Thin-Film Solar Industry Association (PVthin) a.i.s.b.l.

PVthin position paper: Proposed inclusion of lead in REACH Authorisation List

EXECUTIVE SUMMARY

- Including lead on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Authorisation List would carry devastating impacts for current and future photovoltaics (PV) technologies, undermining efforts to scale PV manufacturing in Europe and deepening dependencies in strategic sectors.
- Lead is currently used for soldering in traditional PV panels. Its low melting point protects cells from cracking, increasing durability. Alternatives require higher temperatures, increasing cell-cracking risks. The main alternative to lead is bismuth, which is itself a lead by-product.
- Lead is also critical to the most innovative PV technologies, including Perovskites and Tandems, where it cannot be substituted. Due to their superior performance, the European Union (EU) has allocated significant Research & Innovation (R&I) funding to such technologies under Horizon Europe, with a budget of 167 million EUR in 2021-2022 alone.
- Reaching higher PV module conversion efficiencies through innovation will be critical to achieve global climate goals. Technologies like Perovskites and Tandems are at the forefront of such efforts.
- The EU is already in a position of extreme dependency when it comes to solar PV components. Chinese manufacturers supply roughly 89% of PV components globally. The European Commission has committed to strengthening EU competitiveness in PV manufacturing in its 2021 Industrial Strategy, its 2022 Analysis of Strategic Dependencies, and in the upcoming EU Solar Strategy.
- The REACH Authorisation does not apply to imported products. Including lead on the Authorisation List would prevent EU manufacturers from investing in Europe while having no impact on Chinese PV manufacturers who can continue to import PV components made using lead. This would completely undermine ongoing R&I efforts under Horizon 2020 and Horizon Europe, leaving a vacuum for third countries to surpass the EU in Perovskite and Tandem technologies.
- PV sustainability, including chemical content considerations, is best regulated through a lifecycle approach weighing performance improvements with environmental and health impacts.
- This is the approach used in ongoing efforts from the European Commission to roll out Ecodesign requirements for PV (which builds on 5 years of life cycle assessment work).
- Regulatory concerns around PV at end of life are currently regulated by the Waste from Electrical and Electronic Equipment (WEEE) Directive. This Directive, due to be revised in 2023, is a better risk management option to tackle risks associated with end-of-life PV panels than REACH authorisation.

PVthin | Rue de la Loi 227 bte.4| 1040 Brussels | Belgium | +32 2 669 16 00

http://www.pvthin.org | President@pvthin.org | Secretariat@pvthin.org

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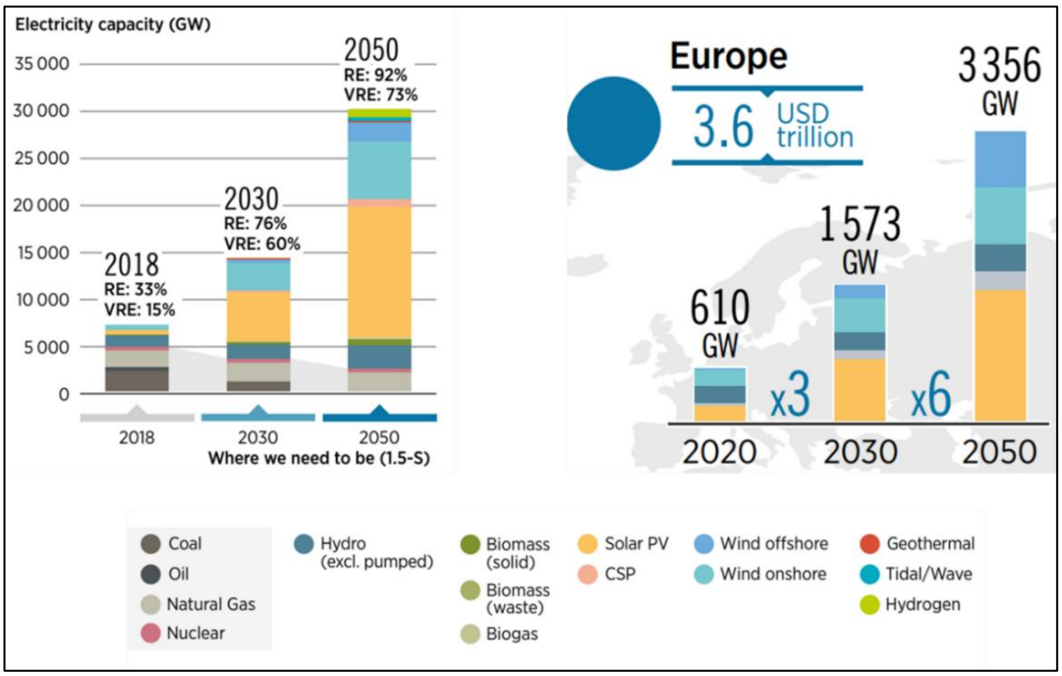
1. The role of PV materials science in a 1.5°C scenario

The rollout of renewable energy will need to increase dramatically over the coming decade, to limit global warming to 1.5°C. According to the International Renewable Energy Agency (IRENA), "wind and solar PV will lead the transformation, supplying 42% of total electricity generation by 2030 (from just over 10% today)"[1]. IRENA estimates that the global installed capacity of solar PV will increase seven-fold by 2030 (to nearly 5 200 GW) and twenty-fold by 2050 (to exceed 14 000 GW). To achieve these goals, Europe will need to install at least 55 GW of solar PV each year by 2030. In its 2021 proposal to review the Renewable Energy Directive, the European Commission raised the binding target for the share of renewables in the EU energy mix to 40% by 2030[2]. In its REPowerEU Communication, the European Commission further commits to double PV and wind capacities by 2025, and triple these by 2030[3].

Figure 1. IRENA (2022): Installed capacity of power sources in 1.5 C scenario (Global and Europe) RE (renewable energy) – VRE (variable renewable energy)



The most efficient way to achieve these targets in the PV sector is through advancements in PV module efficiency (meaning every single PV panel produces more electricity) coming from emerging technologies, in addition to increased deployment of existing technologies. Actors in the PV industry are currently pursuing a range of technological approaches to achieve this.

[1] IRENA: World Energy Transitions Outlook: 1.5°C Pathway - https://www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022

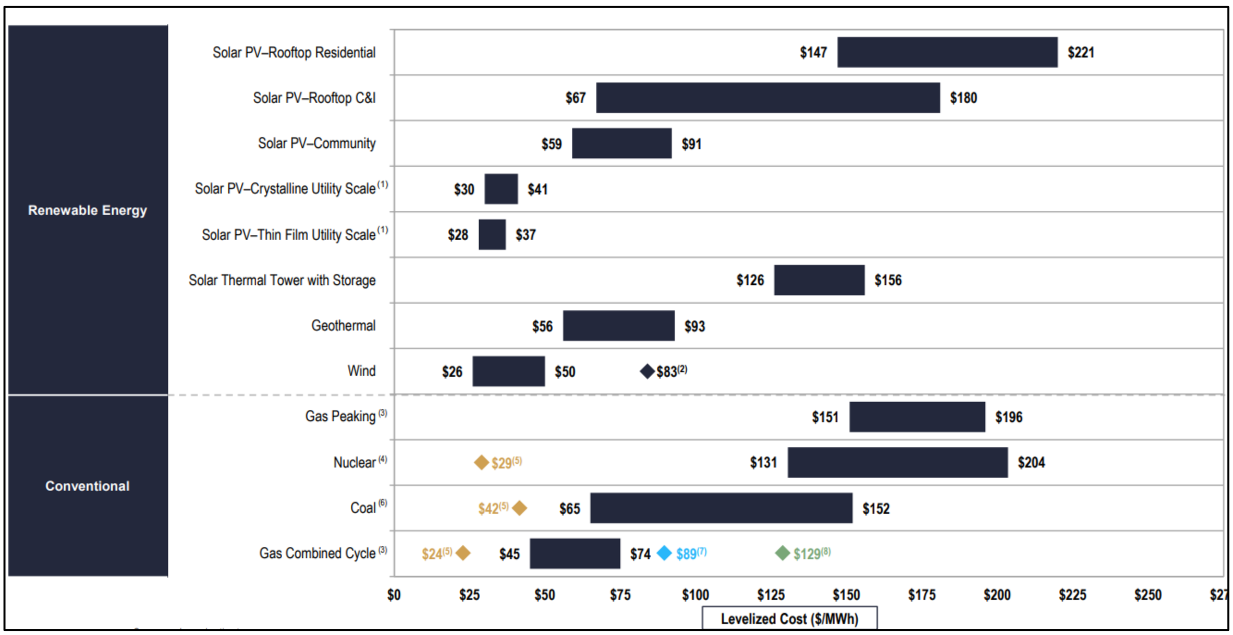
[2] Commission presents Renewable Energy Directive revision - https://ec.europa.eu/info/news/commission-presents-renewable-energy-directive-revision-2021-jul-14_en

[3] European Commission Communication: REPowerEU, Joint European Action for more affordable, secure and sustainable energy - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

Competition among PV technologies has already delivered significant efficiency gains. EU innovations have played an important role here, including Perovskites, CIGS, and Tandem Cells. Further efficiency gains are expected, especially for thin-film technologies. The combination of thin-film PV with second generation Crystalline Silicon PV in Tandem structures will further reduce costs and increase efficiencies.

In parallel, the levelised cost of energy (LCOE) for utility scale PV has fallen continuously. Cost decrease for thin-film PV technologies has been strong, driven mainly by higher efficiency gains and a fast transition from record efficiencies in a laboratory setting to large scale production. Today, the combination of utility-scale thin-film PV with large scale storage is already more competitive than conventional gas powered generation plants in the United States, for example. To maximise the socio-economic benefits of the energy transition, consumers should benefit from the most advanced technologies at the lowest costs.

Figure 2. Lazard (2021): Levelised Cost of Energy Comparison



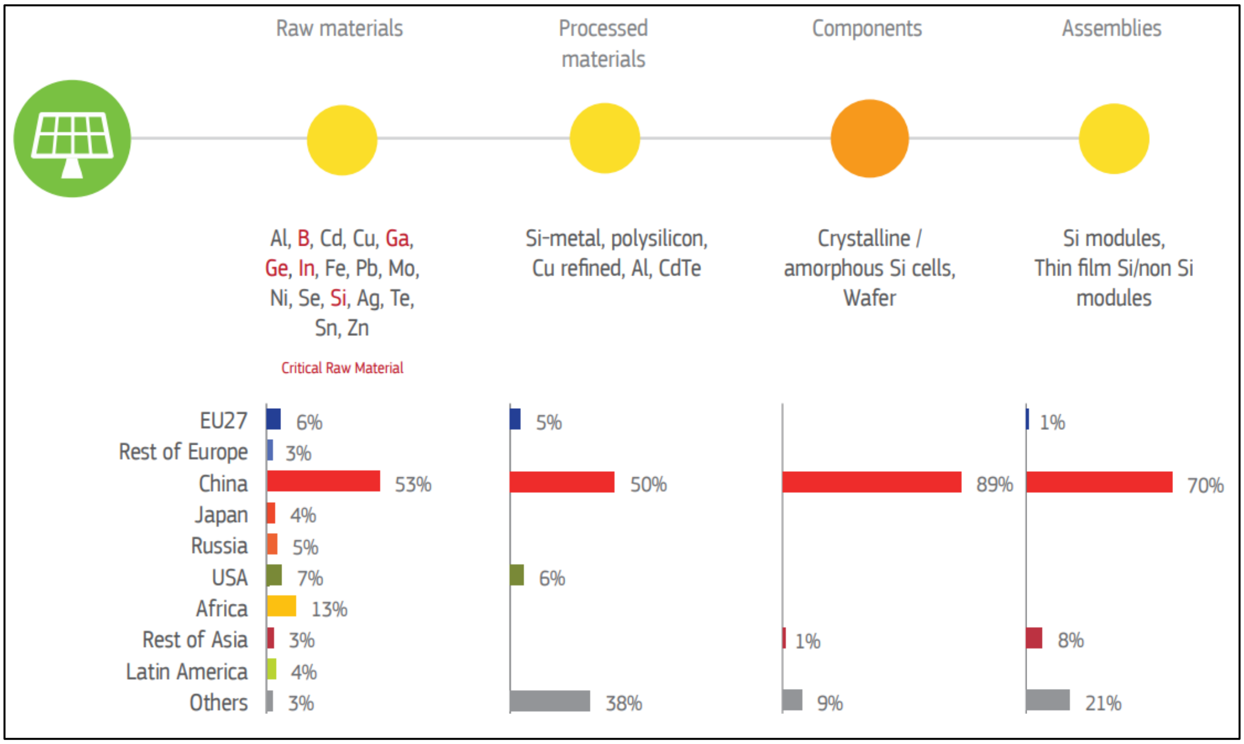
The EU cannot afford to miss out on these developments. Materials science is constantly evolving and pushing the limits of what is possible with today's PV technology. The EU regulatory environment, including chemicals legislation such as REACH, can influence the pace of this transition. Unclear and contradictory policy signals do not help the effective allocation of resources and capital. Regulatory certainty is needed to drive investment in innovation and capacity growth. A range of materials and substances could become essential to future innovations leading to greater module efficiencies while using less resources.

2. EU dependencies strategic sector of PV

The EU is already in a position of extreme dependency when it comes to solar PV components. These dependencies are well documented, including in the Commission's 2020 *Foresight Study on Critical Raw Materials for Strategic Technologies and Sectors*[4] and in the 2022 analysis *on EU Strategic Dependencies and Capacities*[5].

The Foresight Study notes that "China dominates nearly all aspects of solar PV manufacturing and use" and that "the most vulnerable step along the supply chain of PV technology is at the component level, for which China dominates the supply market with about 89%." The heavy concentration of PV manufacturing outside of Europe has created dependencies which have the potential to severely impact the EU's ability to access critical technologies to support its decarbonisation objectives. The 2022 Strategic Dependencies analysis concludes that "the EU will need to address its dependencies notably in the manufacturing segments of the PV value chain, while building on its strengths by continuing to invest in next-generation PV technologies".

Figure 3. European Commission (2020): Solar PV: Risks, bottlenecks and key players along the supply chain



The European Commission will aim to lay the foundations for these investments in its EU Solar Strategy, expected in Q2 2022. This will also be critical in the context of the European Commission's REPowerEU Communication, which

[4] European Commission: Critical Raw Materials for Strategic Technologies and Sectors, a foresight study - https://rmis.jrc.ec.europa.eu/uploads/CRMs_for_Strategic_Technologies_and_Sectors_in_the_EU_2020.pdf
[5] European Commission: EU strategic dependencies and capacities: second stage of in-depth reviews - https://ec.europa.eu/docsroom/documents/48878

aims to make Europe independent from Russian fossil fuels well before 2030[6]. To achieve this, the European Commission notes that it will be critical to roll out 420 GW of solar by 2030 and further develop the solar value chain, boosting EU competitiveness and tackling strategic dependencies. The EU cannot afford to replace its fossil fuel dependencies on Russia with PV technology dependencies on China. To underline this the European Commissioner for Energy added that "Europe used to be known as a manufacturing powerhouse. One that is guided by our own brand of environmental excellence. **We need to bring manufacturing back to Europe and the Commission is willing to do whatever it takes to make it happen**."[7]

3. Lead in current and future PV technologies: Why Authorisation would carry significant negative impacts

Today, lead is primarily found within the ribbon coating and the soldering paste used for connecting cells together in mainstream Crystalline Silicon (c-Si) PV panels. Lead is usually the ideal material due to its low melting point. Lead allows for lower process temperature during stringing, which in turn reduces the stress placed on the solar cells. Alternative materials include a pure tin coating or replacing lead with bismuth (itself a by-product of lead mining), but these require a higher process temperature. Soldering at a temperature of 210 degrees can be done when lead is present in the material, and this is much less stressful than the 260 degrees or higher that would otherwise be necessary. Substitution by lead-free alternatives places increased stress on the cell, which can lead to micro cracking and a higher breakage rate during production. Microcracks also impact the electricity production of Crystalline cells, they hinder the movement of electrons, thereby decreasing the yield of solar installations. Avoiding cracking and ensuring durability is essential for PV panels, which have an expected lifetime of roughly 30 years in the field. Beyond product performance and durability, concerns have also been raised with regard to the adverse impacts of bismuth in terms of recycling, environmental and health aspects, and overall cost effectiveness[8].

Materials science is at the heart of PV R&I, we do not know what the chemical composition of tomorrow's PV panels will be, but it will certainly be more complex than what is sold on the EU market today. The semiconductor industry is a valuable example here. In the 1980s, semiconductor chips used 12 elements from the Periodic Table, now they use 48. If regulations had banned certain chemical elements from being used in that industry 40 years ago, it would have likely stifled innovation and we would not have access to semiconductor technology we benefit from today.

This means EU regulations should ensure that as many materials as possible can continue to be used safely in current and future PV technologies. Beyond current c-Si panels being deployed today, use of lead is critical to some of the most innovative PV technologies, such as Perovskites and Tandems. These technologies are essential to achieve the efficiency gains necessary to support the climate goals discussed in this paper.

EU research stakeholders are aware of these technologies' potential, which is why the EU has already allocated R&I funding to such technologies under Horizon Europe, with a budget of 167 million euros in 2021-2022 alone[9]. The

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[6] European Commission: REPowerEU, Joint European action for more affordable, secure and sustainable energy - https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1511
[7] https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_22_2405
[8] The Deutsche Kupferinstitut: The effects of using bismuth as lead replacement - https://www.kupferinstitut.de/wp-content/uploads/2020/01/Factsheet_Bismut-als-Bleiersatz_English.pdf
[9] IEA-PVPS: Photovoltaic Power Systems Programme, Annual Report 2021 - https://iea-pvps.org/wp-content/uploads/2022/03/IEA-PVPS_Annual_Report_2021_v1.pdf

inclusion of lead on the REACH Authorisation List would significantly hamper the EU's ability to manufacture these technologies identified as Best Not Available Technologies (BNAT) by the Commission's own services.[10]

Raising money to scale manufacturing cannot be done under the risky regulatory context of REACH Authorisation, no matter whether authorisation for these uses were to subsequently be granted. The basic act of selling PV panels, with a use life of around 30 years, becomes near impossible in such a risky regulatory context. Having to continuously reapply for authorisation increases investor risk, and undermines the ability to raise capital for manufacturers, builders, buyers and owners of solar installations. Despite echoes to the contrary from the Commission's political leadership[11], an inclusion of lead on REACH Annex XIV, thereby subjecting lead use in PV to authorisation in domestic manufacturing would de facto discourage EU actors from investing in these technologies at a time when the EU is seeking to strengthen its resilience in the PV value chain.

It is fundamental here to stress that REACH Authorisation does not apply to imported articles. As presented above, the vast majority of PV modules deployed in the EU are currently manufactured in third countries, predominantly in China. The inclusion of lead on the Authorisation List would significantly hamper EU efforts to rebuild a competitive manufacturing base based on new cutting-edge technologies, while giving a "free pass" for manufacturers outside the EU to continue using lead without restrictions. Furthermore, inclusion of lead in Annex XIV would preclude EU manufacturers from investing in the most innovative PV technologies, including Perovskites and Tandems. This vacuum would inevitably be filled by third country manufacturers, who would be able to invest in technologies using lead and export these to the EU regardless of Authorisation. The European Commission already concluded in its 2018 REACH evaluation that "authorisation requirements could be harming the competitiveness of EU companies because articles imported to the EU are exempt from the authorisation obligations"[12].

4. How to effectively regulate PV sustainability

EU regulation must allow the safe use of as many materials as possible in current and future PV technologies, enabling innovation while ensuring containment of substances of very high concern. This holistic approach should cover every step of a PV module's lifecycle, from design to recycling. Against this backdrop, PVthin strongly supports ongoing work by the European Commission to set Ecodesign requirements for PV modules, inverters and systems[13]. Building on years of industry consultations, including a PV industry Product Environmental Footprint (PEF) pilot project leading to industry Product Environmental Footprint Category Rules (PEFCR)[14], the European Commission's Ecodesign approach aims to regulate PV according to where its life cycle impacts are. The current Ecodesign

[10] European Commission: JRC Science Policy Report, Preparatory Study for Solar Photovoltaic modules, inverters and systems - https://susproc.jrc.ec.europa.eu/product-bureau//sites/default/files/2020-12/jrc12431preparatory_study_for_solar_photovoltaic_modules_kj-na-30468-en.pdf

[11] Keynote Speech by Commissioner for Energy Kadri Simson at the Solar Power Summit

[12] European Commission Communication: General Report on the operation of REACH and review of certain elements Conclusions and Actions Conclusions and Actions - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:116:FIN

[13] European Commission: Discussion paper on potential Ecodesign requirements and Energy Labelling scheme(s) for photovoltaic modules, inverters and systems - https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/2021-04/Discussion%20paper%20Ecodesign%20Photovoltaic%20Products.pdf

[14] Product Environmental Footprint Category Rules (PEFCR), photovoltaic modules used in photovoltaic power systems for electricity generation - https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_PV_electricity_v1.1.pdf

proposals address the lifecycle sustainability of PV technologies through rules on durability, degradation, recyclability, repairability, and carbon footprint. Such an approach is far more sophisticated and adapted to the fast-moving reality of the PV industry, than the single-minded focus on lead for all industries alike, as seen with the REACH Annex XIV process.

Adoption of the Ecodesign proposals will be critical to establish a harmonised set of sustainability requirements for PV at the EU level, an action which was recognised as strategic in the updated 2021 Industrial Strategy[15]. To ensure the safe use and recycling of specific materials, the draft Ecodesign requirements already envisage material disclosure obligations, whereby manufacturers would need to declare the content in grams of a number of critical raw materials and environmentally relevant materials, including lead. Whereas the Ecodesign approach creates a nurturing and constructive regulatory environment for technologies such as Tandem Perovskite cells which they recognise as "best not available technology" with future potential (BNAT)[16], REACH Authorisation does not.

In addition to the Ecodesign proposals, PV waste and recycling is currently regulated in the EU under the WEEE Directive, with a mandatory minimum recycling target of 80%. Waste from solar PV will increase exponentially by 2030, as modules across existing installations reach their end of life. While the WEEE Directive already sets a regulatory framework to support PV recycling in the EU, its revision in 2023 is a good occasion to close regulatory gaps caused by patchy transposition in different Member States, create a level playing field, and promote high-quality recycling standards[17]. WEEE will complement that approach laid out by Ecodesign to cover all relevant life cycle impacts.

Thin-film PV technologies go further than current and future WEEE requirements. They can currently be recycled to recover over 90% of their glass and semiconductor metals. Semiconductor metals are then reused in new thin-film PV modules, in closed loop systems.

About PVthin

PVthin - the International Thin-Film Solar Industry Association - is an international, not-for-profit coalition representing global leaders in the Thin-Film Solar Industry and broader value chain based on chalcogenide, perovskite, tandem and/or heterojunction PV technologies, and any other thin-film or emerging PV technology. For further information about our position please contact us at Secretariat@pvthin.org.

[15] European Commission Communication: Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery - https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf

[16] European Commission: JRC Science Policy Report, Preparatory Study for Solar Photovoltaic modules, inverters and systems - https://susproc.jrc.ec.europa.eu/product-bureau//sites/default/files/2020-12/jrc12431preparatory_study_for_solar_photovoltaic_modules_kj-na-30468-en.pdf

[17] For example, making standard CENELEC – CLC/TS 50625-3-5 mandatory instead of voluntary.