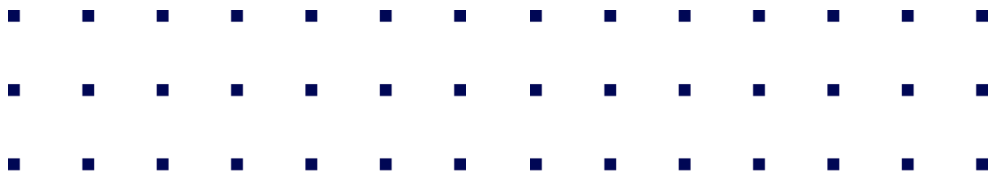




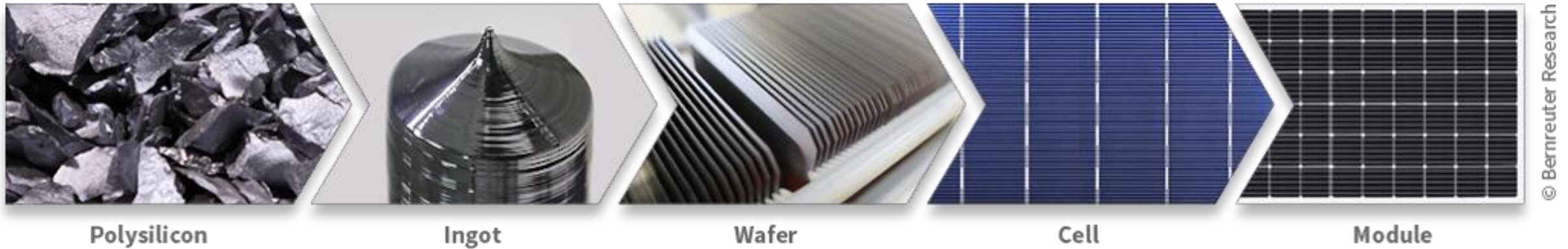
BECQUEREL INSTITUTE
Strategy Consulting in Solar PV

PV Value Chain

By Gaëtan Masson

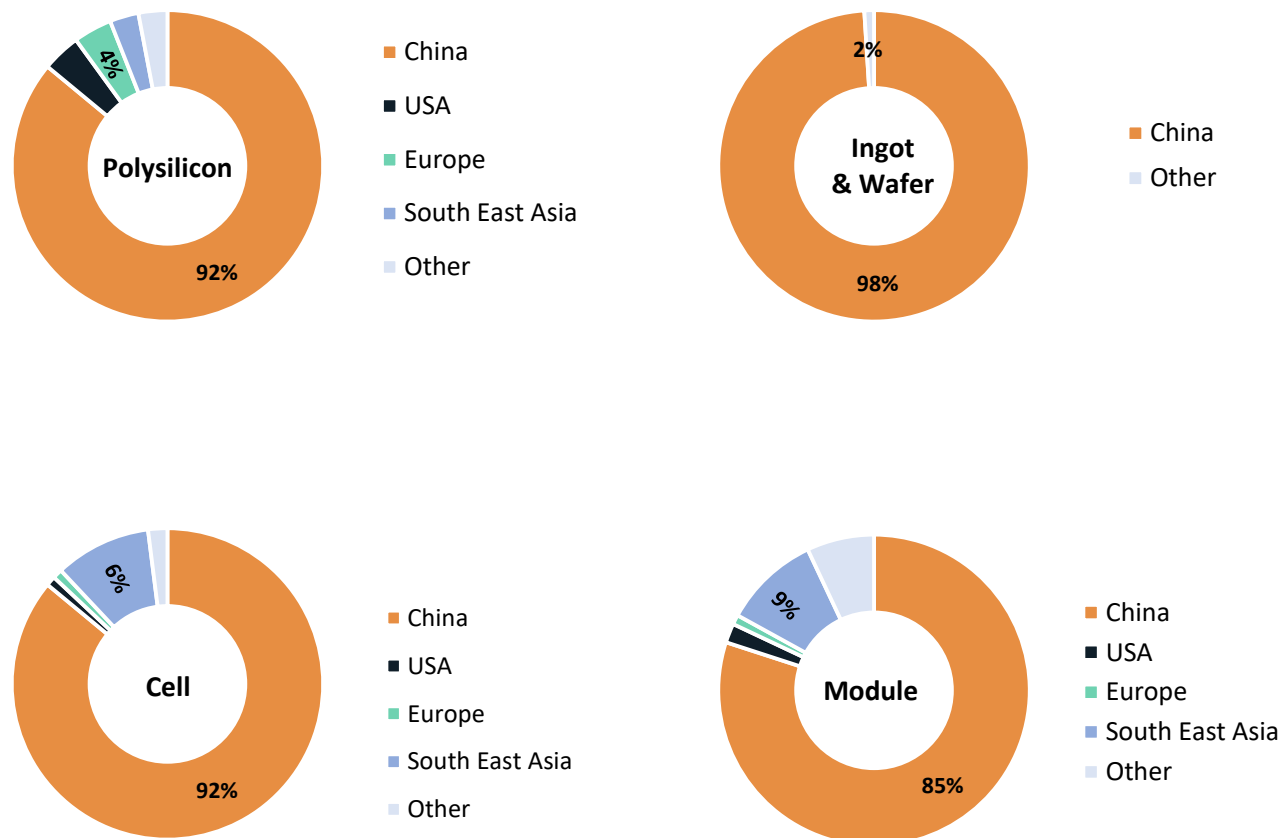


The c-Si PV supply chain (98% of the PV value chain today)



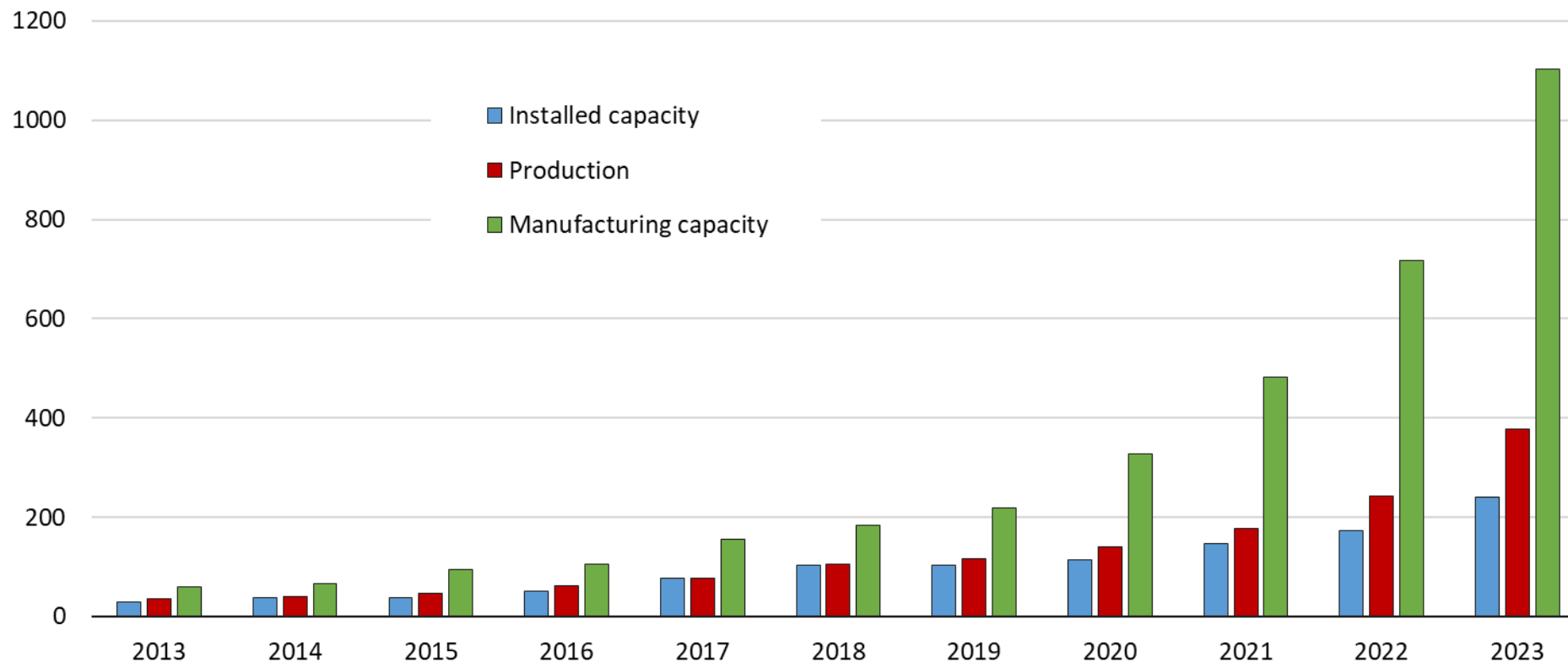
The PV industry is highly concentrated in Asia, especially in China, at all steps of the value chain, with Europe playing a minor role overall

Geographical distribution of production capacities across the c-Si value chain by end of 2023



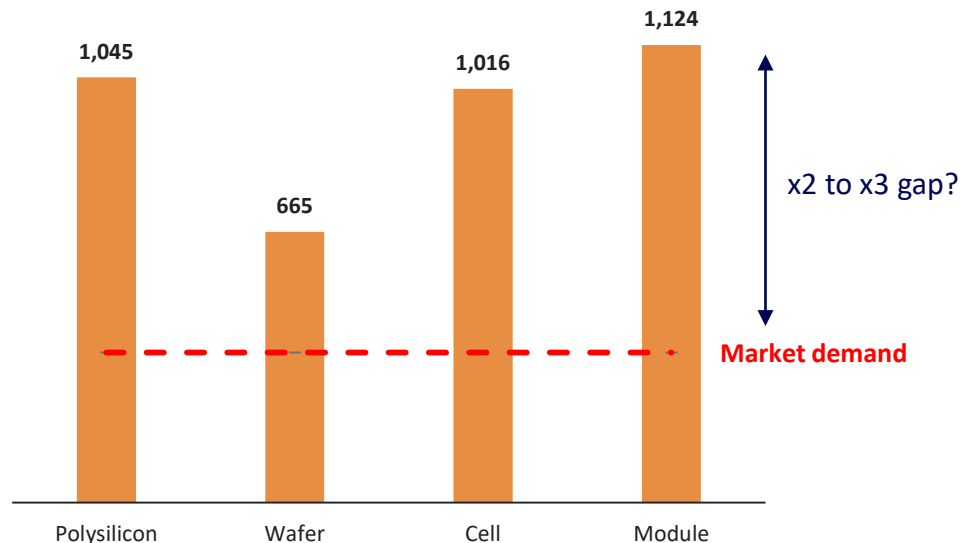
Production capacities' expansion have already led the industry to overcapacity, leading to unsustainable prices along the entire value chain and endangering the sector

Global PV installations compared to the production and manufacturing capacity (GW)

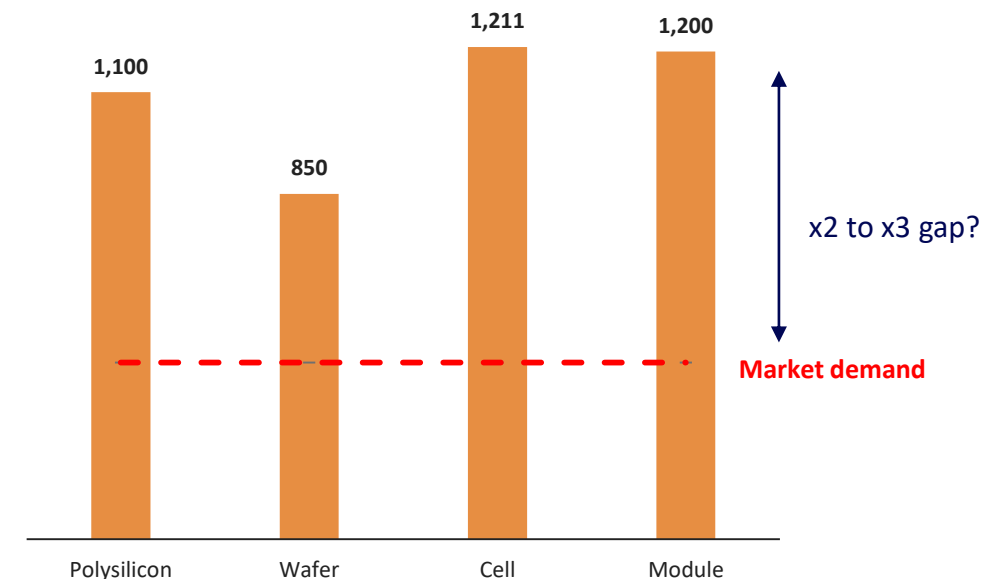


The overcapacity situation is not expected to change in the short-term, which will lead to increasing economic losses, also for big actors, and consolidation, with small actors disappearing

Production capacities vs Market demand (2024)



Production capacities vs Market demand (2025)



1

Overcapacity is present at all steps of the solar PV value chain. This has triggered a **strong downward pressure on prices of all components**.

2

The **ongoing price war** creates many **difficulties for both market incumbents and new entrants**, in China and outside.

3

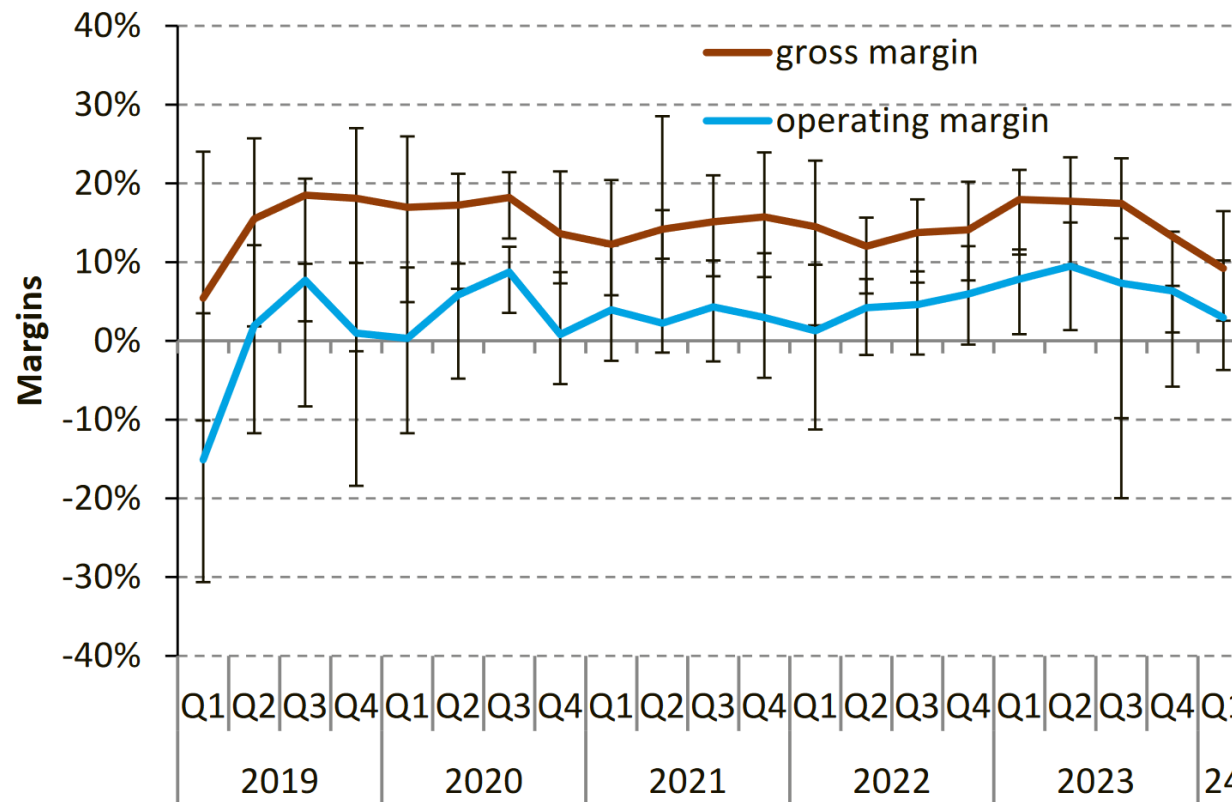
Consolidation is expected in the short-term, as **only companies that can handle losses or paper-thin margins** for a duration 12 to 24 months will survive.

4

Overall, **this strategy of massive capacity expansion is a deliberate strategy by major actors**, allowing to create a natural barrier to entry for new entrants

All actors are suffering, even the major ones, with revenues decreasing much faster than costs, leading to decreasing margins

Comparison of PV manufacturers' margins

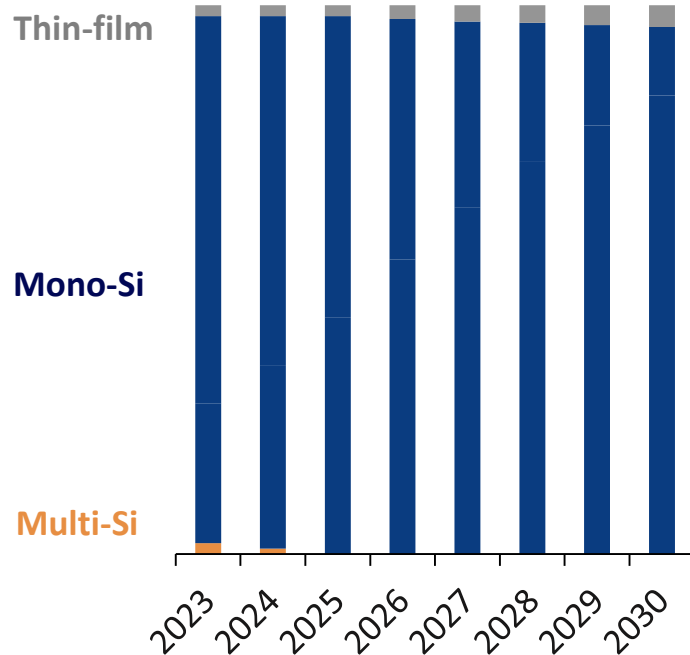


3rd quarter of decline in a row...
where will it stop?

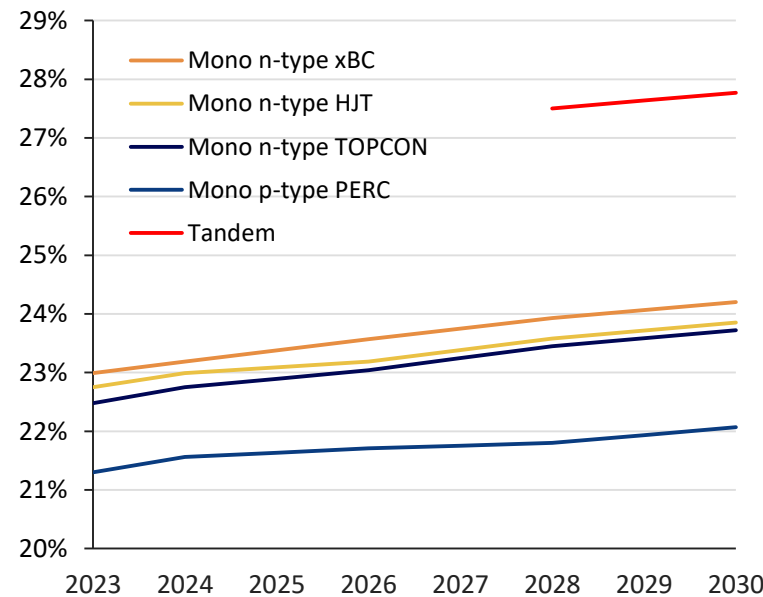
Source: NREL

An impressive array of PV cells technologies exist, with an increasing number of thin film options, although only a few are mature and competitive

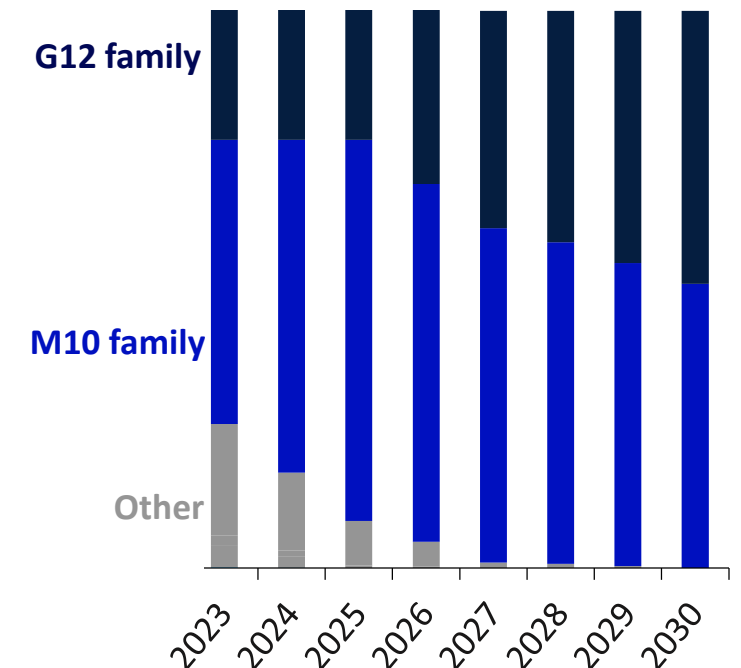
PV market share per technology: mono c-Si will keep on dominating, in particular n-type



PV module efficiencies: mono c-Si n-type technologies will converge and soon

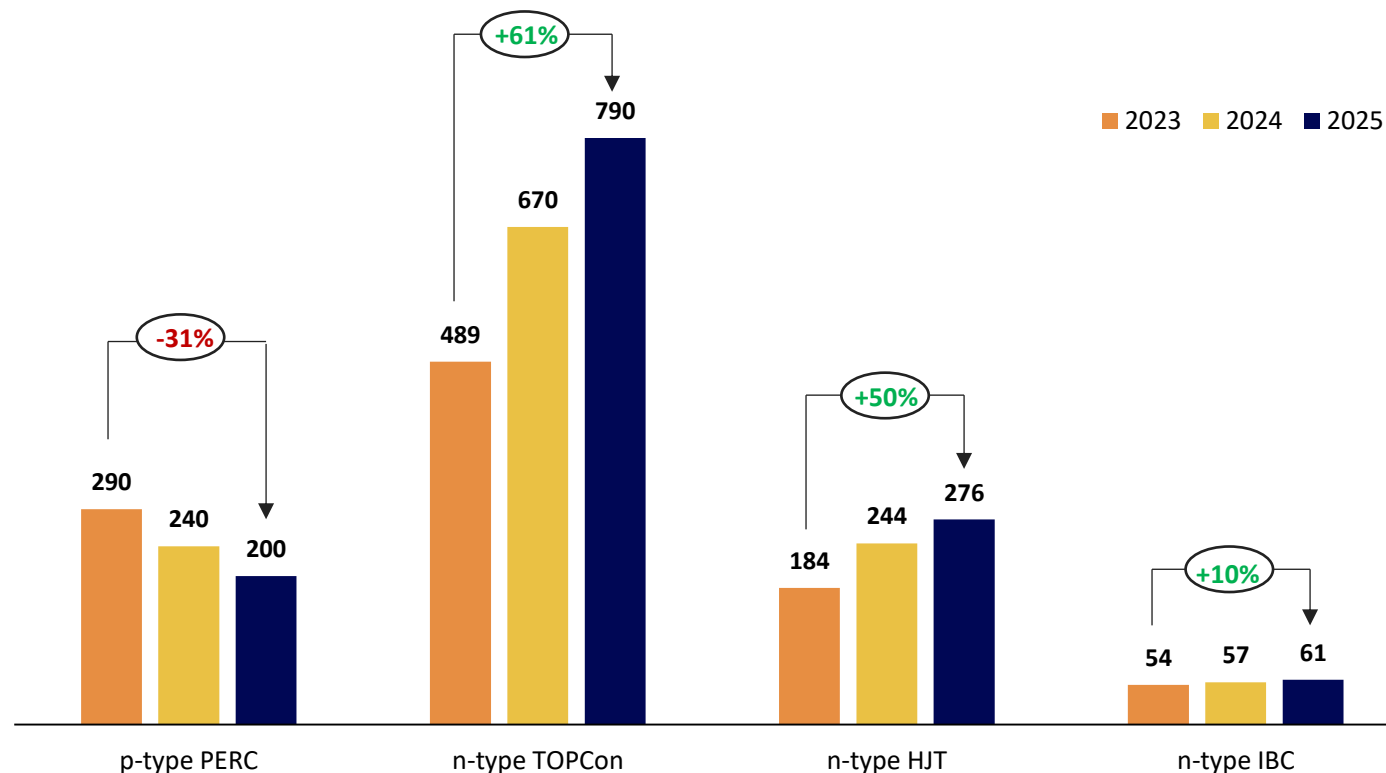


PV market share per wafer size: large wafers have rapidly taken over & will reinforce their position



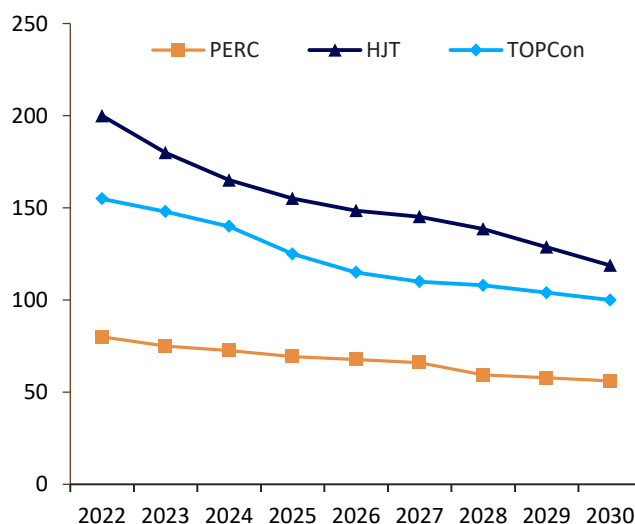
PERC is already being ditched and its capacity will soon disappear, as n-type technology cells are the number 1 choice for capacity expansions, especially TOPCon

Estimated global production capacities per cell technology in GW

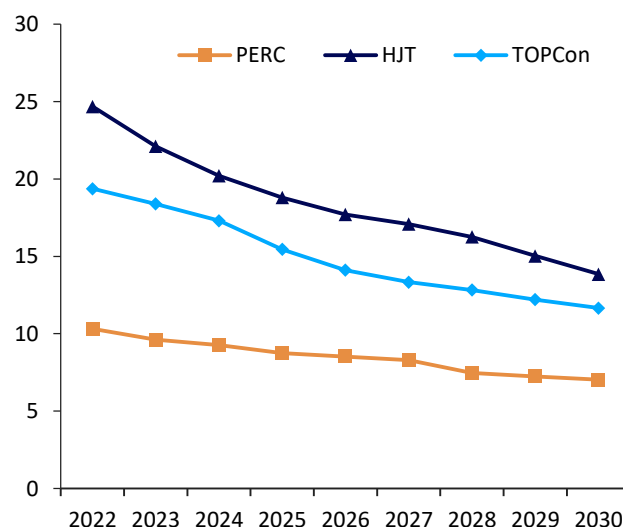


Few doubt of the ability of n-type c-Si to dominate or at least play a major role on the solar PV market even after 2030, but threats exist in terms of material supply, e.g. concerning silver

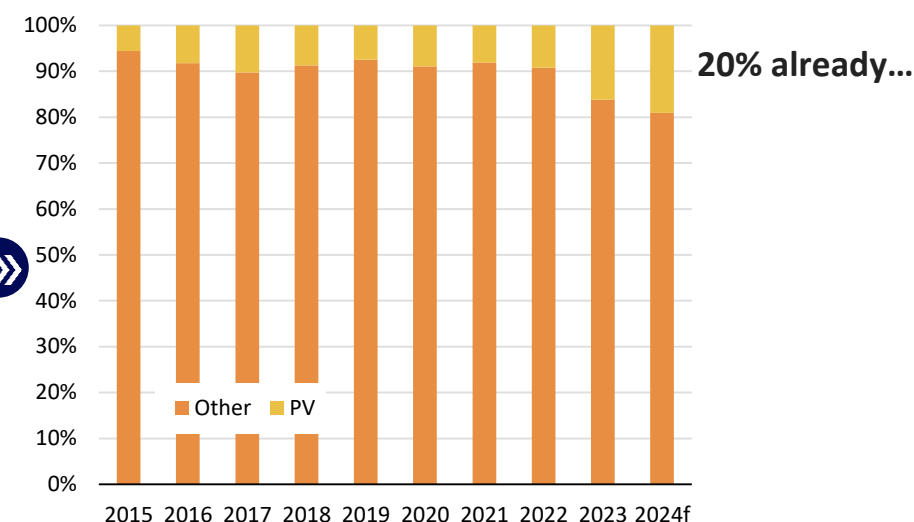
Average Ag use per technology (mg/cell)



Average Ag use per technology (mg/Wp)

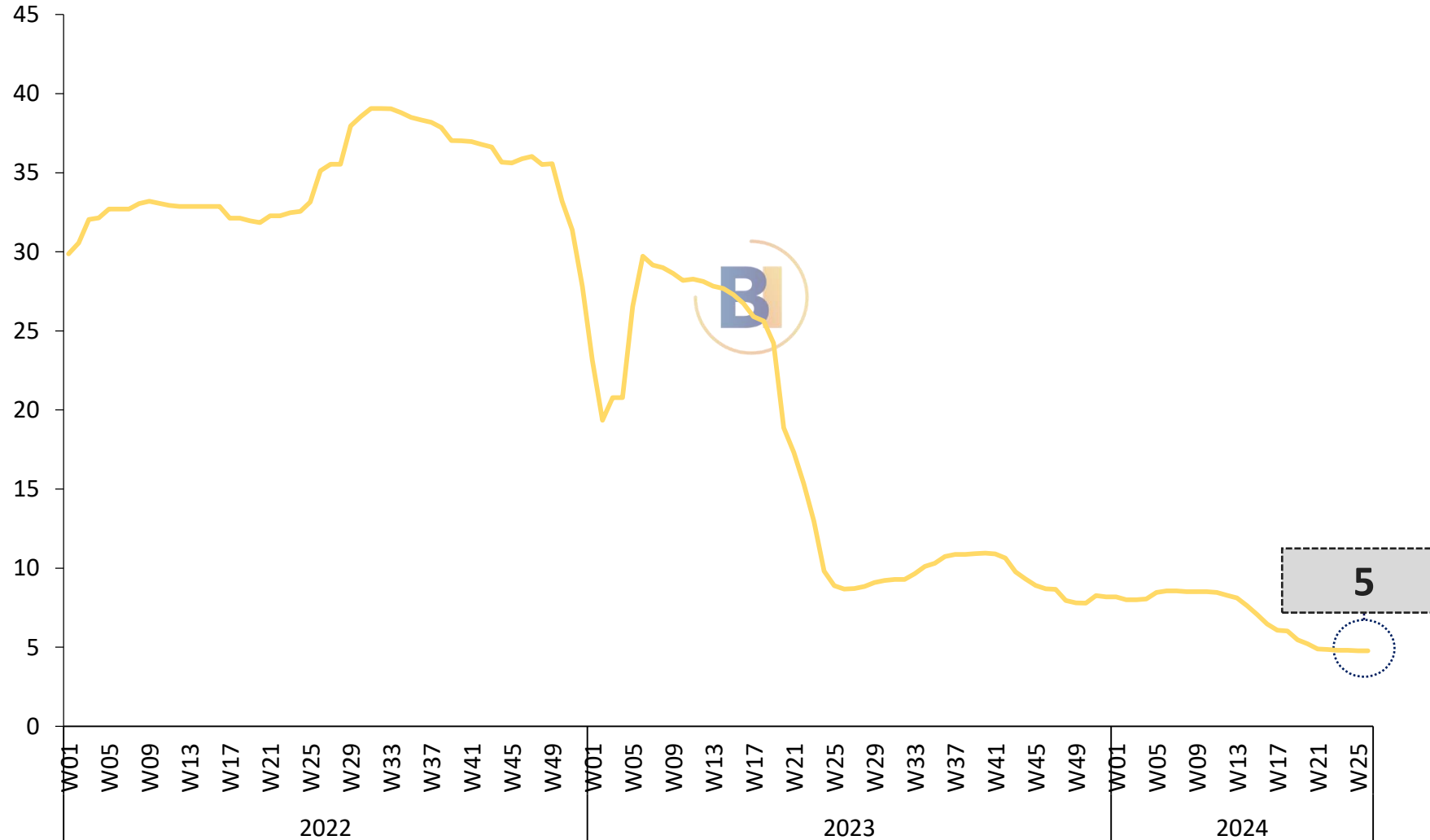


Share of PV in the global silver demand

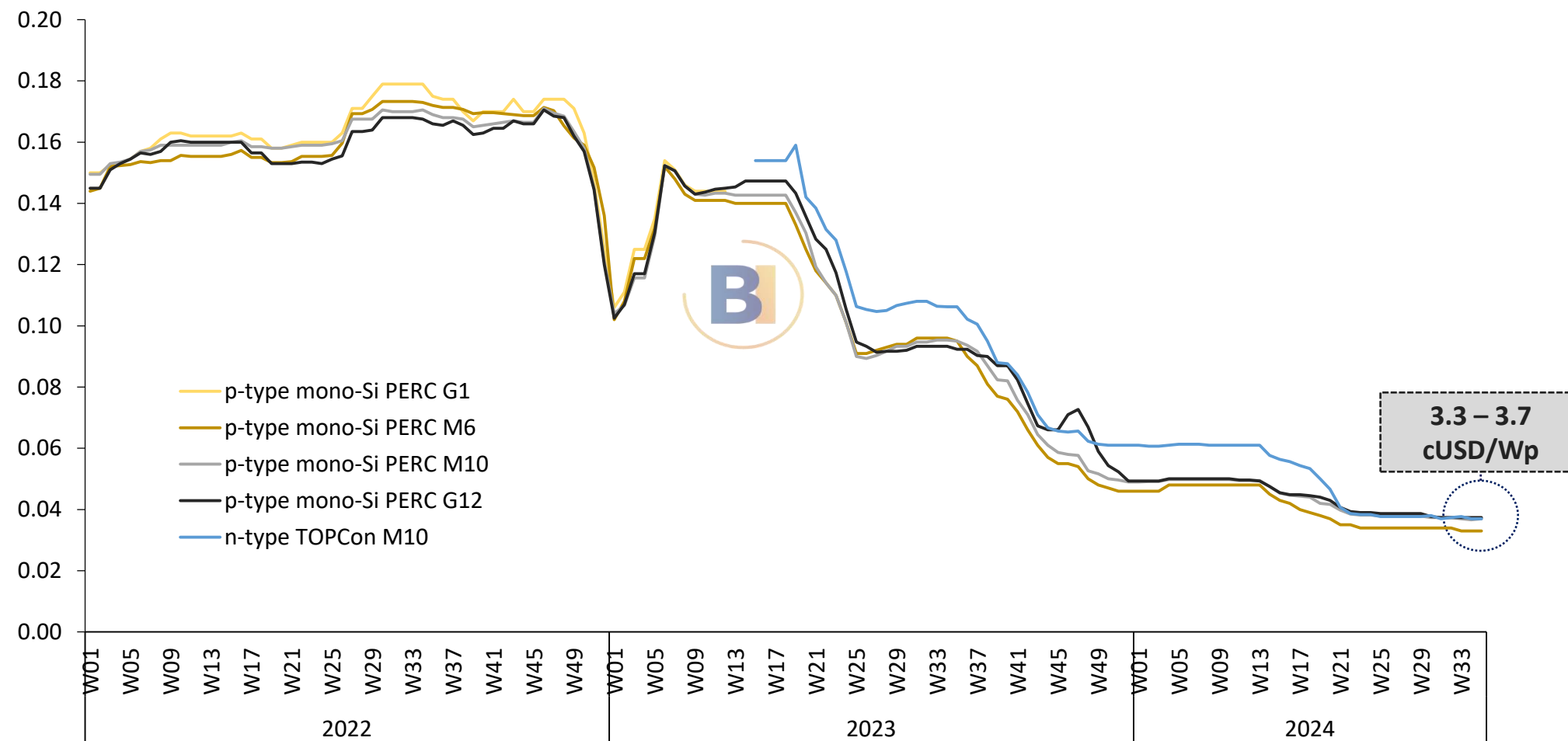


Note that TBC's average consumption of Ag is difficult to define, as it refers to a cell architecture rather than to a cell technology. Back contact can be associated with multiple cell technologies. Here, presented values are an average from the back contact technology as designed by ISC Konstanz ("polyZEBRA").

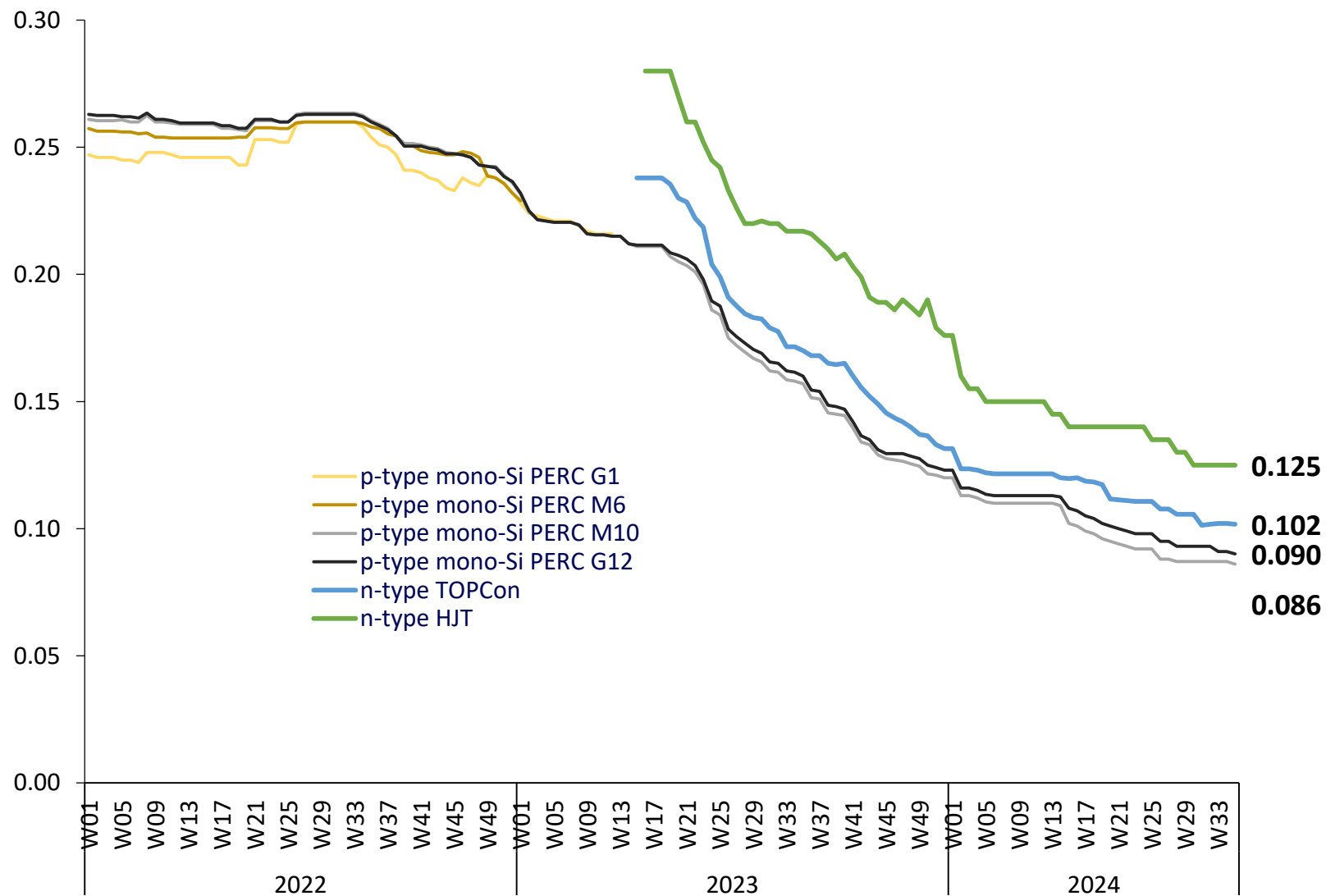
Evolution of POLYSILICON spot prices in USD/kg



Evolution of CELL spot prices in USD/Wp

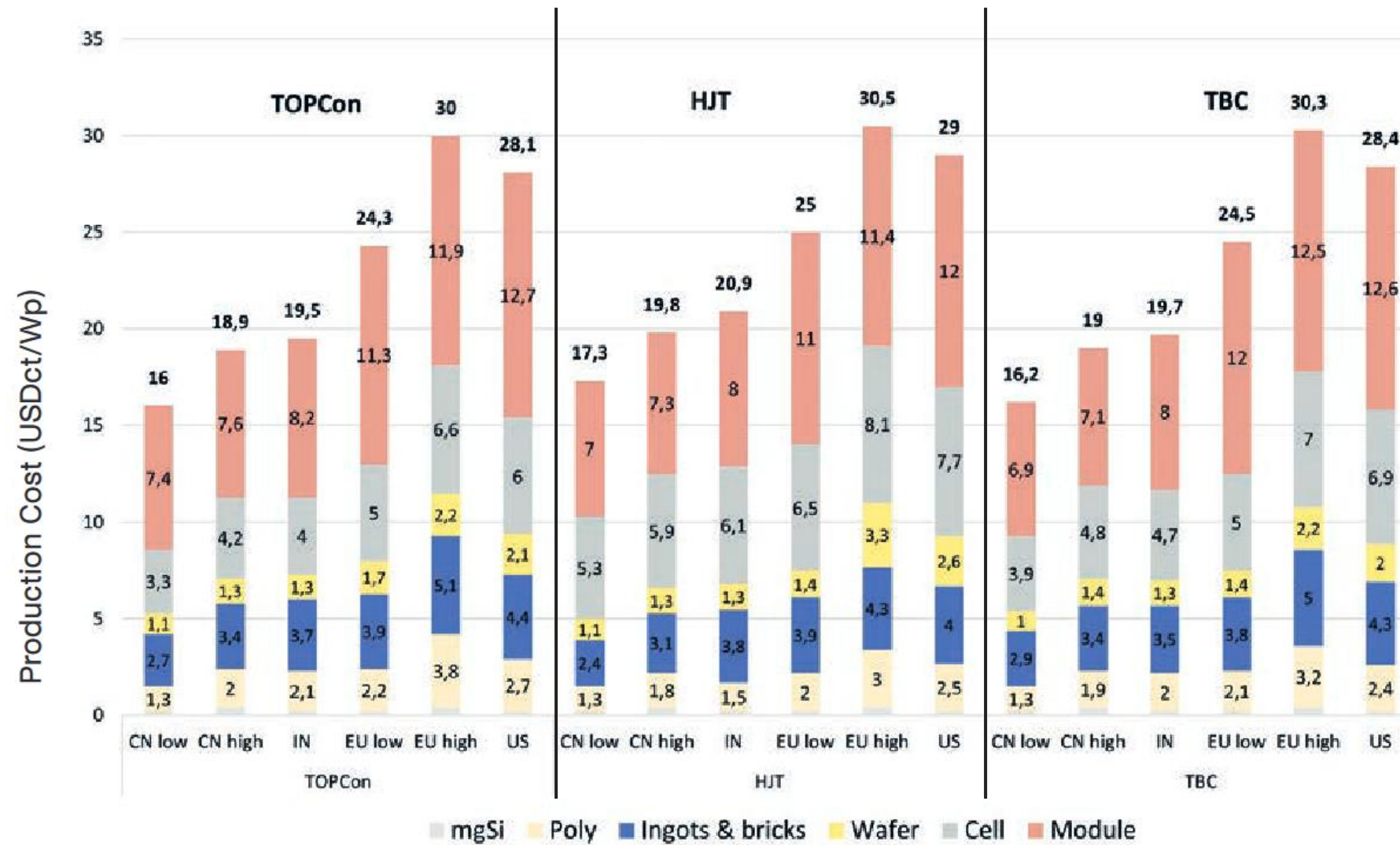


Evolution of MODULE spot prices in USD/Wp



PERC
< 0.10 USD/Wp

Comparison for a 5 GW vertically integrated factory in different regions



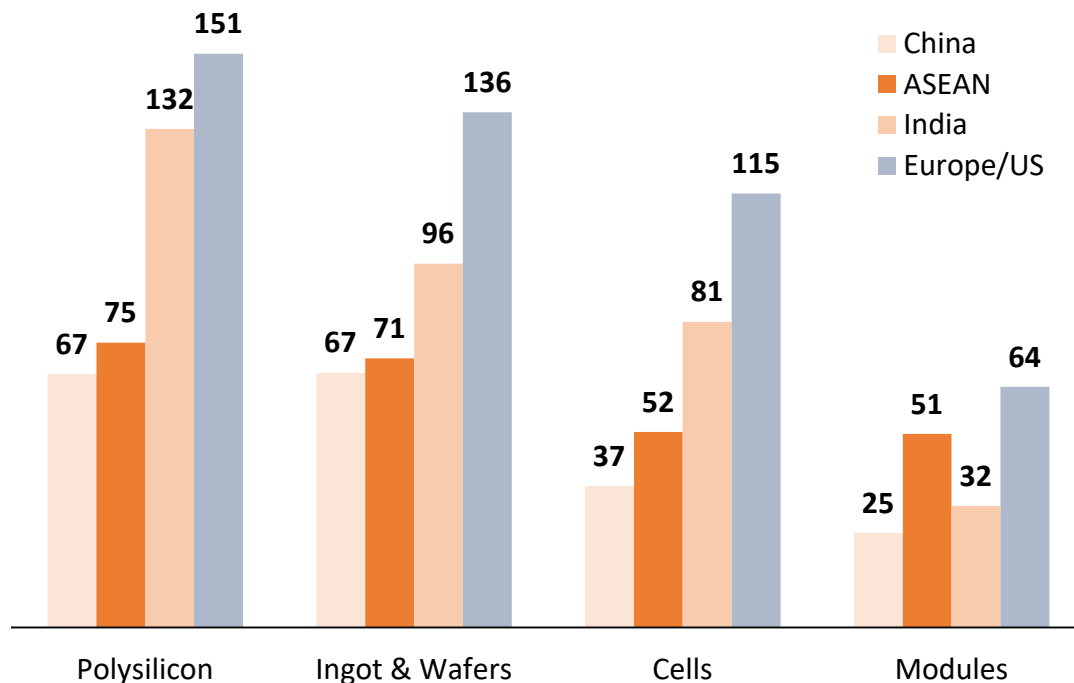
Key factors to consider

- CAPEX needed
- Utilities cost (especially electricity)
- Footprint (land availability & cost..)
- Scale
- Operating time
- Operational excellence
- Vertical integration level
- Labour cost

Source: ETIPV PV & RCT Solutions

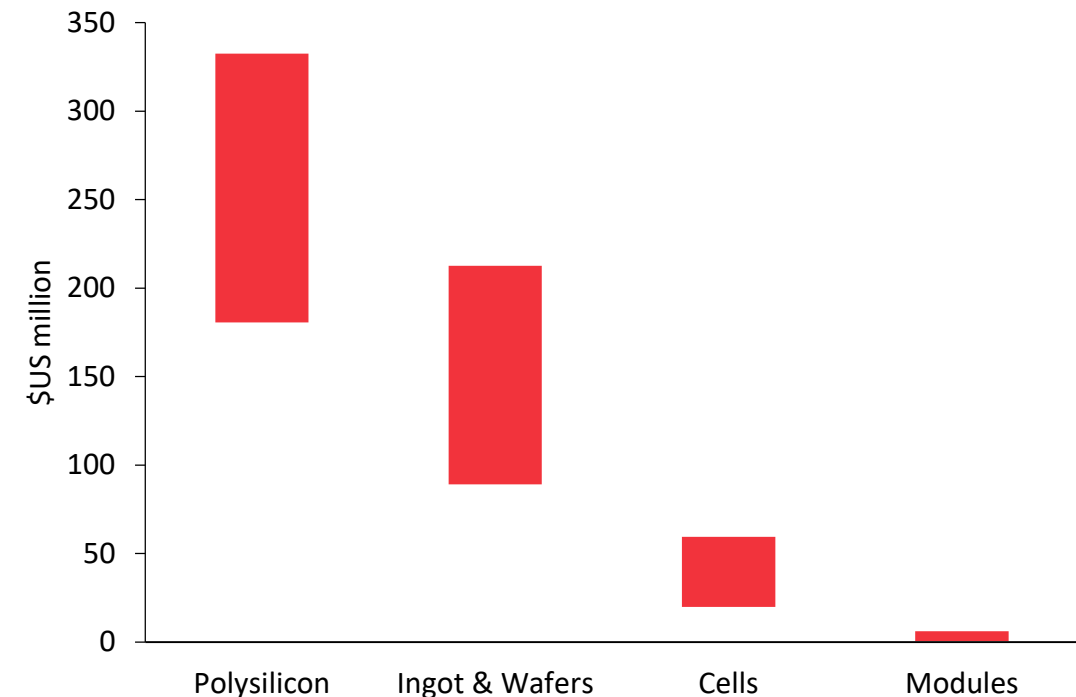
The first key constraint when talking about manufacturing cost is the initial investment (CAPEX)

Average capital investment intensity per region & per value chain step [MUS\$/GW]



Source: IEA

Average minimum investment required per value chain step



Source: IEA

The solar PV industry is in transition phase

- 1 The global PV market is on an upward trend and proved its resilience. It is expected to keep on growing and the **500 GW/year threshold is in sight.**
- 2 **The race to efficiency gains and cost reductions is still on.** The market is rapidly transitioning to n-type, with TOPCon already being the new mainstream. HJT and IBC are growing but still lagging behind
- 3 Global **modules' spot prices** are in freefall, pushed by **production capacities' expansion which have already led the industry to overcapacity.** This will lead to consolidation, and prices should stabilize upwards by the end of 2025.
- 4 Many solar PV manufacturing projects have been announced in Europe, USA, India, but the road remains full of obstacles. **With the right supporting measures, they could compete with Asian imports without damaging the development of solar PV market.**