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FULLY CONNECTED **VI**RTUAL AND PHYSICAL

PEROVSKITE PHOTOVOLTAICS **LAB**

Market perspectives of Perovskite PV

Presented by Philippe Macé, **Becquerel Institute**

VIPERLAB 1st Public Event

11.05.2023

Becquerel Institute at a glance

- Est. 2014 in **Brussels, Belgium**
- Est. 2022 in **France**
- Focused on **solar PV and its related ecosystems** (storage, electro mobility, buildings)

Strategy Consulting

Applied Research

Support to international organizations

Project Developers

TotalEnergies, EDF renouvelables, WÄRTSILÄ, innogy, BayWa r.e. renewable energy

Manufacturers

posco, SAINT-GOBAIN, ArcelorMittal, GSE Intégration

Associations

ETIP Photovoltaics, IEA PVPS, REN21 Renewable Energy Policy Network for the 21st Century, eit InnoEnergy, SolarPower Europe

Research projects

VIPERLAB, BIPV boost, ProLight, SEAMLESS-PV, IBC4EU, NEXUS, SERENDIPV, VALHALLA, PROMISE

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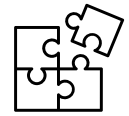
The promising high efficiency of perovskites as well as their potential low manufacturing cost could put this technology on a very rapid market growth path

Main potential assets of perovskites

High efficiency potential
(>30% by 2050)

Lower manufacturing costs

Smaller carbon footprint compared to c-Si



Free-form design options

Possibility for very low weight devices

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To quantify the market potential of perovskites, a methodology in 5 main steps has been applied, from global PV market development to PKS market penetration

Summary of the methodology used to evaluate the market potential of perovskites

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First, the PV market is modeled with a logistic curve that follows the historical evolution of the last 20 years up to 20 TW of cumulated PV by 2050

1. Estimate the evolution of the global PV market by 2050

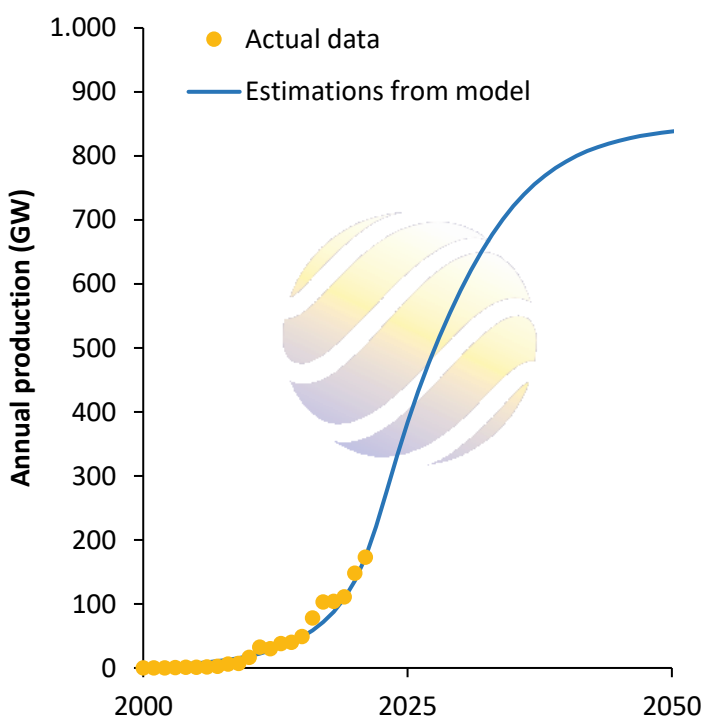
20 TW target in 2050
+
Data up to 2021

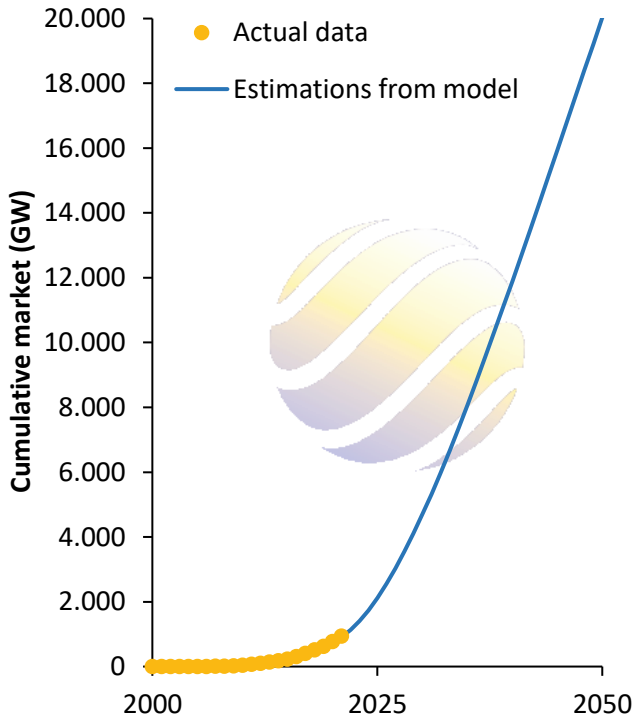
Regression with S-curve

Estimation of total market (annual and cumulative)

Inputs:

1. Historical market figures
2. Cumulative target of **20 TW of PV in 2050** (BNEF scenario target)





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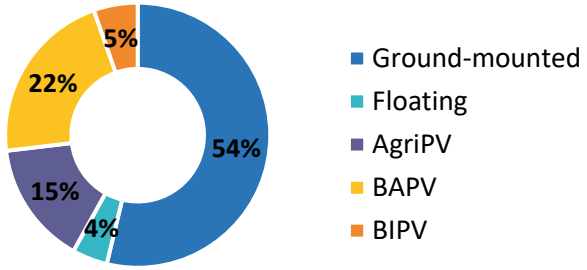
The market shares of the key PV sub-segments are then estimated based on past data, development potential, as well as cost and technical constraints

2. Estimate the evolution of PV market sub-segments

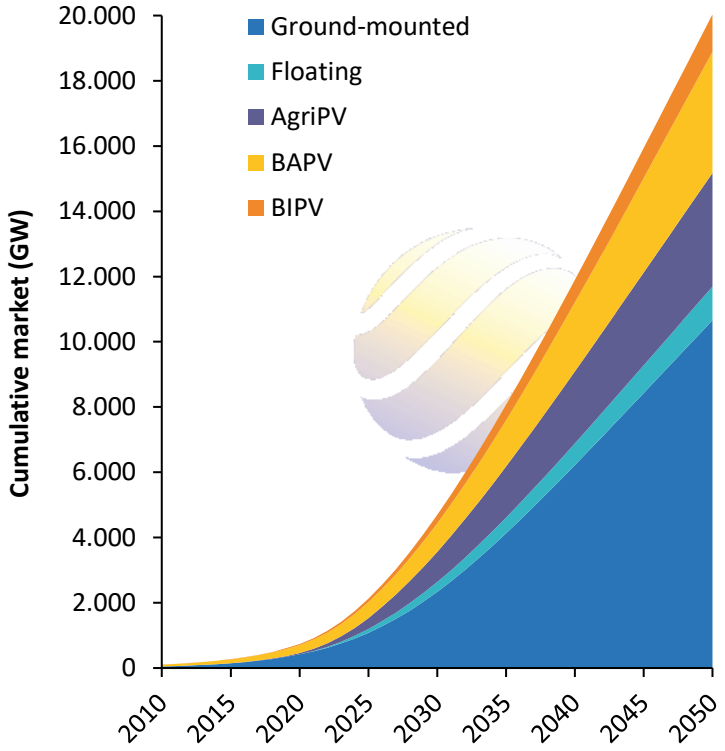
Total market & Data up to 2021

Estimation of annual market share by subsegment in 2050

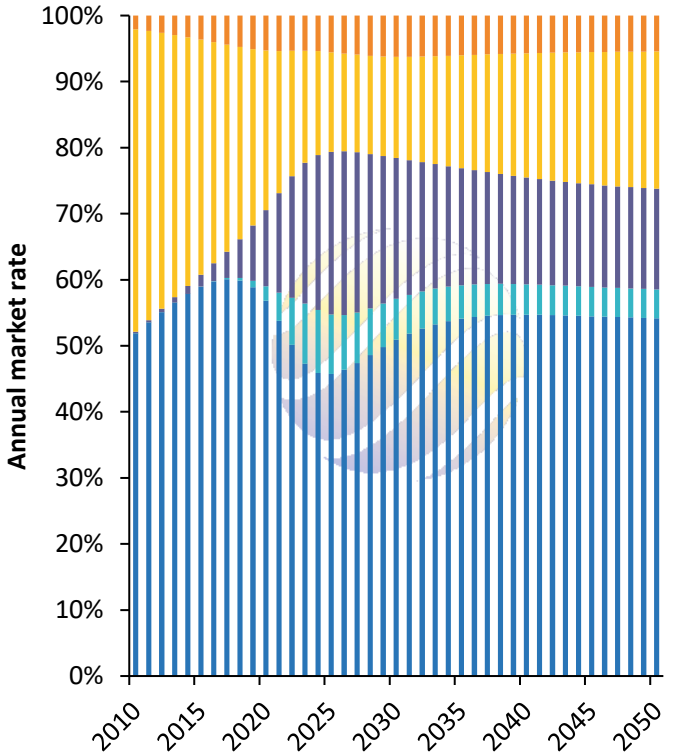


The estimated evolution of these sub-segments is made using an S-curve to **model the annual market and the cumulative market volumes per segment by 2050**.

Simulation of annual market share by subsegment by 2050



Estimation of subsegments evolution



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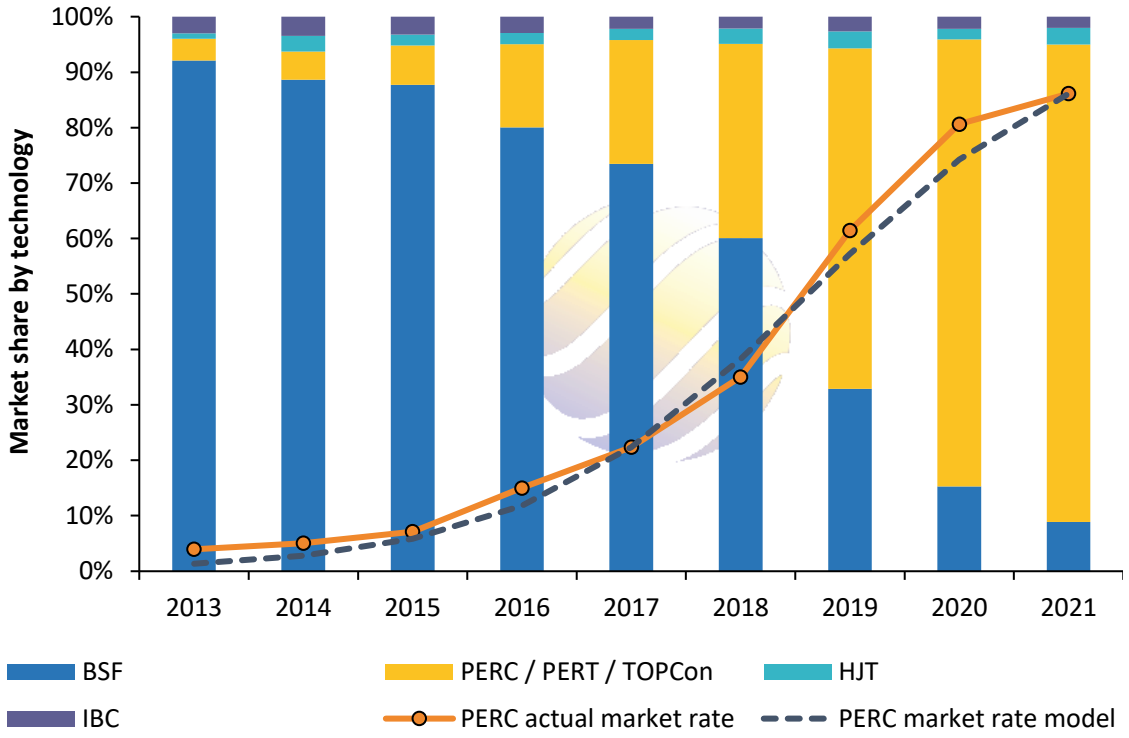
The annual market entry curve of perovskites is assimilated, as for previous technologies like PERC, to an S-curve between 2026 and 2034

3. Modeling the market entry of a new PV technology

Model the trend of how previous technologies entered the market

Apply it to the future penetration of the perovskites



- Market entry **S-curve based on PERC** in recent years
- **The maximum annual market penetration rate is** defined depending on the scenario considered
- First commercial product expected around **2026**
- **Lag time of 8 years** until peak adoption, around **2034**
- Note that these assumptions are **relatively optimistic**. Most experts do not expect commercial PKS products before 2030. Also, the lag time of 8 years is in the lower range of the spectrum of possibilities. It could easily by above 10 years in reality, as PKS are more innovative than PERC, thereby likely to face more resistance to change in the market.

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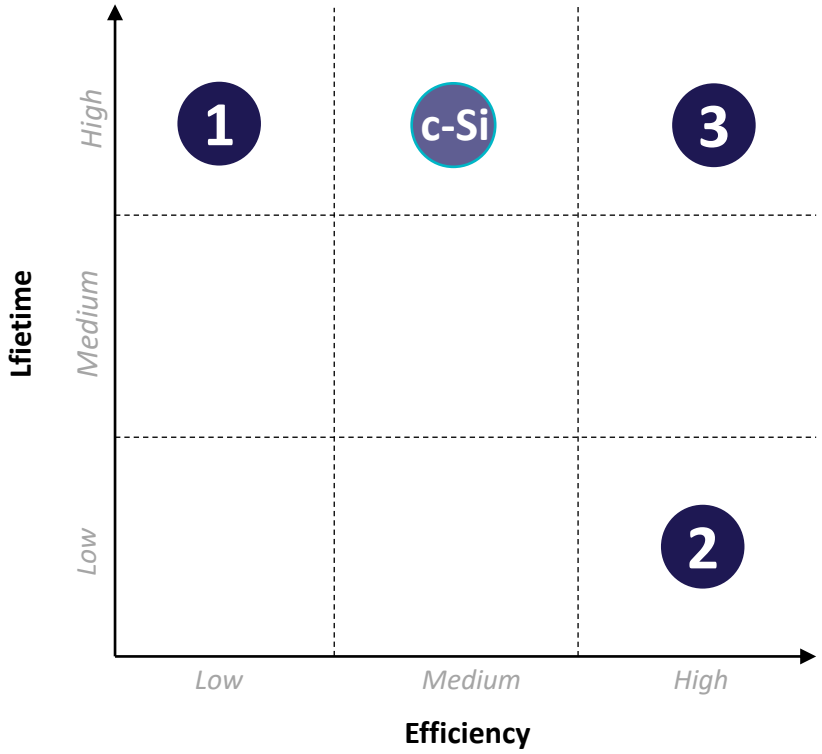
Depending on the module efficiency and theoretical lifetime of PKS modules, 3 market entry scenarios are envisaged, which will impact their maximal penetration rate

4. Definition of possible scenarios for market penetration of PKS depending on their performance

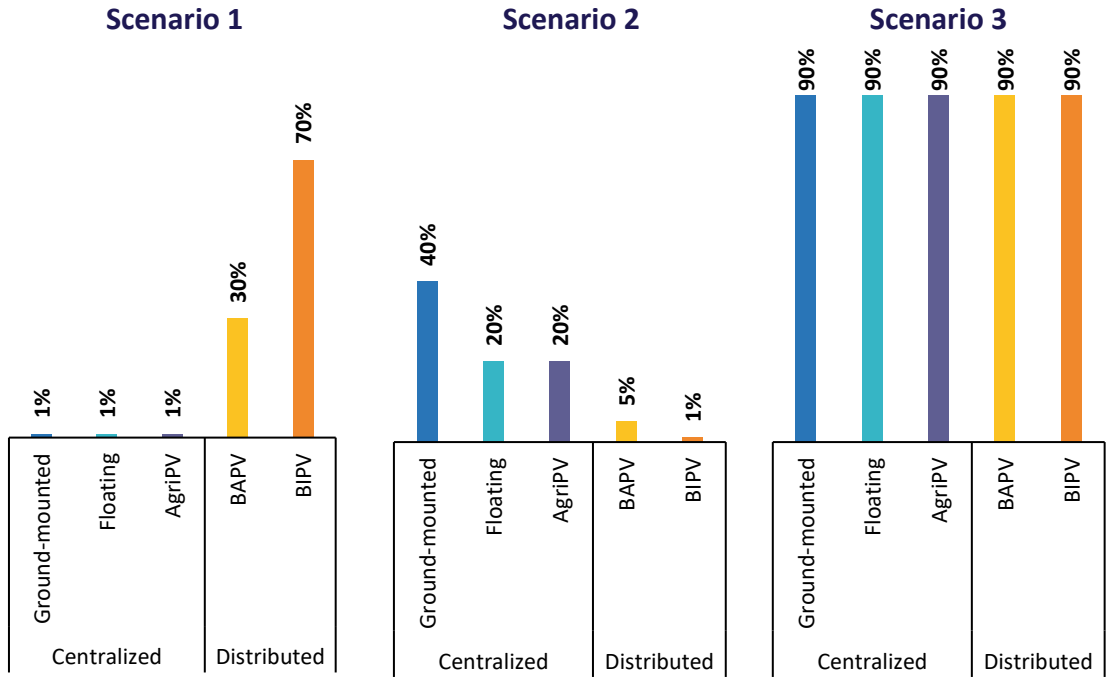
Define 3 possible scenarios regarding the performances of PKS

Deduce 3 market penetration scenarios for the perovskites, with their maximum annual market share by subsegment

Presentation of the defined scenarios



Maximum annual market share by sub-segment in each scenario scenario



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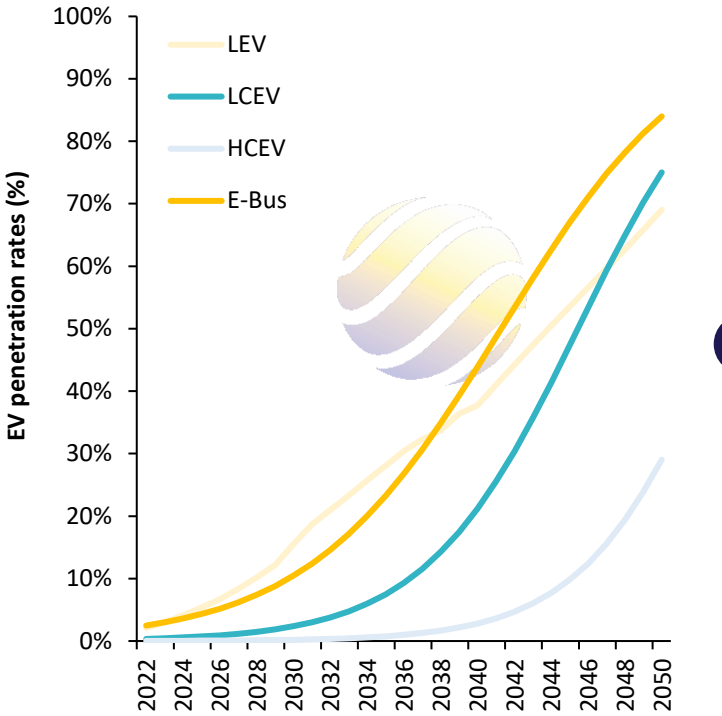
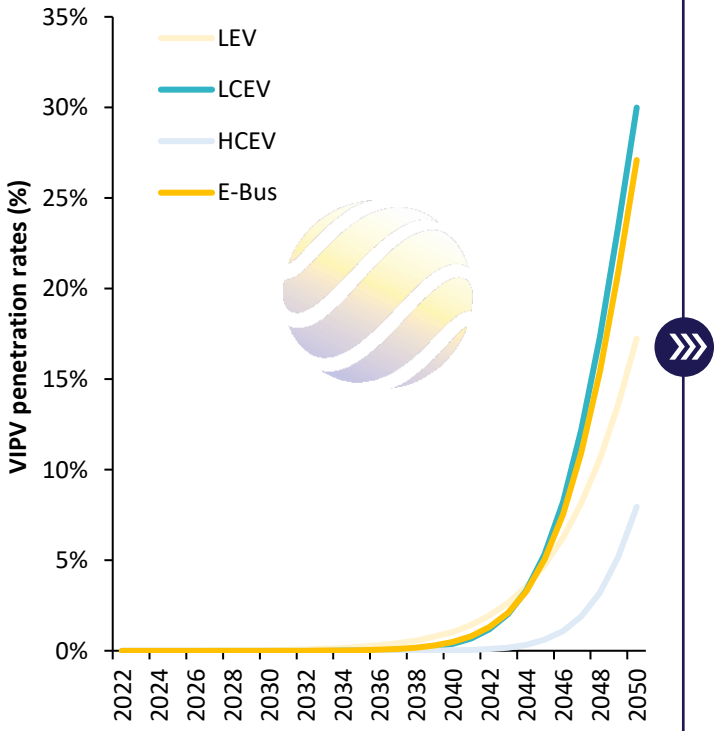
The VIPV market is expected to expand with the development of e-mobility and thus also constitutes an important source of growth for PV, including for perovskites

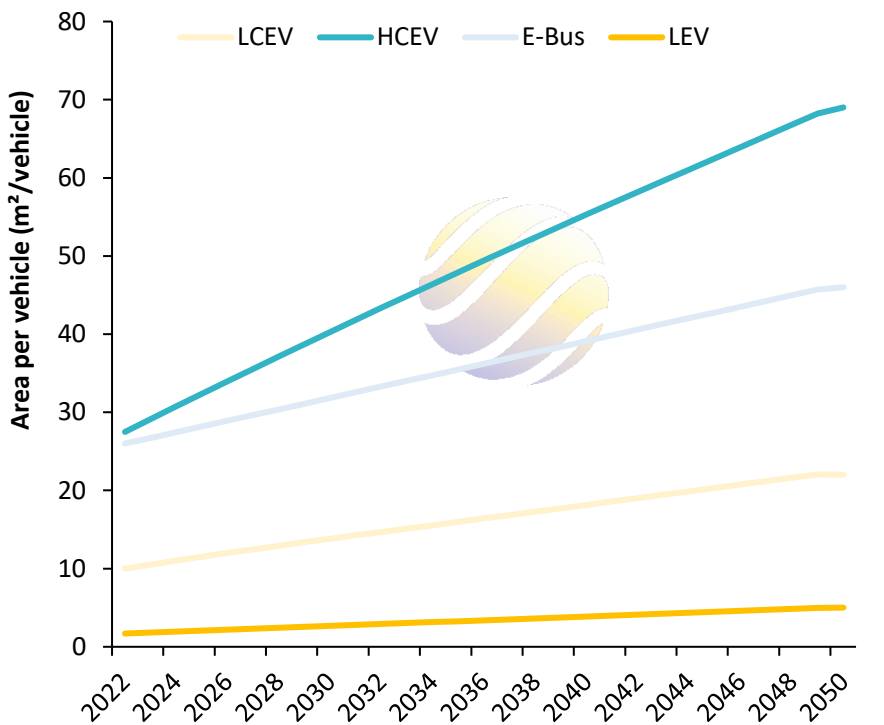
EV penetration rate estimation on automotive market



VIPV penetration rate estimation on EV market



Area per VIPV vehicle



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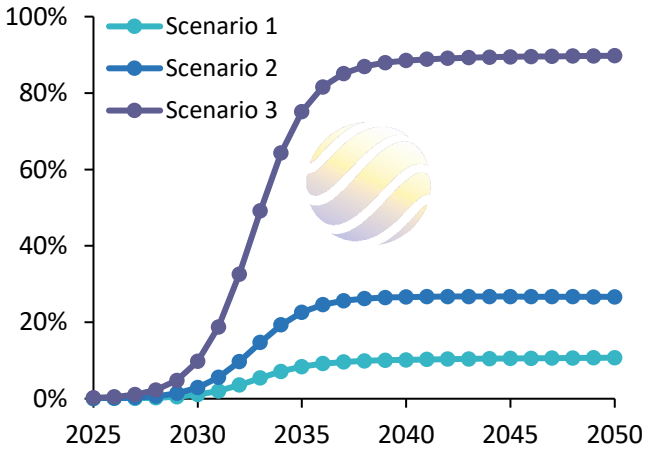
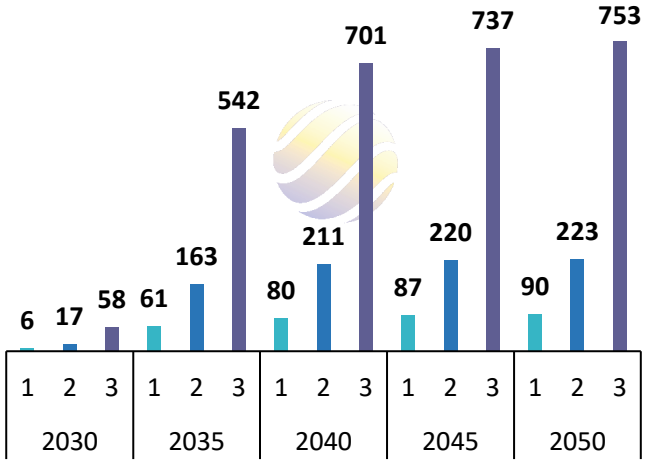
The penetration of PKS on the PV market will depend greatly on the performances achieved, with annual market values lying between 100 and 750 GW by 2050

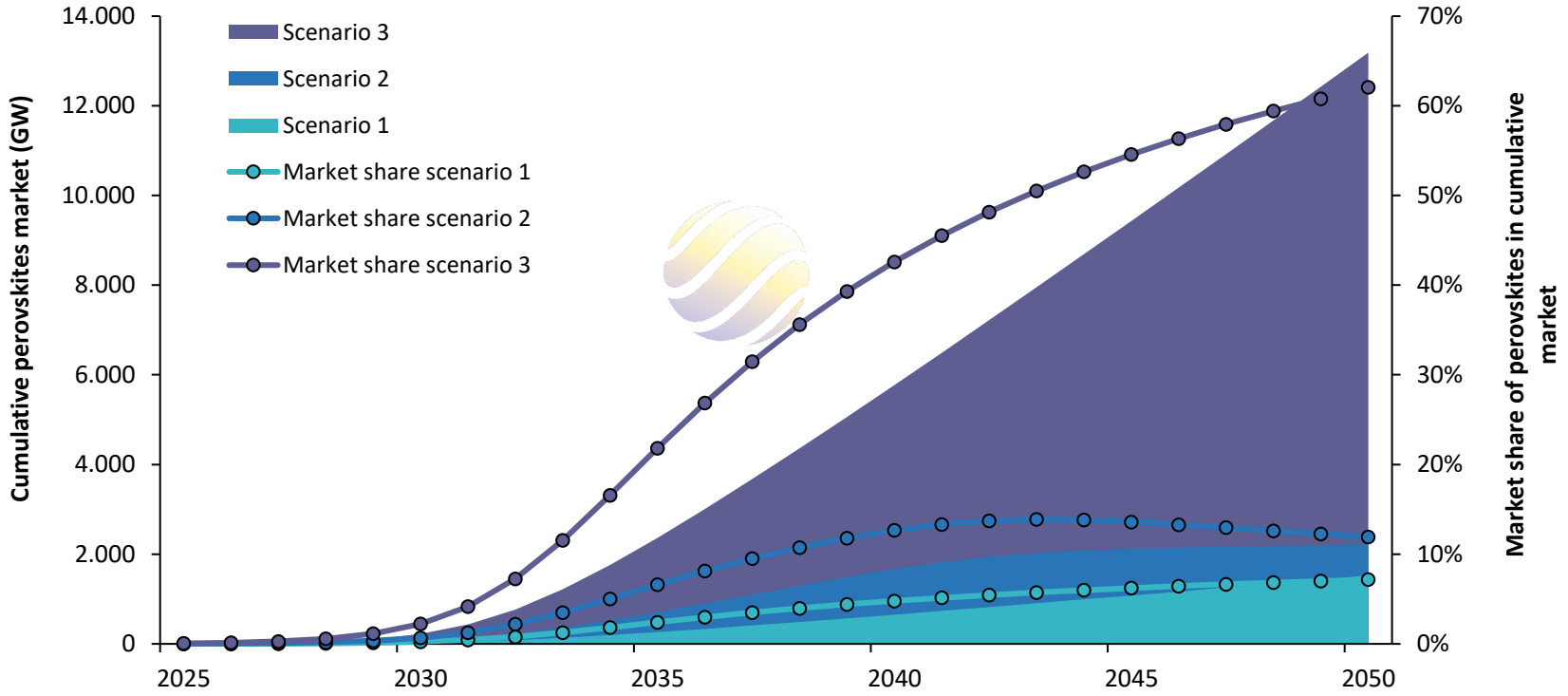
Market share of PKS in annual PV market



PKS annual market (in GW) by scenario



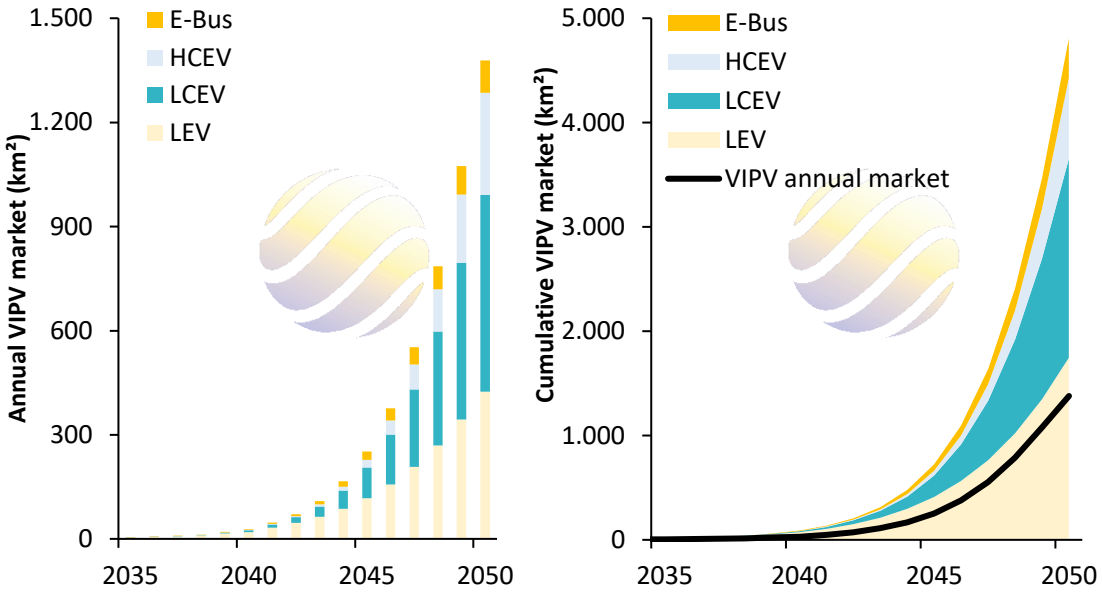
PKS cumulative installed capacities and market share



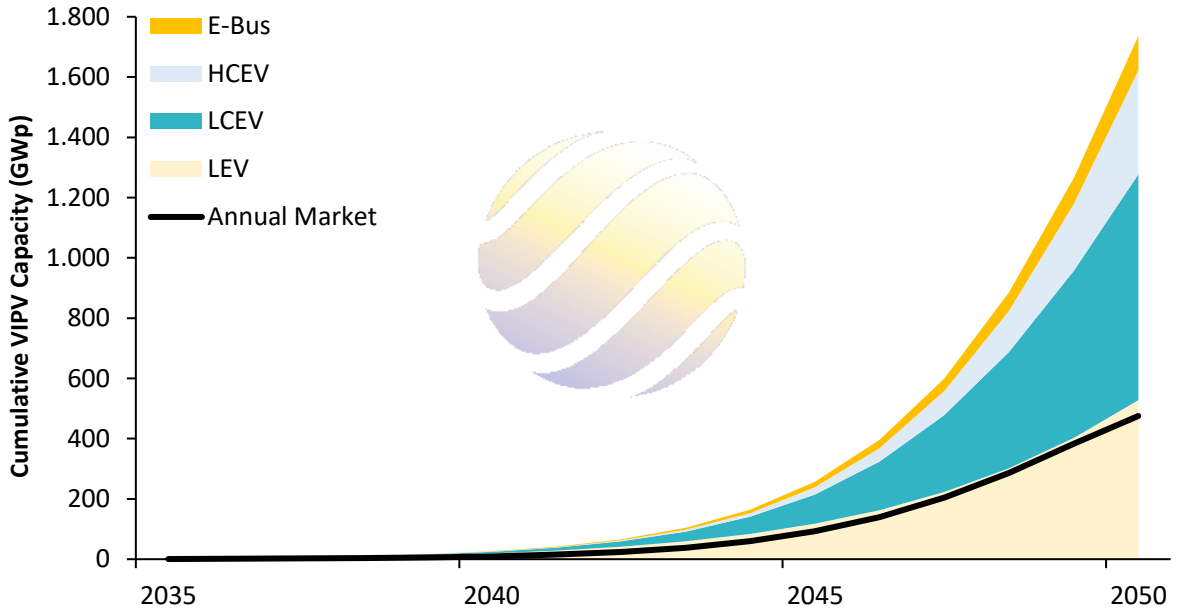
Scenario 1	Scenario 2	Scenario 3
• Annual market penetration: **<10%**	• Annual market penetration: **<30%**	• Annual market penetration: **<90%**
• Annual market: **<100 GW**	• Annual market: **~200 GW**	• Annual market: **>500 GW**
• Cumulative market by 2050: **<1,5 TW**	• Cumulative market by 2050: **~2 TW**	• Cumulative market by 2050: **>12 TW**

In addition to conventional grid-connected PV applications, VIPV could also be a major source of growth for PKS, where lightweight and aesthetics could be leveraged

Annual and cumulative VIPV area potential until 2050



Global cumulative VIPV capacity potential until 2050



- VIPV market is **currently almost non-existent**
- More than **1 000 km² sales per year by 2050**
- The annual and cumulative markets (quantified by area) are then **converted to capacity using the average efficiency** of different tandem cell technologies.
- It aims at **providing an order of magnitude of the VIPV potential.**

- Subpar module lifetimes compared with conventional PV technologies **should not be a barrier for PKS on the VIPV market** as EVs (first) lifetime is also constrained by **batteries' lifetimes and vehicle's useful lifetime**.
- Expected annual VIPV market of **1 GWp in 2035** and **475 GWp in 2050**, leading to a cumulative VIPV market of 1736 GWp by 2050 would be within range for PKS **if they reach attractive efficiencies**

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The market potential of PKS is highly dependent on the ability of this technology to hold its promises in terms of cost, efficiency and stability, which remain subpar

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1. The gateway to commercialization for perovskites could be the **IoT market**

2. Looking at grid-connected PV applications:
   - PKS will fail to penetrate **significantly** the market if attractive **lifetime and efficiency are not reached simultaneously**
   - BUT… in a global PV market in the TW range, low annual penetration rates can still lead to **attractive absolute volumes,** focusing on **niche segments**
   - In the best-case scenario, PKS could capture **a vast majority of the market, on all segments**
   - BUT… the **market is taking-off now**, and PKS need to hit the market as fast as possible to avoid missing the ship

3. PKS have a **large potential in the VIPV market** due to their characteristics. BUT… **lead-content** may pose a potential barrier

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Thanks! Questions are welcome

Contact: **p.mace@becquerelinstitute.eu**

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