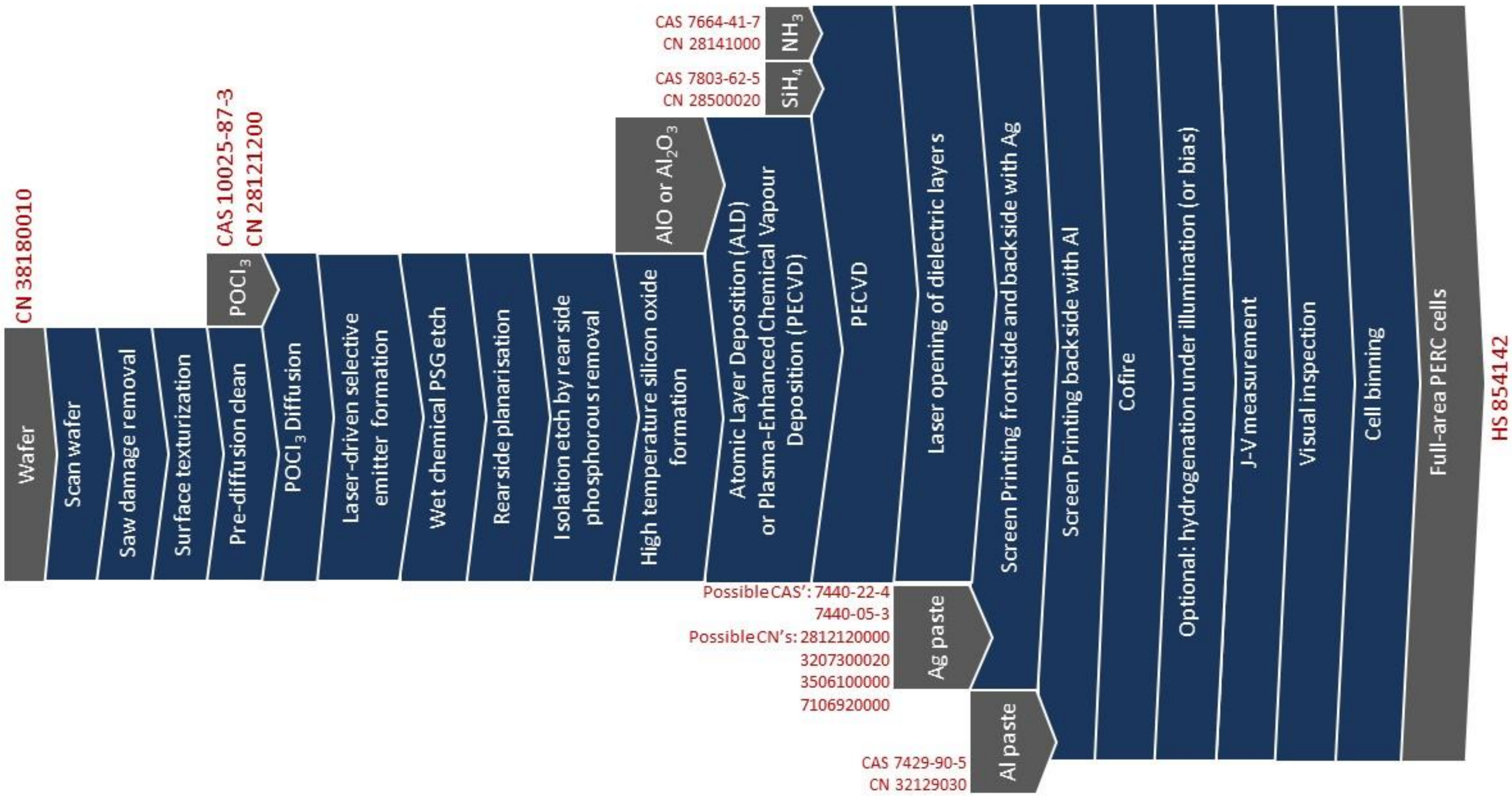


I.VI Multicrystalline silicon wafers

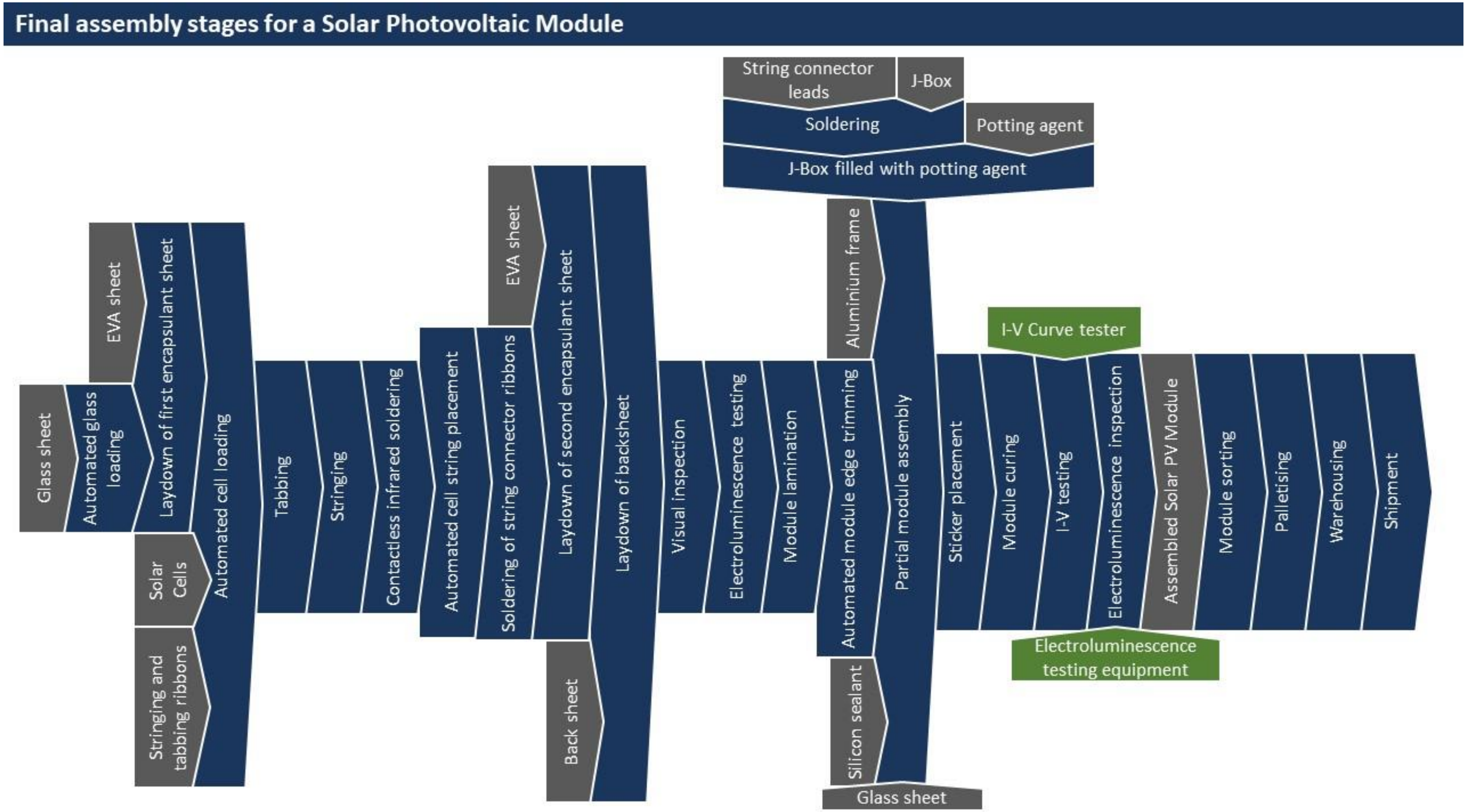


I.VII Full-area PERC cells

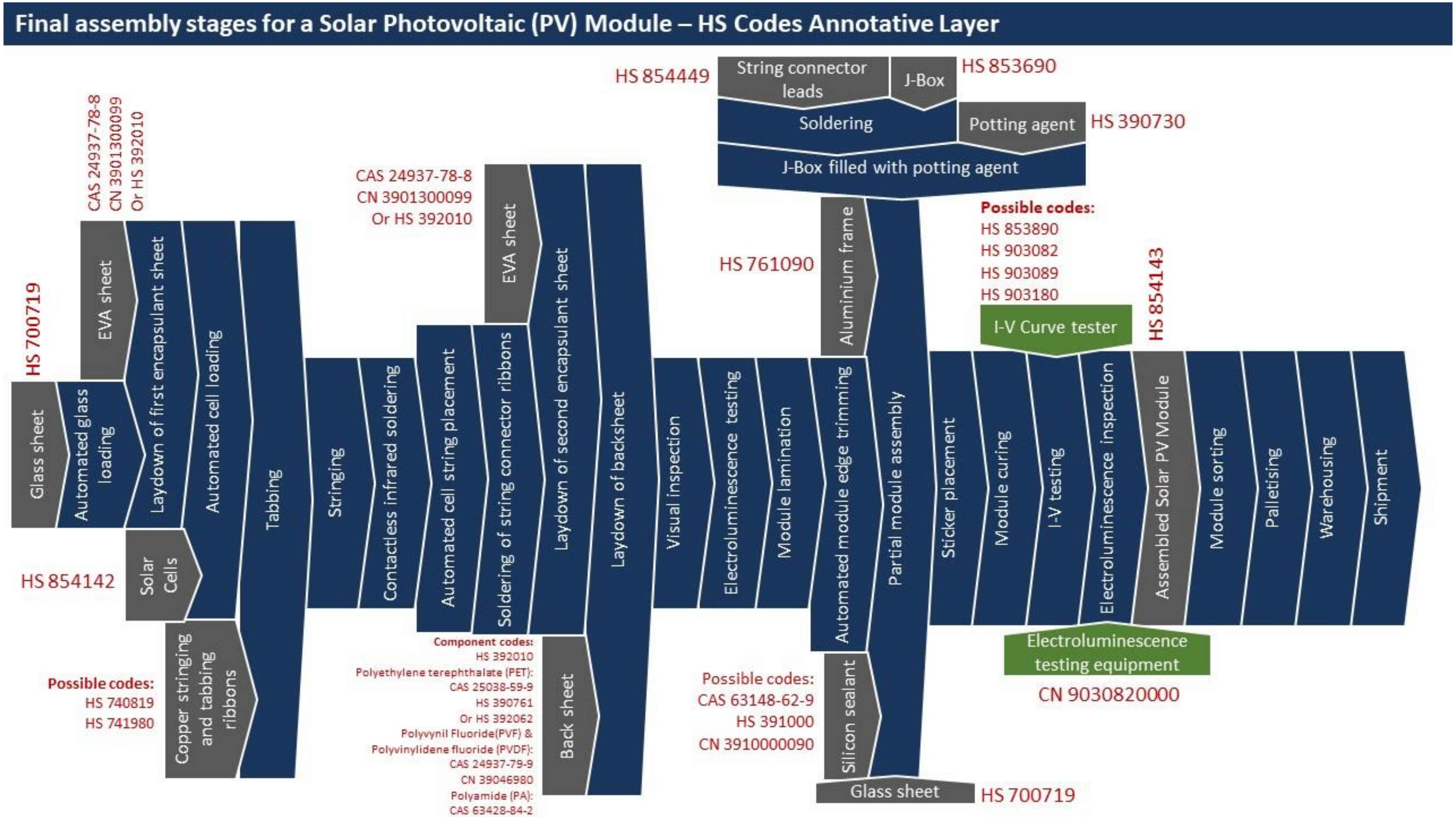
Full-area PERC cells



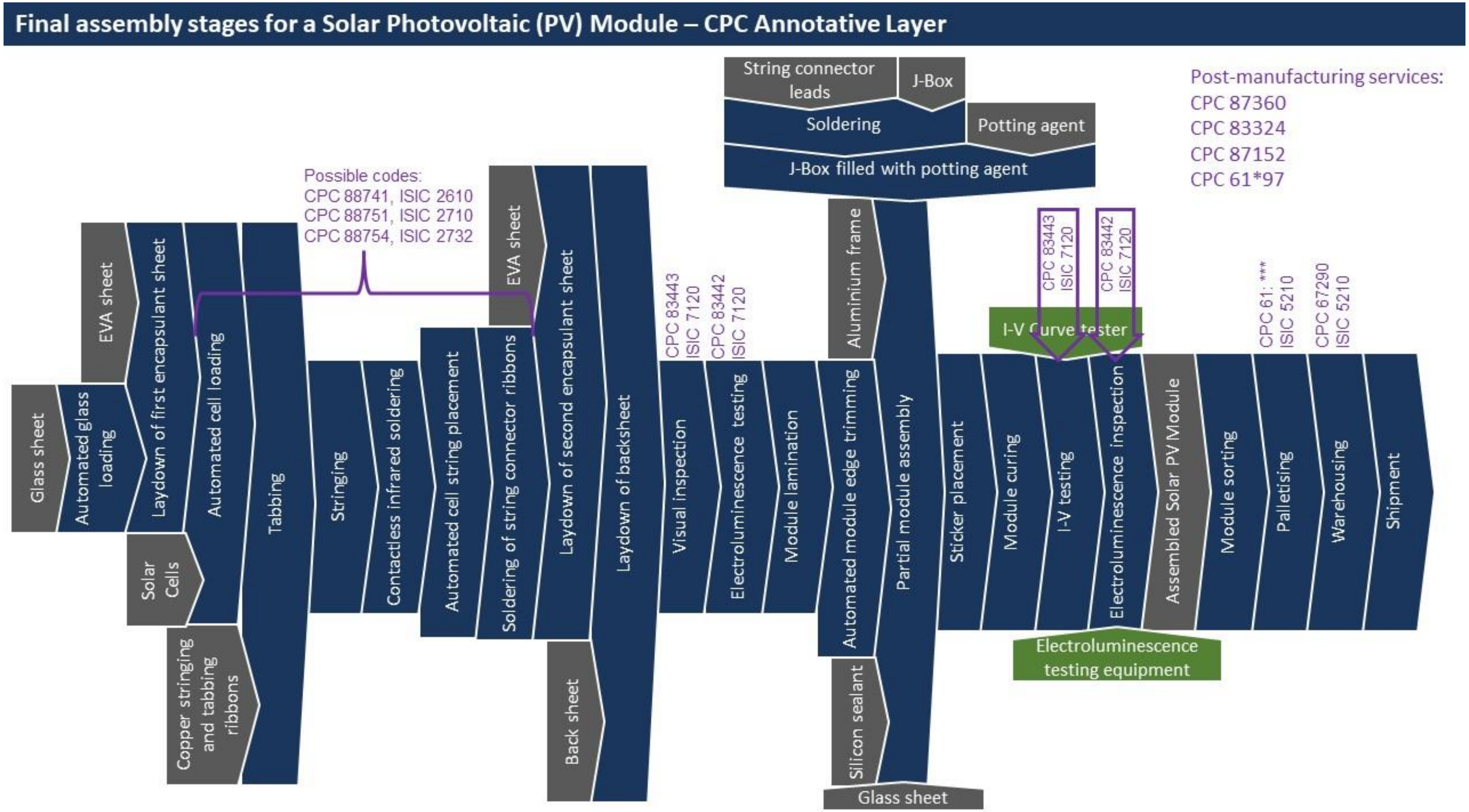
I.VIII Final assembly stages for a solar photovoltaic module



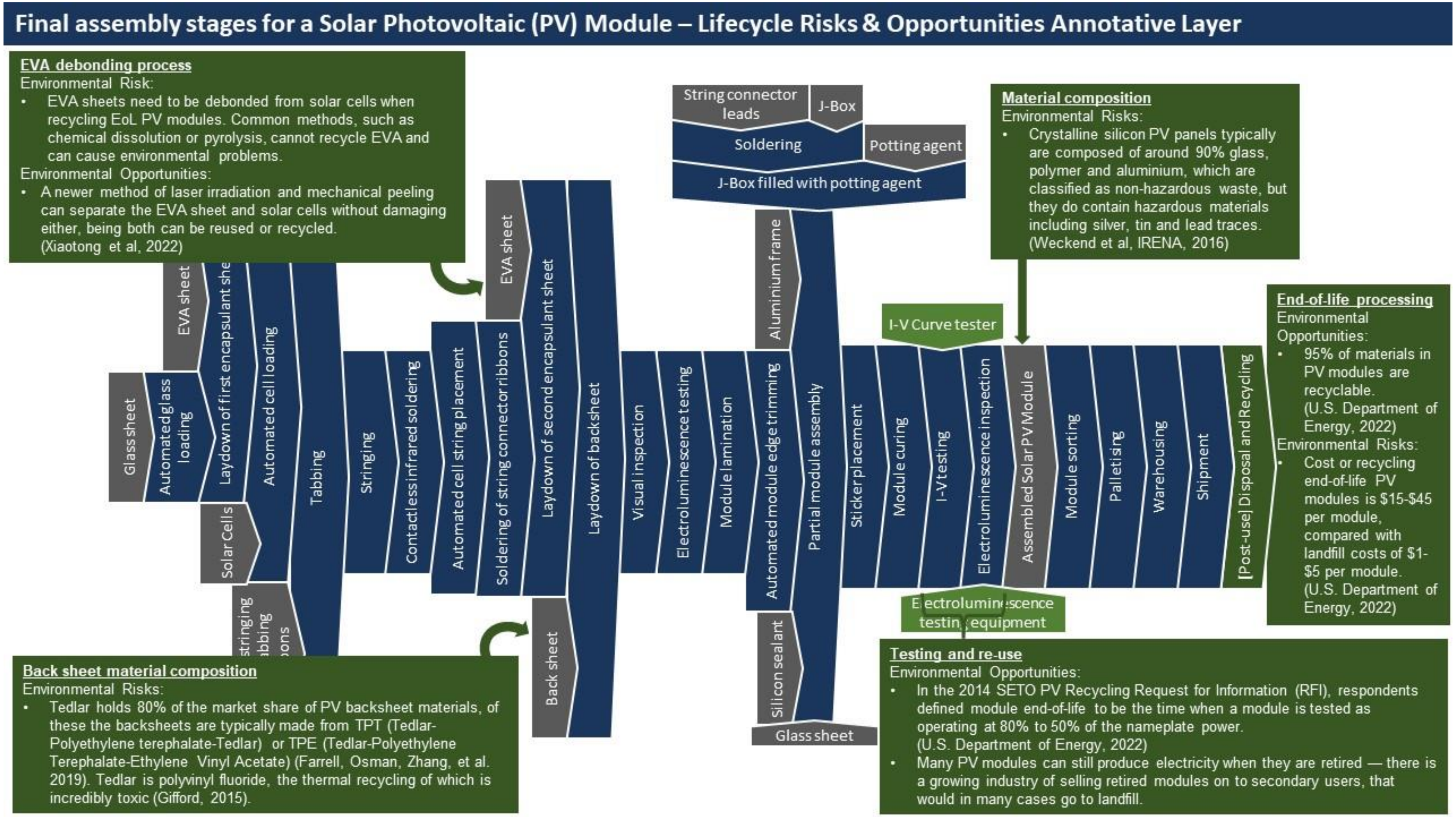
I.IX Final assembly stages for a solar photovoltaic module annotated with commodity codes



I.X Final assembly stages for a solar photovoltaic module annotated with CPC codes



I.XI Final assembly stages for a solar photovoltaic module annotated with exemplary lifecycle considerations



References for lifecycle considerations:

- Farrell, C., Osman, A.I., Zhang, X. *et al.* Assessment of the energy recovery potential of waste Photovoltaic (PV) modules. *Sci Rep* 9, 5267, 2019. https://doi.org/10.1038/s41598-019-41762-5

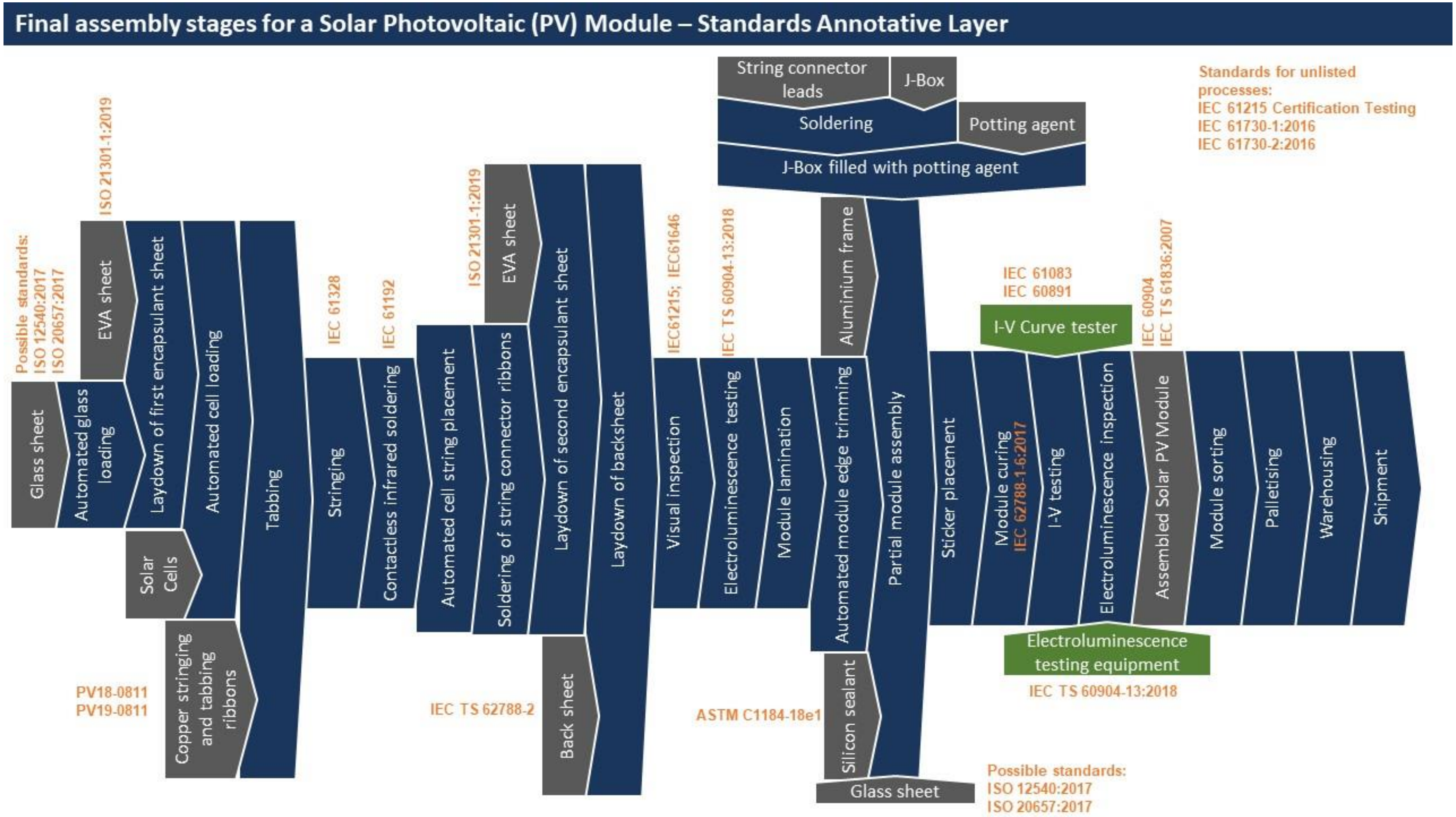
- Gifford, J. Recycling the whole module, PV-magazine, 2015. https://www.pv-magazine.com/magazine-archive/recycling-the-whole-module_100018150/

- U.S. Department of Energy. Solar Energy Technologies Office Photovoltaics End-of-Life Action Plan. Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, 2022.

- Weckend, S., Wade, A., Heath, G. End-of-Life Management Solar Photovoltaic Panels. Irena.org, 2016. https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.

- Xiaotong Li, Huan Liu, Jiachuan You, Hongwei Diao, Lei Zhao, Wenjing Wang, Back EVA recycling from c-Si photovoltaic module without damaging solar cell via laser irradiation followed by mechanical peeling, Waste Management, Volume 137, 2022, Pages 312-318, ISSN 0956-053X, https://doi.org/10.1016/j.wasman.2021.11.024.

I.XII Final assembly stages for a solar photovoltaic module annotated with standards codes



ANNEX II – SELECTION OF WIPO GREEN DATABASE ENTRIES FOR SOLAR PV TECHNOLOGIES

Database ID	TRL	Conditions for use – collaboration type
7894	9 – Scaling up	Other -> bSolar seeks today for complementary funding, as well as for new customers who will join a list of strategic customers from Germany, China and Japan.
147587	9 – Scaling up	For sale
145206	9 – Scaling up	For sale, For service
138915	9 – Scaling up	For sale, For service (Available technical assistance: personnel or training, materials)
138866	9 – Scaling up	For sale, For service
20048	7 – Technology optimization/prototype validated in operational environment	License
9558	3-4 – Proof of concept	License
8198	7 – Technology optimization/prototype validated in operational environment	R & D contract or research collaboration, For service, Joint venture (Available technical assistance: Materials, Documentation, Other -> Personnel/Training)
7963	9 – Scaling up	Other -> The company is looking for partners in the field of PV/PVT installation/EPC to install millennium's modules in Germany/worldwide, Solar thermal manufacturing to sign a joint venture licensing technology transfer agreement and investments.

ANNEX III – WIDER ENVIRONMENTAL IMPACT CONSIDERATIONS

The *effectiveness of EGS for achieving environmental outcomes* and how this is measured can vary between sectors. In renewable energy for example, IRENA has investigated the criteria and indicators used to evaluate renewable energy deployment, which examines four collections of criteria relating to: 1) effectiveness, 2) efficiency, 3) equity, and 4) institutional feasibility.[9]

Nascent and innovative technologies continue to emerge as the environmental goods policy space progresses. Different interventions will be suitable for technologies at different levels of development. When considering the nascence of a technology there are a variety of factors we can account for, but these can be organised into two overarching scales of technological maturity and market maturity. Regarding technological maturity, there are already well-established metrics in the literature for assessing the Technology Readiness Level (TRL) and the Manufacturing Readiness Level (MRL).[10]

State of commercialisation - Are they already in the market? Are they widely produced? The MRL helps us to address a part of this question, but we may also account for the diversity of products available in the market for any given group of environmental technologies and the ubiquity of their production around the world.[11] One way of narrowing our focus could be to look at those products with a high TRL, high MRL, low diversity, low ubiquity, and highly positive environmental impact to ensure that the solutions we design will be both effective and scalable.

How easy are they to deploy? Some solutions are simple and cheap to deploy, for example solar water pumps, for which decentralised decision making regarding uptake or installation can be taken by an individual farmer. Alternatively, the solution may be part of a much more complex process such as a tidal barrage, for which much more complex centralised decision making will be required to achieve effective installation.

Can they effectively be targeted in trade policy? Using the example above, solar powered water pumps appear in past lists of environmental goods but possess no dedicated subheading in the harmonised system nomenclature, as first highlighted by the IISD in their paper on the issue.[12] In line with the recommendations of this report, the UK has substantively engaged in the HS reform process at the WCO and proposed that a dedicated subheading be granted to this product. This example shows that even where a product cannot be targeted effectively, this can form the basis for collective action among members through the collaborative development of HS reform proposals to achieve better distinguishability for environmental goods.

State of commercialisation - are they already in the market? Are they widely produced? The MRL helps us to address a part of this question, but we may also account for the diversity of products available in the market for any given group of environmental technologies and the ubiquity of their production around the world. One way of narrowing our focus could be to explore those products with a high TRL, high MRL, low diversity, low ubiquity, and highly positive environmental impact to ensure that the solutions we design will be both effective and scalable.

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[9] https://www.irena.org/publications/2014/Feb/Evaluating-Renewable-Energy-Policy-A-Review-of-Criteria-and-Indicators-for-Assessment.

[10] US Government Accountability Office (GAO). (2010). Best practices: DOD can achieve better outcomes by standardizing the way manufacturing risks are managed (Report No. GAO-10-439). Washington, DC: GAO.

[11] https://atlas.cid.harvard.edu/glossary (see terminology for: diversity and ubiquity).

[12] https://www.iisd.org/publications/report/code-shift-environmental-significance-2022-amendments-harmonized-system.

Wider frameworks can also be instructive. In the UK, when making claims about environmental goods and services, under domestic consumer protection law businesses must not mislead consumers. The Competition and Markets Authority provides a checklist of ways of effectively capturing the environmental impact of products.[13]

Within the deep dive discussions, we welcome reflections from Members of which goods are likely to achieve the biggest impact and why.

[13] https://www.gov.uk/government/publications/green-claims-code-making-environmental-claims/environmental-claims-on-goods-and-services.