TOWARDS A MORE RESOURCE-EFFICIENT SOLAR FUTURE IN EUROPE: BOOSTING PERFORMANCE OF PEROVSKITE SOLAR CELLS

VIPERLAB First Public event on 11 May 2023

The VIPERLAB First Public event titled "Status of achievements in the perovskite based PV field-Performance, Infrastructure, Community and Strategic Research and Innovation agenda" was held in conjunction with the ETIP-PV Annual Conference on 11 May 2023. The event featured a panel of VIPERLAB partners and key stakeholders from academia, industry, and policy representatives.

Perovskite PV has a huge potential over conventional solar technology. Perovskite-based solar cells have shown remarkable progress in a very short time with rapid increases in efficiency from report of about 3% in 2009 to more than 33,7% today for a lab-scale perovskite/silicon tandem solar cell. Perovskite tandem solar cells are getting momentum as was highlighted by the German Chancellor Olaf Scholz recently in the World Economic Forum 2023 in Davos, and are now backed up by important community and infrastructures for their further development. However, to this day the technology does not meet yet the requirements for mass-production of commercial-scale modules, particularly regarding manufacturability, sustainability, and stability.

It is within this context that the VIPERLAB event aimed to present the current status of achievements in the perovskite field and the main barriers that need to be removed to facilitate the massive scale market deployment of perovskite photovoltaics (PV).

The VIPERLAB event was opened by Dr. **Nader Akil**, Operations Manager of PNO Innovation, project partner supporting exploitation activities in the VIPERLAB project, who welcomed all the participants and presented the context and concept of the event.

The event proceeded with a series of presentations beginning with Dr. **Natalia Maticiuc**, VIPERLAB project manager at Helmholtz-Zentrum Berlin (HZB). As a first step and to better understand the VIPERLAB project, she gave a short introduction presenting its context, concept as well as objectives and impacts. Backed by 15 partners from 9 countries, the VIPERLAB project aims to stimulate European academic and industrial researchers to work together on the research and development (R&D) of the next generation of solar cell technology, which will accelerate the perovskite PV technology development in Europe. Nowadays the project offers **free access** to industry and academia to top-ranked transnational (processing and characterisation) and virtual infrastructures involved in innovative materials synthesis, state-of-the-art device design and development, standardised testing and simulation methods.

VIPERLAB infrastructures and partners (VIPERLAB project)

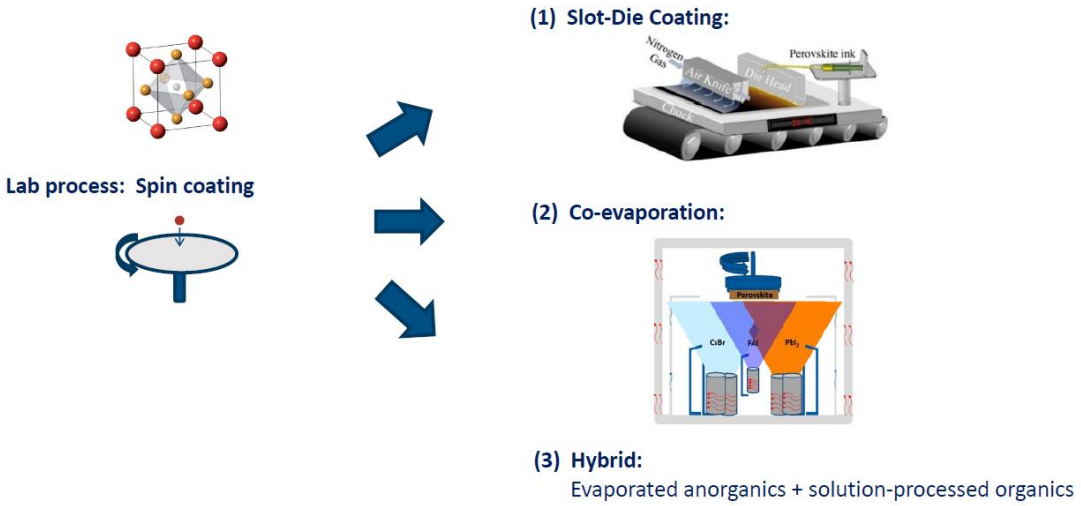
Furthermore, the VIPERLAB project gathers a wider perovskite PV community of researchers and industry working together on networking and joint research activities. In a nutshell, all VIPLERAB infrastructures, data, technical documents as well as events can be accessed for free on the Knowledge Exchange Platform (KEP), Virtual Access Portal (VAPo) and VIPERLAB GATE platforms.

You can access to the video and the presentations by the event web page 👉 here

In this framework, HZB has shown a remarkable progress in perovskite solar cells and rapid increase in their efficiency in relatively short time to reach a world record efficiency of 32.5% by end of 2022. However, bringing this technology from the lab to a production scale level entails debugging many technical issues. **Prof. Rutger Schlatmann**, Head of the Solar Energy Division at HZB and Chair of the European Technology and Innovation Platform PV, set out the latest achievements of Perovskite PV investigated by HZB. The first achievement is based on the **material quality and conversion efficiency**.

This is the core goal aiming to develop different high-efficiency tandem solar cells combining different absorbent materials and investigating novel device concepts. Secondly, Prof. Schlatmann highlighted the importance of **upscaling and industrialisation**. To overcome these limitations, HZB is developing scalable deposition methods such as slot die coating with N_2 gas quenching, co-evaporation, and hybrid methods.

Routes for perovskite upscaling (HZB)



As a third topic, **long-term stability** is essential for perovskite-based solar cells to become competitive with current solar cell technologies, but it is still under development. Moreover, the **sustainable profile** of the perovskite PV is under debate since the most efficient perovskite solar cells are made from lead halide salts and thus are potentially toxic elements. During the last years, HZB has engineered new materials with promising efficiency and stability such as CIGS[1]-Perovskite tandem, silicon or perovskite organic. As a results, they have achieved "a perovskite-silicon tandem solar cell with a certified power conversion efficiency of 29,15% and a perovskite-CIGS tandem solar cell with a certified power conversion efficiency of 24,16%". Based on these key points and according to Prof. Schlatmann, "there are a lot of **opportunities for the technology** to start investing".

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To better understand the market perspective of Perovskite PV, Mr. **Philippe Macé**, Head of Strategy and Analytics at Becquerel Institute (BI) provided an overview of the different scenarios. The market potential is based on the promising high efficiency of perovskites as well as their potential low manufacturing cost, that could put this technology on a very rapid market growth path. Other potential assets are its high-efficiency potential (>30% by 2050), smaller carbon footprint compared to c-Si (crystalline silicon), free-form design options and possibility for very low weight devices.

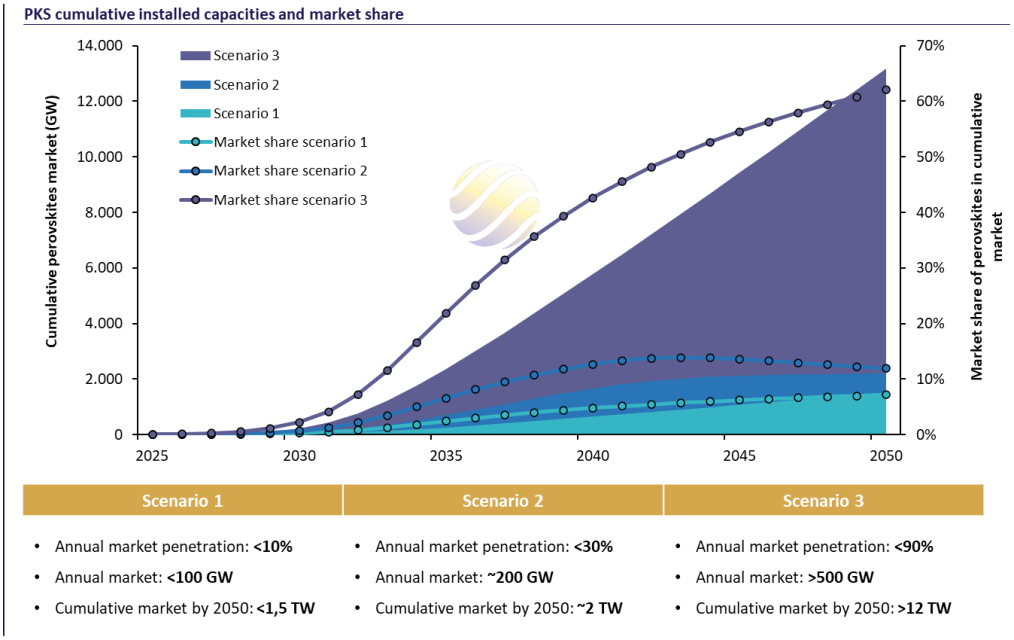
To carry out this study, Becquerel Institute qualified the market potential of perovskite following a methodology in five steps, from global PV market development to perovskite market penetration.

[1] CIGS stands for copper indium gallium diselenide ($CuInGaSe_2$)

Firstly, to estimate the evolution of the global PV market by 2050, BI modelled the PV market with a logistic curve that follows the historical evolution of the last 20 years up to 20 TW cumulated in 2050. Secondly, they estimated the evolution of PV market per sub-segments that were estimated based on past data, development potential as well as cost and technical constraints. As a third step, BI also modelled the market entry of a new PV technology showing that the annual market entry curve of perovskites is assimilated, as for pervious technologies like Passivated Emitter and Rear Contact (PERC) solar cells, with a first commercial product excepted around 2026, and a lag time of 8 years until peak adoption around 2034. As a result, BI defined three market entry scenarios depending on the module efficiency and theoretical lifetime of perovskite models which will impact their maximal penetration rate.

To summarise, **the market potential of perovskite PV is highly dependent on the ability of this technology to hold its promises in terms of cost, efficiency, and stability, which remain subpar**. Based on the analysis of the three scenarios, the penetration of perovskites on the PV market will depend greatly on the performances achieved, with annual market values lying between 100 GW and 750 GW by 2050. In addition to conventional grid-connected PV applications, the vehicle-integrated photovoltaics (VIPV) market could also be a major source of growth for perovskite where lightweight and aesthetics could be leveraged. As stated by Mr. Macé, "the vehicle-integrated photovoltaics (VIPV) market is expected to expand with the development of e-mobility and thus also constitutes an importance source of growth for PV, including for perovskite".

Analysis of PEROVSKITE potential by Becquerel Institute



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In terms of R&D, Prof. **Ivan Gordon**, Head of the photovoltaic technology and energy systems activities at IMEC, has been leading the VIPERLAB Strategic Research and Innovation Agenda (SRIA) for

perovskite single-junction PV[2]. After several discussions over a series of workshops with stakeholders the main outcomes were:

- Need of more emphasis on commercially available perovskite modules that have been produced in Europe and that are in line with the EU safety requirements (e.g., in terms of Pb content).
- The CO2-footprint Key Performance Indicator (KPI) was considered as one of the main differentiators compared to traditional Si-PV.
- The Levelized Cost of Electricity (LCoE) target was found to be unrealistic since this would require large-scale production of perovskite PV modules by 2030 at a similar scale as Si-PV production which is unlikely.

As a result, the VIPERLAB project is currently preparing a **Strategic Research and Innovation Agenda for single-junction perovskite photovoltaics** based on the comments received during the workshops. This has resulted in the update of the 2030 KPI's, the prioritisation of activities needed as well as the definition of a clear timeline and roadmap to obtain the KPIs. The VIPERLAB SRIA will be finalised in the upcoming months.

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How Research and Innovation can help boost the deployment of perovskite-PV in Europe?

VIPERLAB event: panel discussion' speakers

Looking back, 15 years ago a large part of the value chain for manufacturing silicon-based solar cells was still in Europe. However, today Europe has lost this manufacturing value chain leading to the dependency of the European Union on PV imports from third countries. In this context, a panel

[2] The starting point was the European Strategic Research and Innovation Agenda for PV drafted in 2022 by ETIP-PV and EERA-PV, covering all PV technologies and applications, including perovskite PV.

discussion was led by Dr. Akil with the participation of several policy and industrial representatives as well as experts in the PV and perovskite fields, to discuss the future production of novel solar modules in Europe and what barriers need to be removed to achieve this objective.

First, **Mr. Jaceck Truszczynski**, Deputy Head of the Green and Circular Unit (DG GROW), discussed how the European Solar Photovoltaic Industry Alliance that was launched by the EC in 2022 to accelerate solar PV deployment in the EU via facilitating investment, de-risking sector acceleration and supporting Europe's decarbonization targets, could support emerging communities and businesses such as the perovskite PV.

Mr. Truszczynski explained that the Alliance is meant to build resilience and strategic autonomy for Europe's solar photovoltaic value chain. This initiative was created to support the objectives of the EU's Solar Energy Strategy that aims to deploy over 320 GW of solar PV by 2025, more than doubling the 2020 output, and almost 600 GW by 2030. The alliance is a forum for stakeholders in the sector focused on ensuring investment opportunities for European solar PVs and help diversify the supply chains, retain more value in Europe and deliver efficient and sustainable PV products. Moreover, Mr. Truszczynski also mentioned the last initiative proposed by the European commission, the Net-Zero Industry Act (NZIA). This initiative aims to help strengthen the EU manufacturing capacity of net-zero technologies and overcome barriers to scaling up the manufacturing capacity of Europe. He stressed that "the NZIA will create the necessary conditions to facilitate **investments** in net-zero technology manufacturing projects and support project promoter to build up net zero industrial manufacturing".

From the point of the view of the industry, **Dr. Johan Lindahl**, Secretary General of the European Solar Manufacturing Council, highlighted that "photovoltaics will be the largest source of electricity in the near future" and, thus "today is becoming the new oil". This statement was reflected in the fact that countries such as United States (Inflation Reduction Act), India (import tariff) or China are increasing their investments and approving new regulations to support the development of their PV manufacturing capacity. Therefore, this new international scenario is today pushing European policymakers to make sure Europe s restores a strong PV manufacturing industry in the future. As a priority throughout a viable scenario for achieving these goals, Dr. Lindhal stressed that "Europe needs to establish first the silicon production to be able to produce tandem solar cells" and not be left behind. Currently, Europe is taking the first steps to establish new regulations and subsidies alongside the EU Member States.

Harmonisation and **standardisation** topics were also discussed during the event**. Dr. Tony Sample**, Senior Researcher at EU's Joint Research Center and standardisation expert in the PV field, provided insights on the needs for an emerging technology such as perovskite to get ready for industrial deployment in terms of maturity, testing and qualification standards. According to Dr. Sample "**characterisation**, **lifetime** and **type of approval"** are essential to accelerate the scale-up process of modules made from tandem PV cells. In addition, Dr. Sample highlighted that to enhance this technology it is very important to analyse the degradation mechanism and failures modes of PV modules that have been exposed in the field for long periods of time. In terms of harmonised measurements, **Dr. Stephan Abermann**, Head of Competence Unit Energy Conversion & Hydrogen at the Austrian Institute of Technology, pointed out that from a scientific perspective "today the biggest challenge is the large variety of materials, device concepts, and fabrication approaches used in perovskite-based PV". He stressed that "harmonisation is difficult in this field due to the wide range of measurements, devices, and other features that everyone uses" giving rise to many challenges for research and development.

All speakers agreed that to support the growth of perovskite-PV in Europe the **EU needs to continue investing in research and innovation** to diversify and scale-up perovskite-PV technologies. Research funding should focus on scaling-up the PV technology as well as enhancing harmonisation and standardisation processes. Supporting the industrialisation of these technologies will ensure Europe maintains its technological leadership, increases its competitiveness in a global strategic sector and delivers on its climate targets in the most sustainable and co-effective way.

The conference in numbers

The **VIPERLAB First Public Event,** organised by PNO Innovation in collaboration with the VIPERLAB partners, attracted a diverse range of stakeholders from industry, academia, institutions, and organisations. The event was organised in a hybrid format and was recorded for the conference participants who were not able to join or for other interested stakeholders that could not attend online or onsite.

Overall, 104 people registered to the event and more than 70 joined onsite or online. The conference was predominantly attended by representatives of the academia (research centres and universities) with approximately 60% of the overall attendance, while participants from the industry sector accounted for almost 33%. Institutions and organisations representatives also attended the event representing 7% of the participants.

👉 **Watch the full event (video)**