

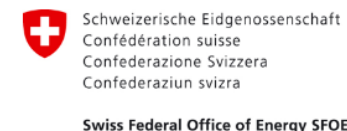


Metallization & Interconnection

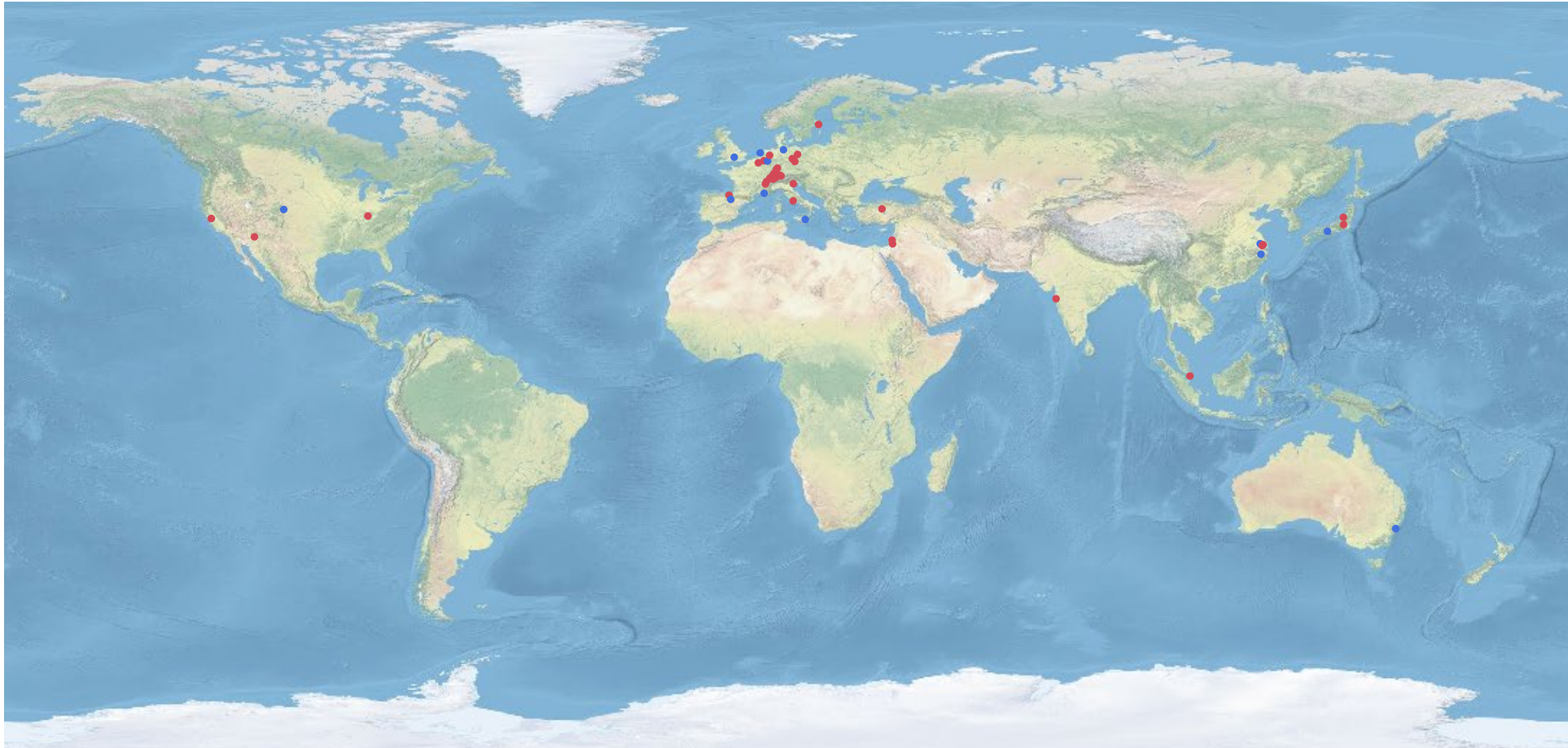
WORKSHOP 2023

11TH EDITION for Crystalline Silicon Solar Cells

Our Sponsors



Location of participants



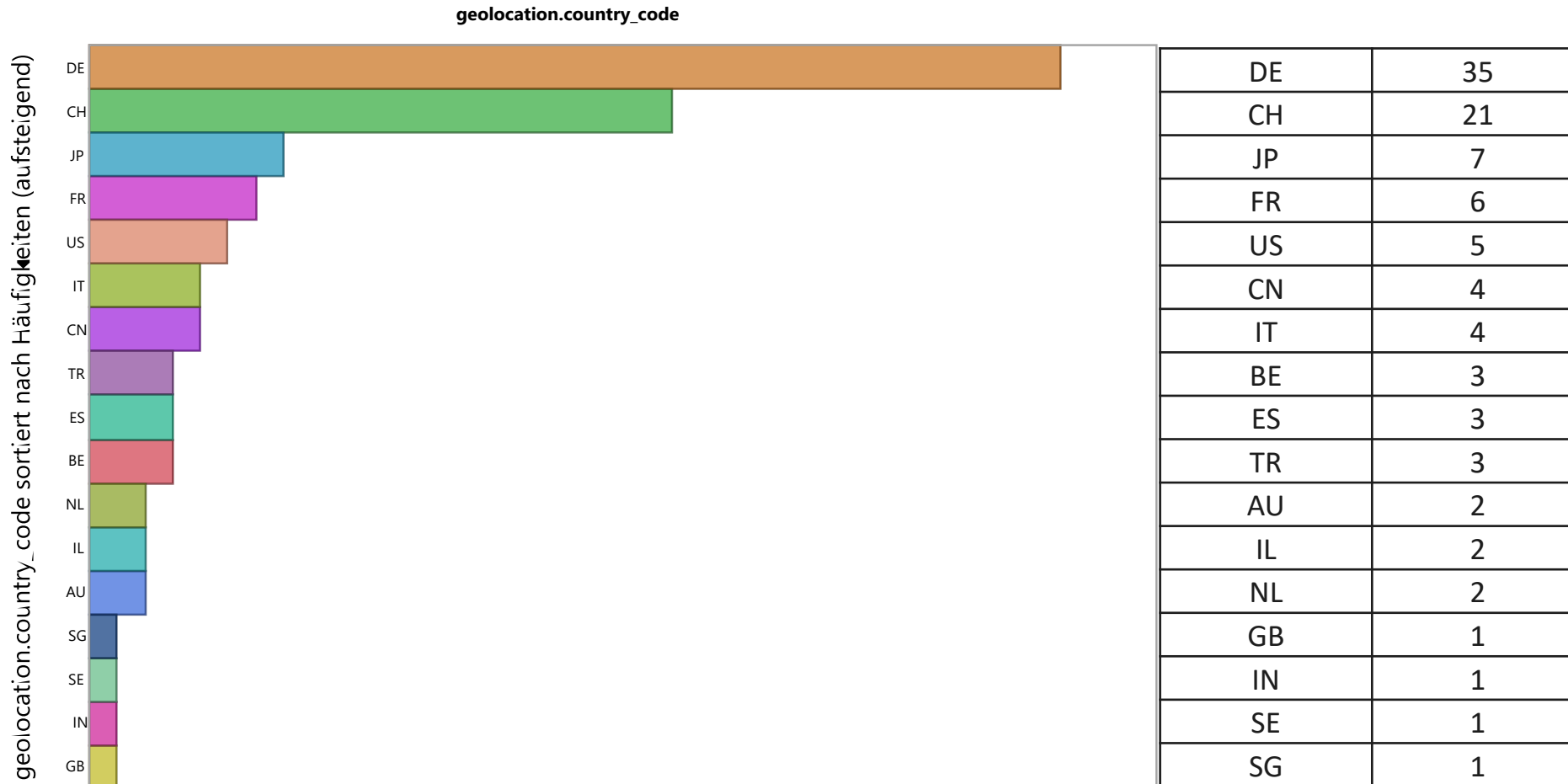
MIW 2023

103 participants

17 countries

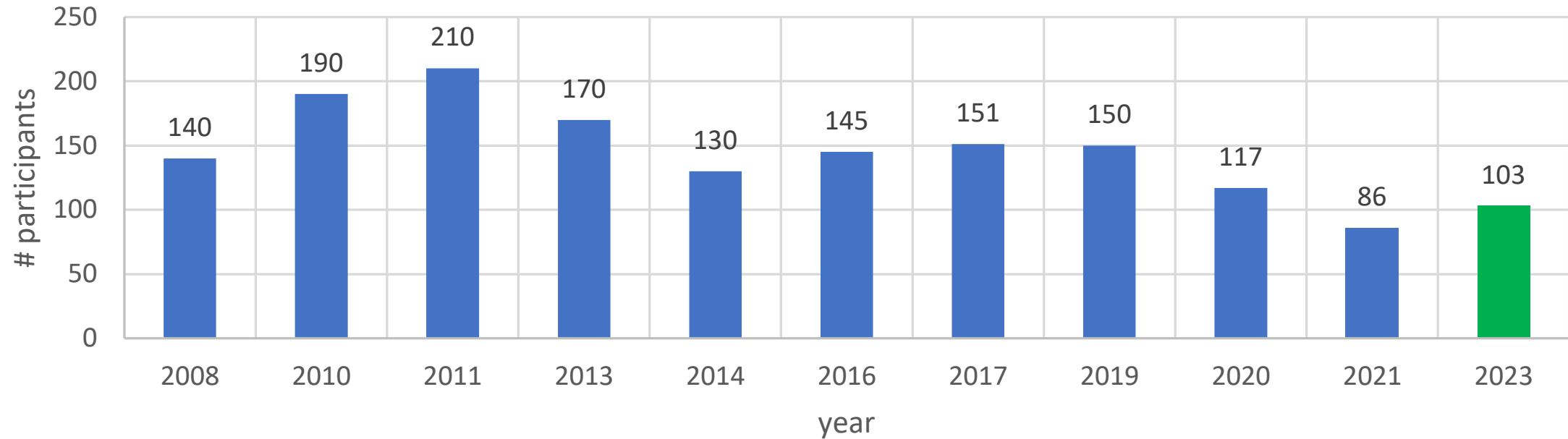
87 onsite /16 online

Distribution of countries



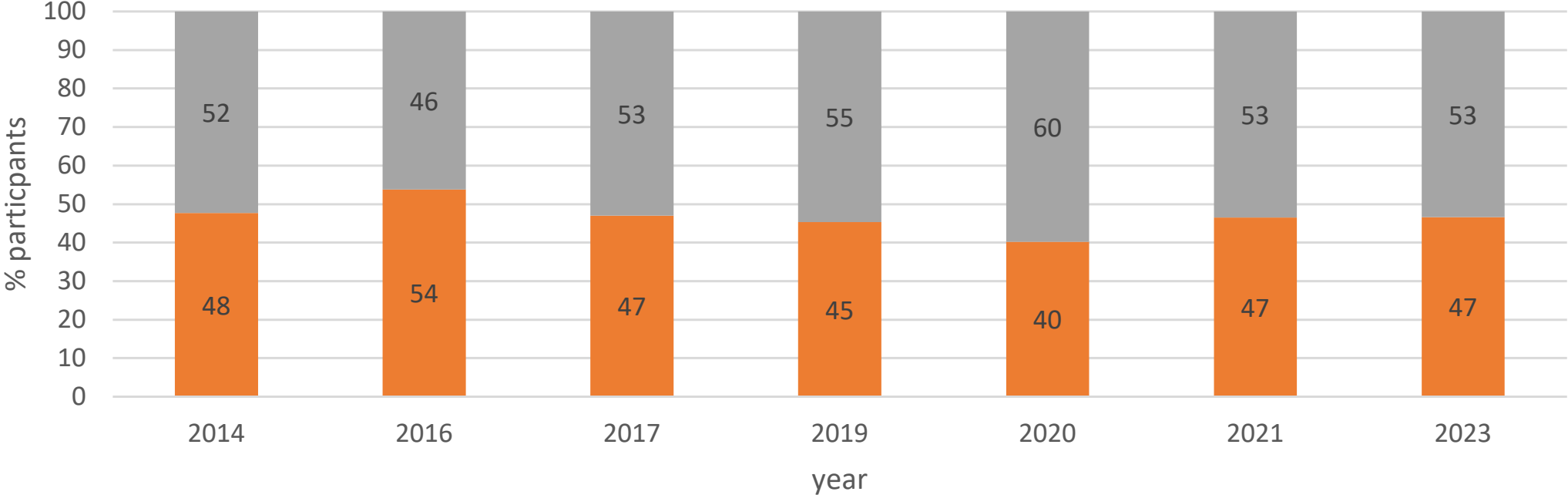
Number of participants of time

participants for last 11 editions

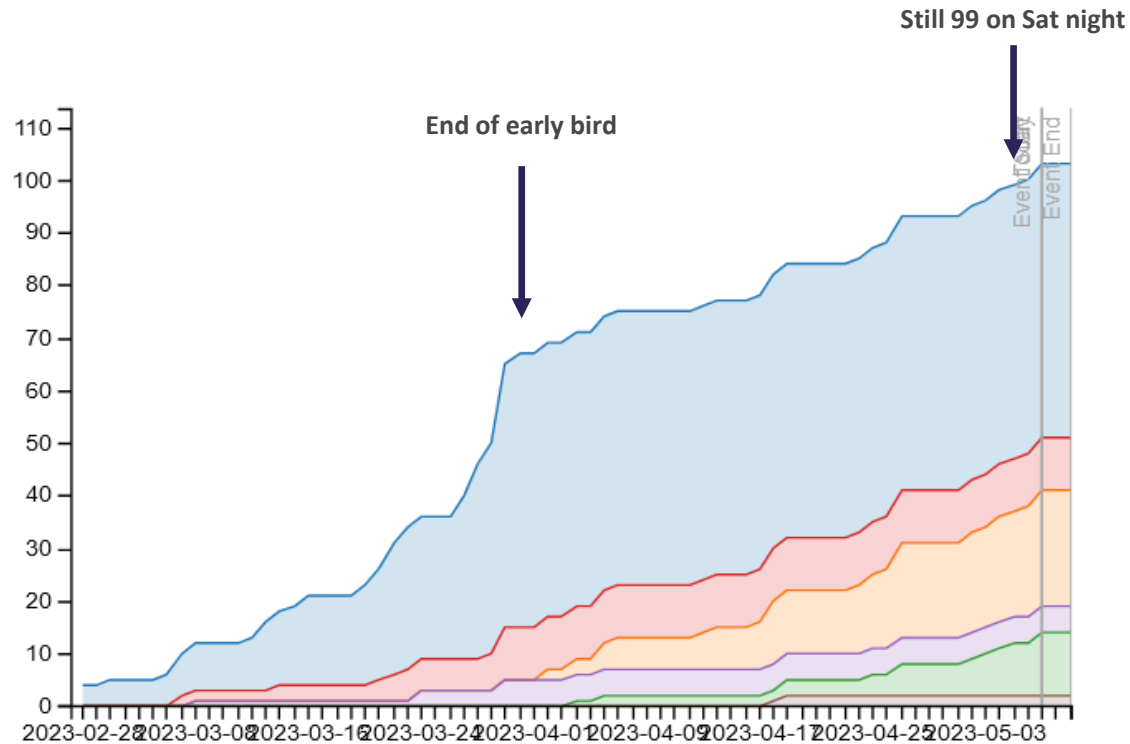


Share of industry

% industry participants



Progress of registration



- -2700 BC: Fisherman house from the Bronze Age by the lake
- Between the Lake of Neuchâtel and the Jura mountains
- 44'000 inhabitants
- Strong activity on
 - Watch making
 - Microtechnology
 - CSEM
 - IMT Microcity-EPFL
 - HE-ARC: University of Applied Science



Fisherman House by [Lathenium](#)



- Research and Technology Organisation (RTO) non-for profit



1984
FOUNDED



205
PATENT
FAMILIES



6
SITES



44
SPIN-OFFS

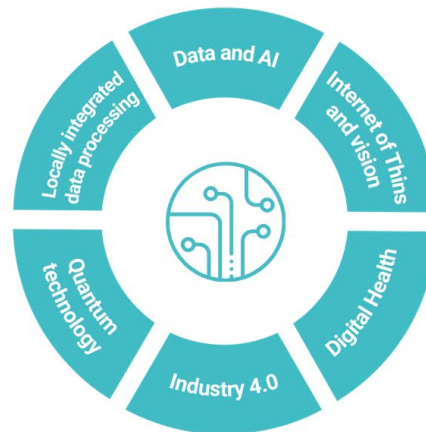


96.9
CHF Mio
INCOME
2021



225
INDUSTRIAL
CLIENTS / YEAR

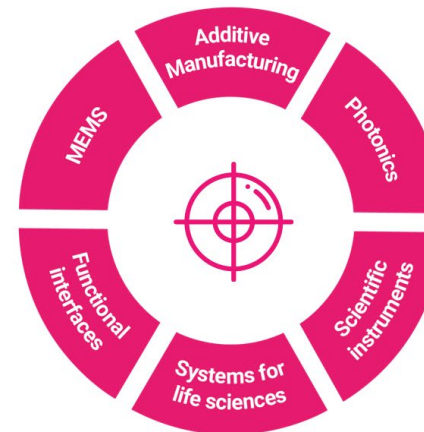
Digital technology



First Electronic Watch



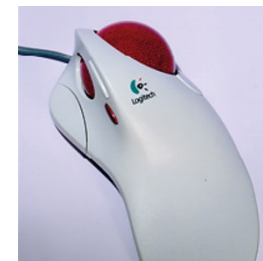
Precision manufacturing



First commercial stand alone AFM in EU



The first large-volume optical mouse



Sustainable energy



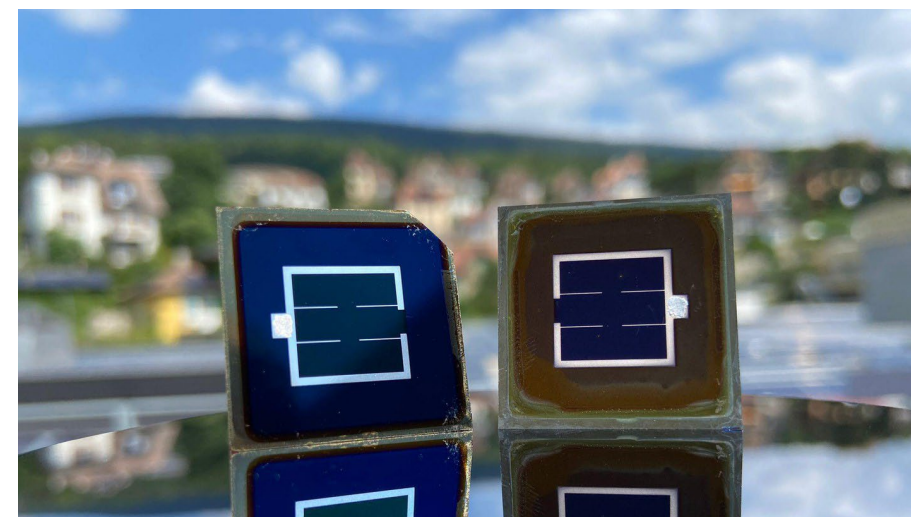
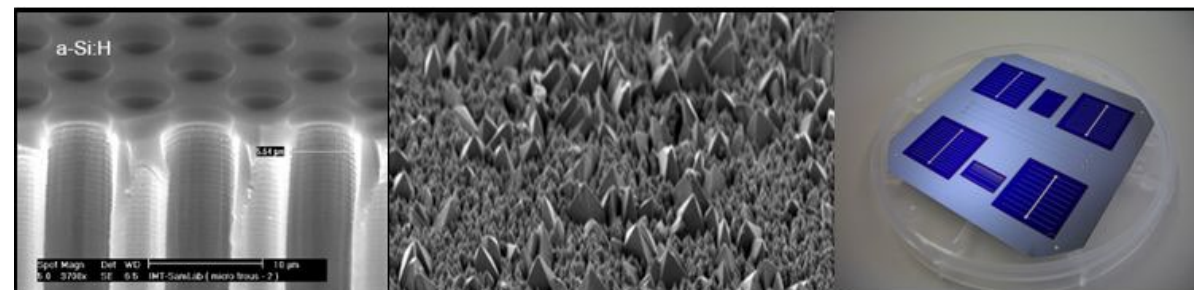
The first 3D TOF camera in the world



Camera from Rosetta who land on Philae

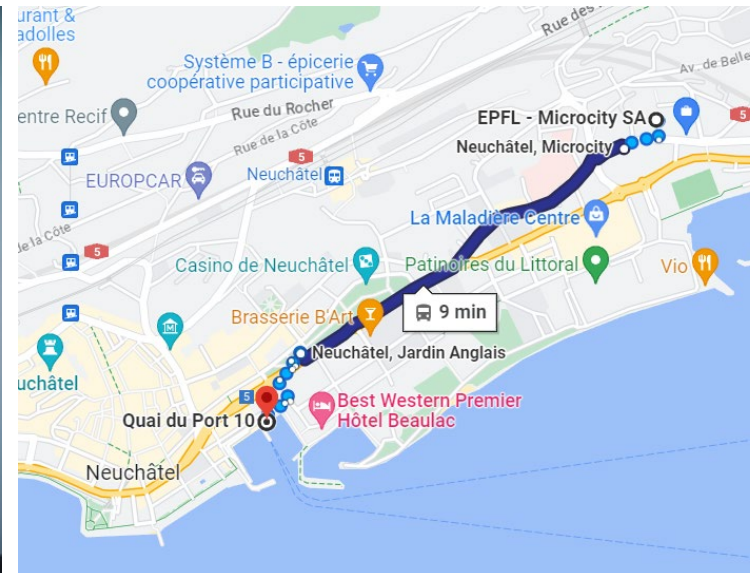


1. The Photovoltaics-Laboratory (PV-Lab) of EPFL, founded in 1984 by Prof. Arvind Shah and headed by Prof. Christophe Ballif since 2004.
2. 40 people
3. **Thin-film** silicon, very high frequency (VHF) plasma deposition and microcrystalline silicon → Oerlikon Solar
4. **Heterojunction** Si cells → Meyer Burger HJT
5. Tandem solar cell – perovskite on c-Si – with **last year world record efficiency above 30%** with 31.2%.
6. **EPFL Microcity** buildings done in 2013.



Boat Trip and Dinner

- **Boat Trip at 18h30** in Quai du Port 10 (1.4 km from Microcity)
- Boat name: le Fribourg
 - 17 min walk
 - 9 min Bus + walk
- **Dinner on the boat at 20h** (at dock)



Lab-Tour Tuesday from 15h30 to 17h30

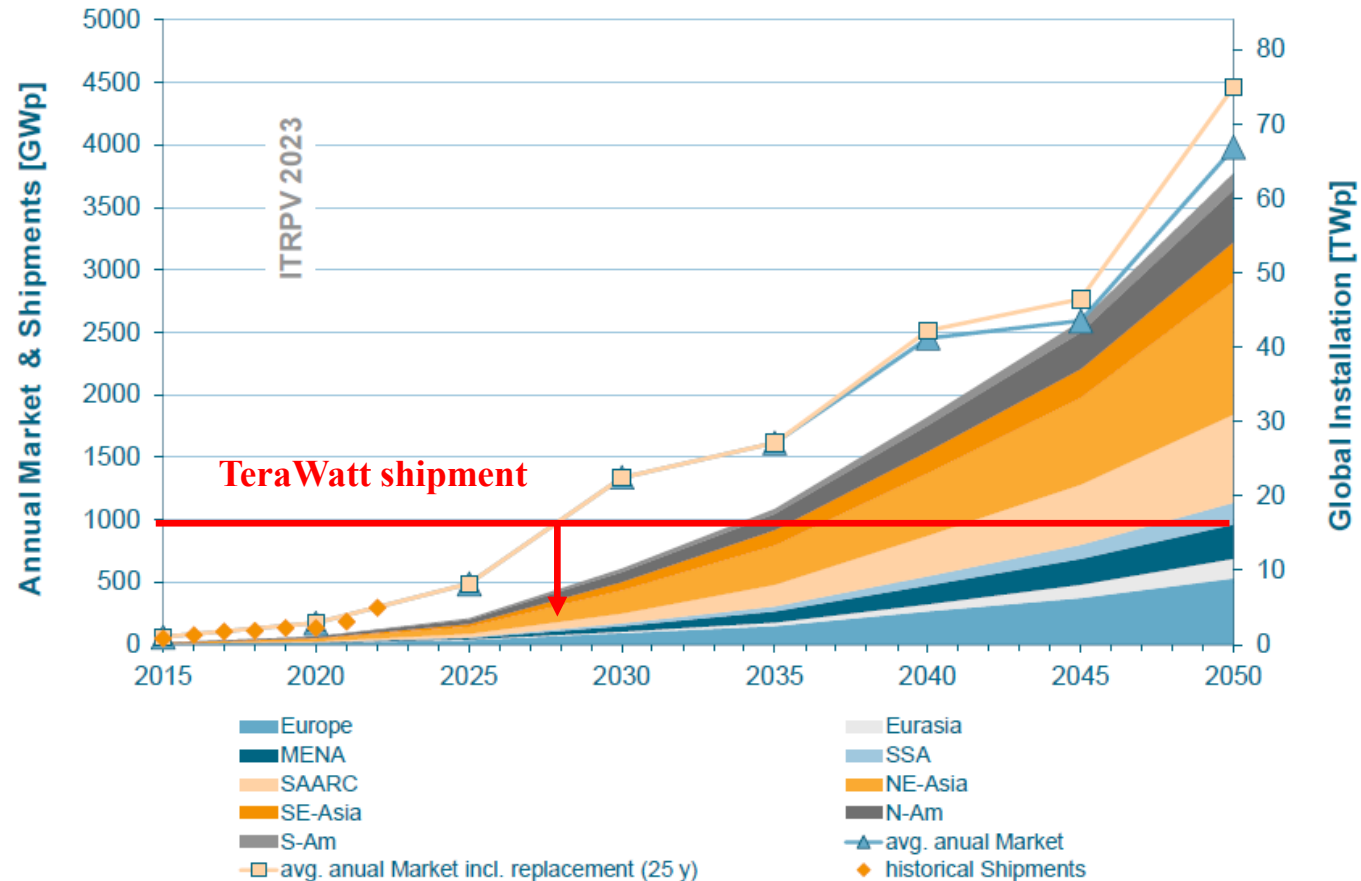
- **Take your public transport ticket from the hotel** (ask for it, if you did not receive it)
- **6 groups of 10-12 people = 6 guides** (65 people subscribed)
- **3 sites (CSEM, EPFL, Innoparc): 7 stations = 7 presenters**
- **If you have only short time, join group 5, 6 or 7 (only EPFL/CSEM)**

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7		Groups	Guides
Mardi a-m 15h30 à 17h30		00:15:00				end Innoparc	end Innoparc		Group1	Beatriz
									Group2	David
									Group3	Marie
									Group4	Jean-Davide
Go Innoparc	15:30:00	15:45:00	16:00:00	16:15:00	16:30:00	16:45:00	17:00:00		Group5	Florian
Innoparc 2	15:45:00	16:00:00	16:15:00	16:30:00	16:45:00	17:00:00	17:15:00		Group6	Patrick
Innoparc 1	16:00:00	16:15:00	16:30:00	16:45:00	17:00:00	17:15:00	17:30:00		Group7	Antonin
Return Innoparc	16:15:00	16:30:00	16:45:00	17:00:00	17:15:00	17:30:00	17:45:00			
EPFL PV LAB 1	16:30:00	16:45:00	17:00:00	17:15:00	17:30:00	15:30:00	15:45:00		Stations	Presenter
EPFL PV LAB 2	16:45:00	17:00:00	17:15:00	17:30:00	15:30:00	15:45:00	16:00:00		Inno1	Matthieu
CLEAN ROOM	17:00:00	17:15:00	17:30:00	15:30:00	15:45:00	16:00:00	16:15:00		Inno2	Jacques/D
SHOWROOM M83	17:15:00	17:30:00	15:30:00	15:45:00	16:00:00	16:15:00	16:30:00		EPFL PV LAB 1 (module)	Umang
FACADE	17:30:00	15:30:00	15:45:00	16:00:00	16:00:00	16:30:00	16:45:00		EPFL PV LAB 2 (Pk)	Christian
									CLEAN ROOM	Bertrand
Possible groups	OPTION: Only innoprac option	OPTION: Only innoprac option				OPTION: Only EPFL/CSEM part option	OPTION: Only EPFL/CSEM part option		SHOWROOM M83	Alejandro
Groups 10 à 12									FACADE	Bahaa

Shipment of PV

Global PV Installation and corresponding PV market

PV based energy mix scenario



**Total electrification
TW scale reached in 2027**

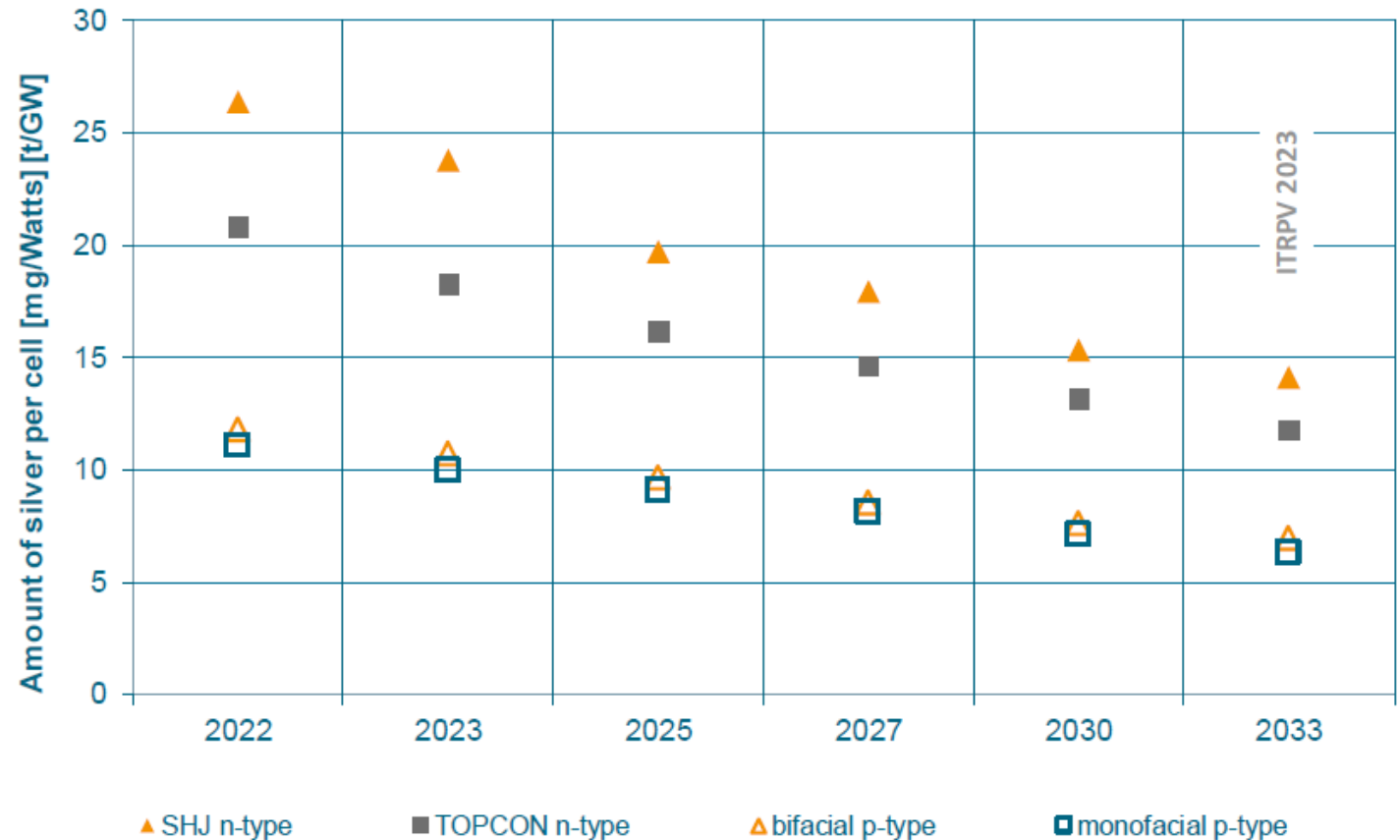
Tons of silver per GW or mg/W

PV consumed 10% of silver production in 2022

300 GW PV shipment in 2022
→ >3'300 tons silver in 2022

Trend for remaining silver for metallization per cell (front + rear side)

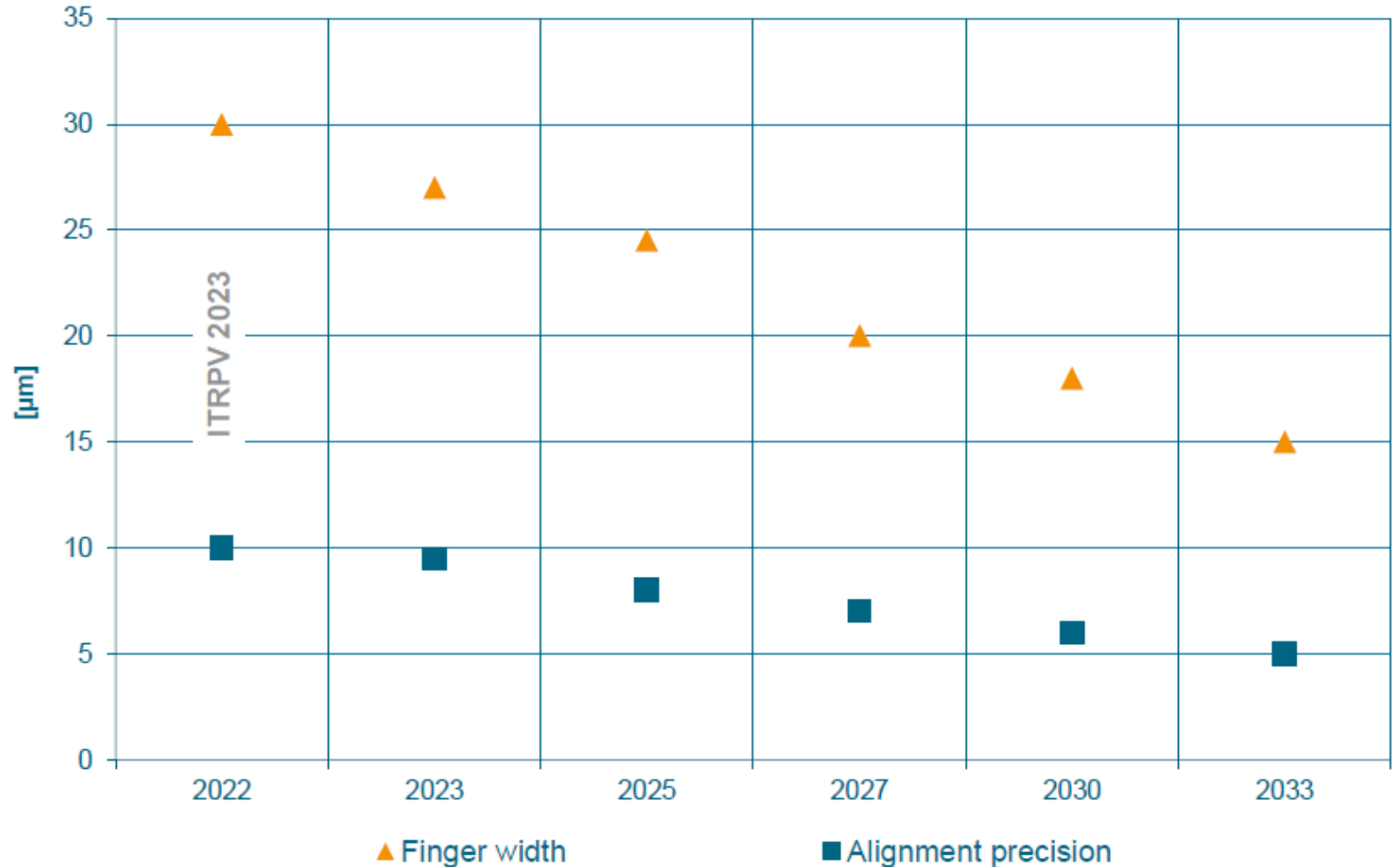
(Values for M6, M10, and G12 cell size, average)



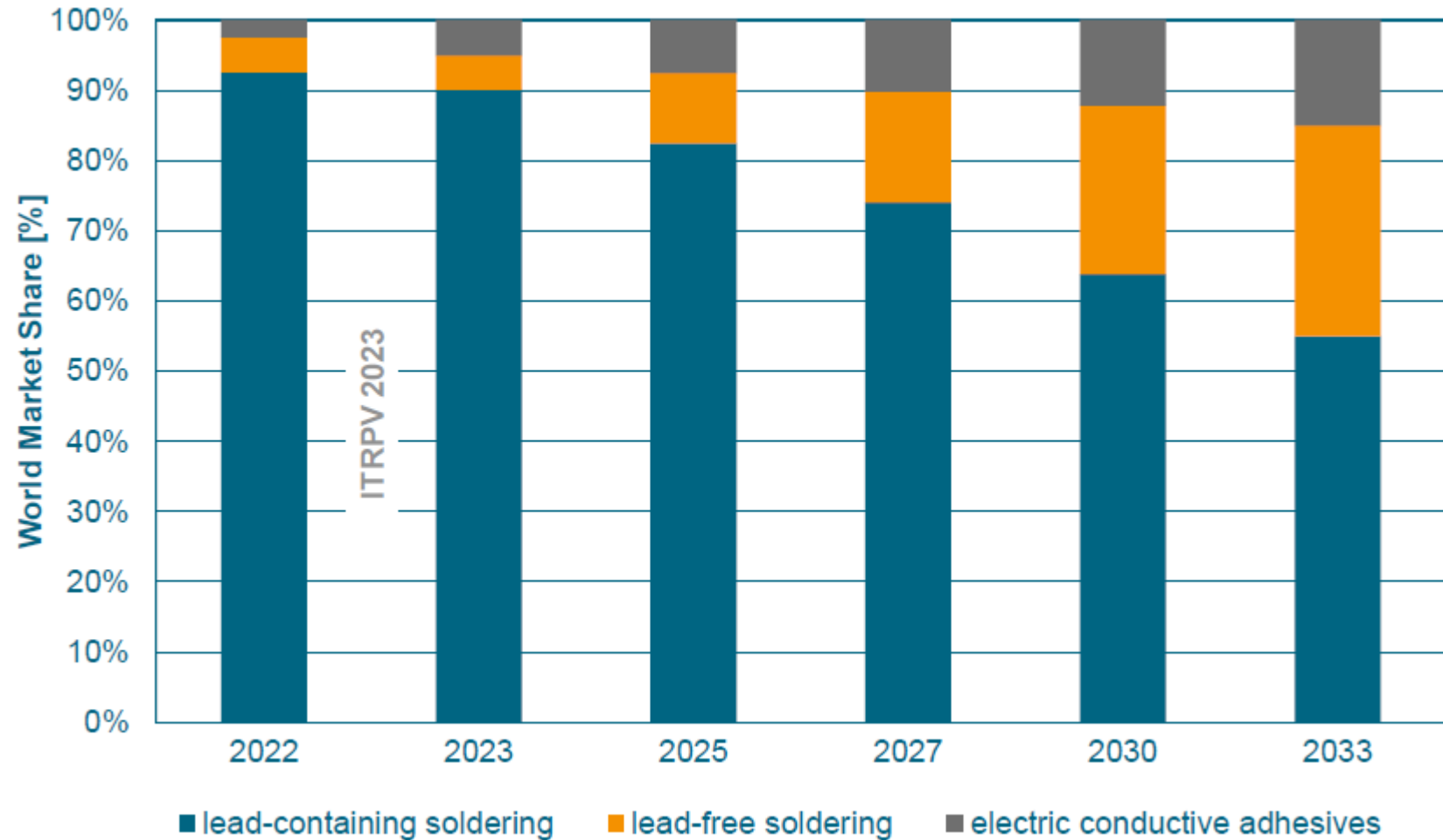
Screen-printing to the limit

Below 30 microns finger width today

Only 15 microns finger width in 10 years from now!



Interconnection technology



AI questions



- How much silver will be consumed by the photovoltaics industry in 2030?



As an AI language model, I do not have access to real-time data or future projections. However, according to a report by the Silver Institute, in 2020, the photovoltaic industry consumed approximately 100 million ounces (3,110 metric tons) of silver, which accounted for about 11% of total silver demand.



AI questions



- How to print the narrowest metallization fingers on a solar cell?



Printing narrow metallization fingers on a solar cell requires precision and attention to detail. Here are some general steps that can be followed to print narrow metallization fingers on a solar cell:

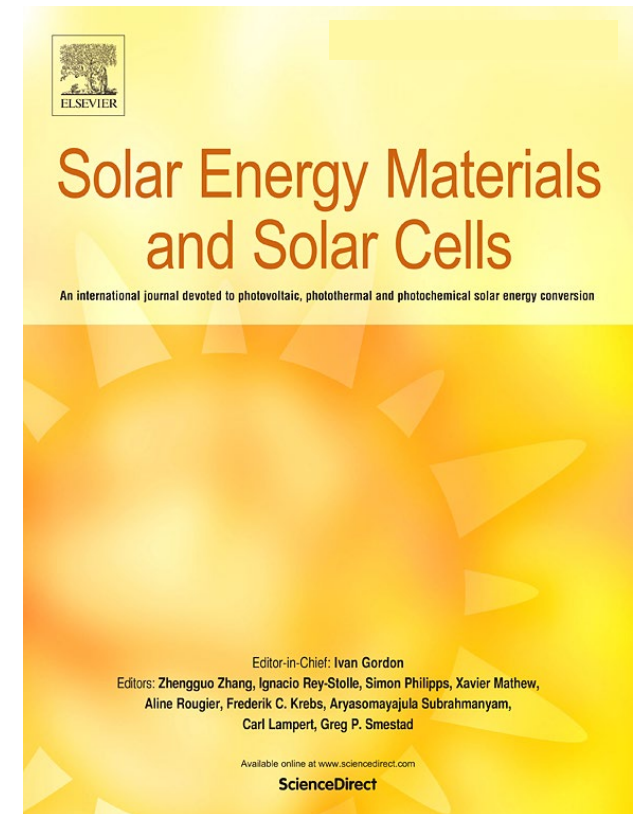
1. **Choose the right screen-printing mesh:** A finer mesh will be required to print narrow lines. Choose a mesh that has a high number of threads per inch (TPI).
2. **Use high-quality stencil:** Ensure that the stencil has **high resolution and sharp edges**, and also be properly aligned with the solar cell.
3. **Use the right ink:** Choose an ink that is compatible with the substrate and the printing process. The ink should be able to form a thin, uniform layer on the solar cell.
4. **Optimize printing parameters:** Adjust the printing parameters, such as squeegee pressure and angle, to achieve the desired line width.
5. **Perform quality control:** Inspect the printed lines under a microscope to ensure that they meet the required specifications. Any defects or variations should be corrected immediately.



Overall, printing narrow metallization fingers on a solar cell requires careful planning, precise execution, and constant monitoring. **It is essential to have a skilled and experienced team to achieve the desired results.**

- Proceedings of of 10th workshop published in November 2022 (AIP Proceedings), one year after workshop
- Looked for better solution for proceedings
- Decided on collaboration with Solar Energy Materials and Solar Cells
 - High quality journal
 - Quicker publication
 - Access is not as easy as AIP, but deemed acceptable

- Special issue of Solar Energy Materials and Solar Cells
 - Submission deadline: **16th of June** at SolMat website → aim to publish by early 2024
 - **Requirements:** format of journal paper and very strongly recommend that you read to
 - <https://www.elsevier.com/journals/solar-energy-materials-and-solar-cells/0927-0248/guide-for-authors>
 - During submission: select „MIW2023 proceedings“
 - 1st action: Please confirm your interest by end of the workshop (if not already done)

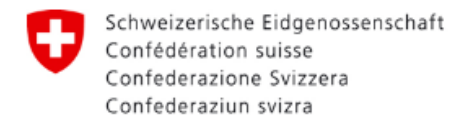




Metallization & Interconnection WORKSHOP 2023

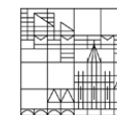
11TH EDITION for Crystalline Silicon Solar Cells

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OUR MEDIA PARTNER AND SUPPORTERS



Market place discussion (17:15-18:30)

Topic 1: PK/Silicon Tandems, how to connect two worlds?

Low-temperature metallization adhesion questions, screen-printing versus emerging technologies.

Moderators:

Veronika Nikitina (ISE)

Christophe Ballif (CSEM/EPFL)

Topic 2: Is Copper diffusing too fast in the market (and into the cells)?

Cu plating and Cu pastes fight to be the solution to our Ag problem. What is the industrial status?

Moderators:

Agata Lachowicz (CSEM)

Marco Balucani (Rise Technology)

Topic 3: Is Gap-less thoughtful?

Are we forgetting something? Encapsulation challenges, potential reliability problems.

Moderators:

Jean-Philippe Aguerre (Mondragon)

Angela De Rose (ISE)

Topic 4: The fight at the frontier: how can we advance further printing?

What is today limiting the printing to go further (screen, paste, squeegee, printer, other)?

Moderators:

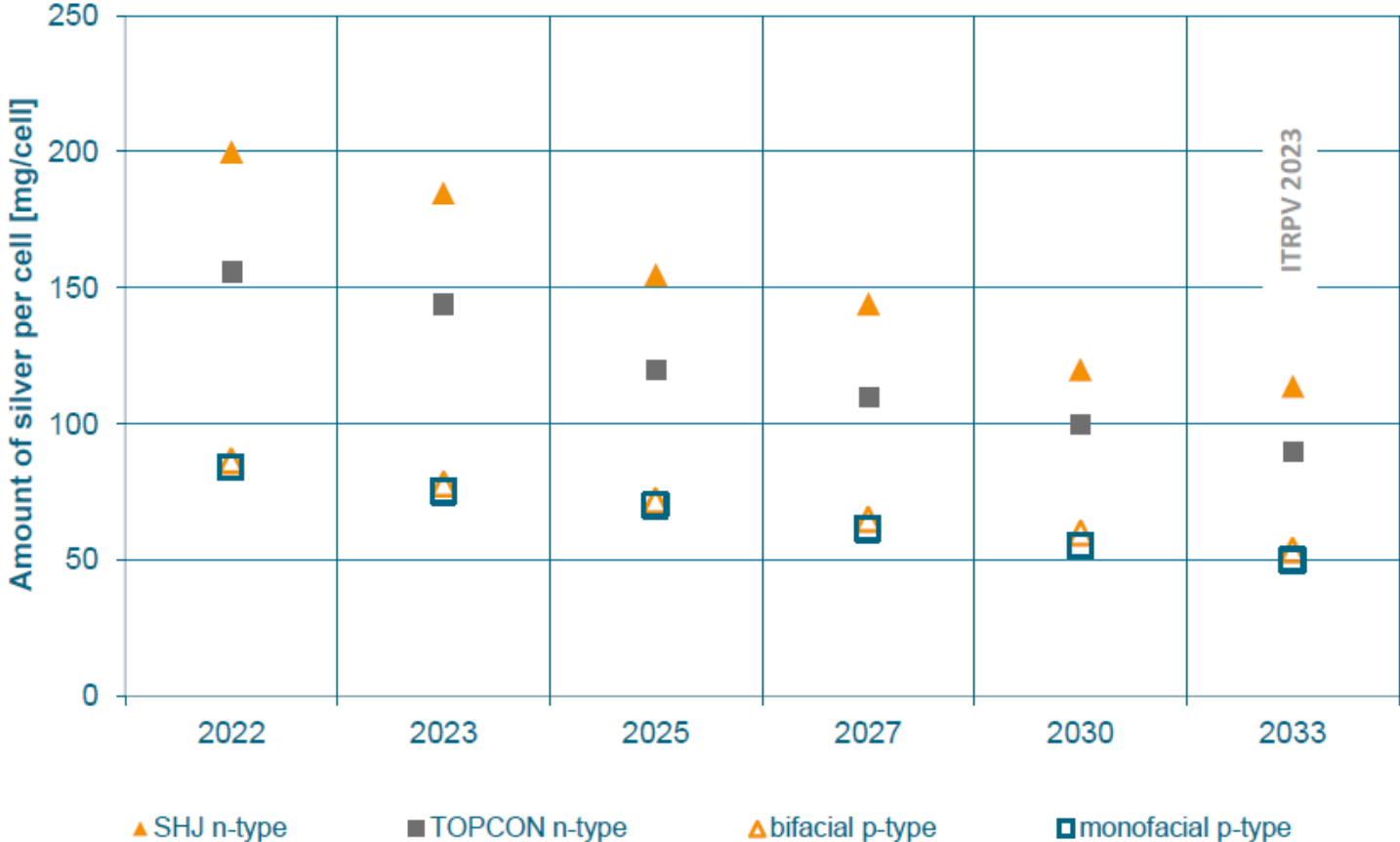
Pradeep Padhamnath (SERIS)

Stefan Hörnlein (qcells)

Silver weight per cell

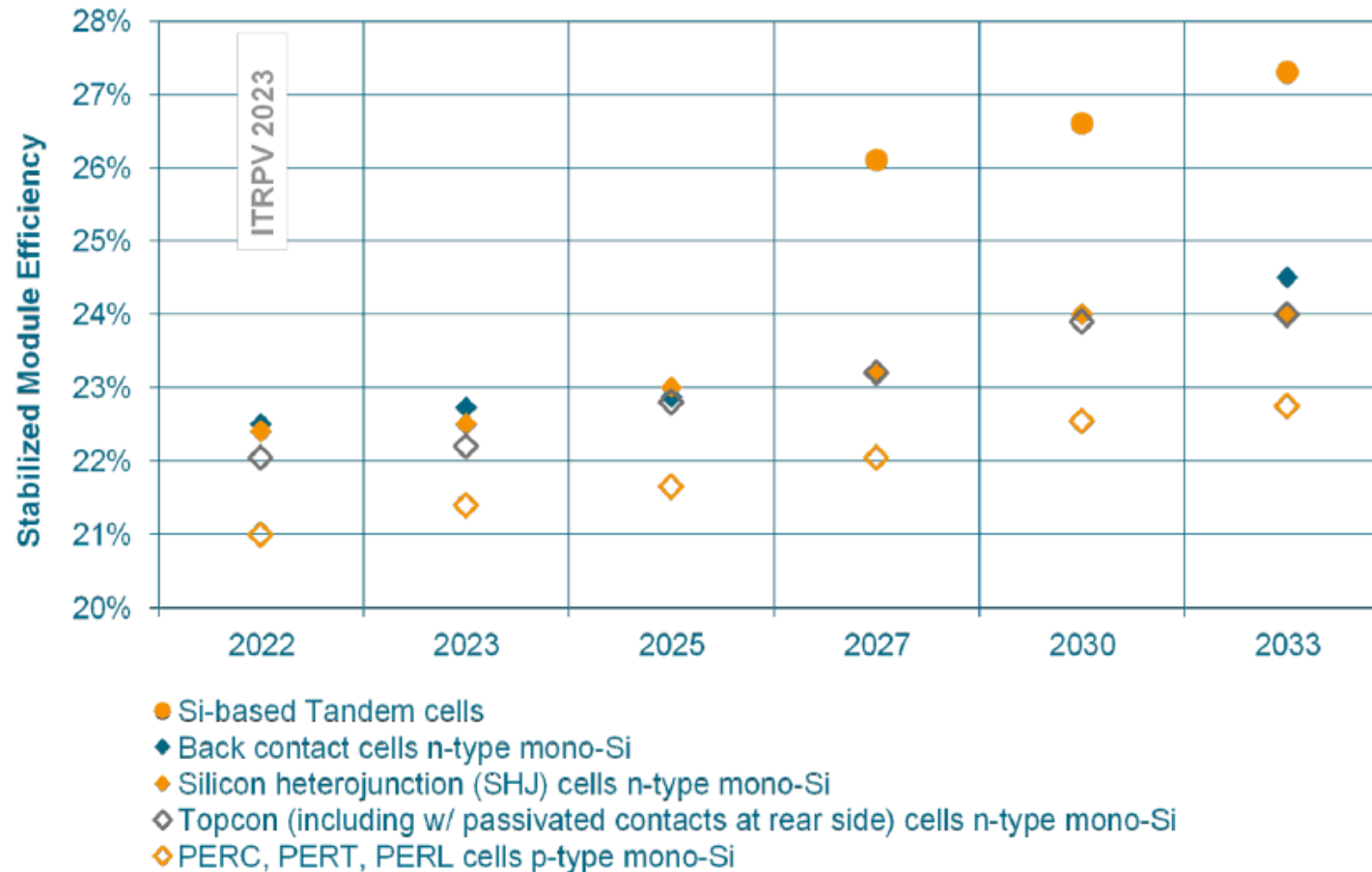
Trend for remaining silver for metallization per cell (front + rear side)

(Values for 182.0 x 182.0 mm² cell size)



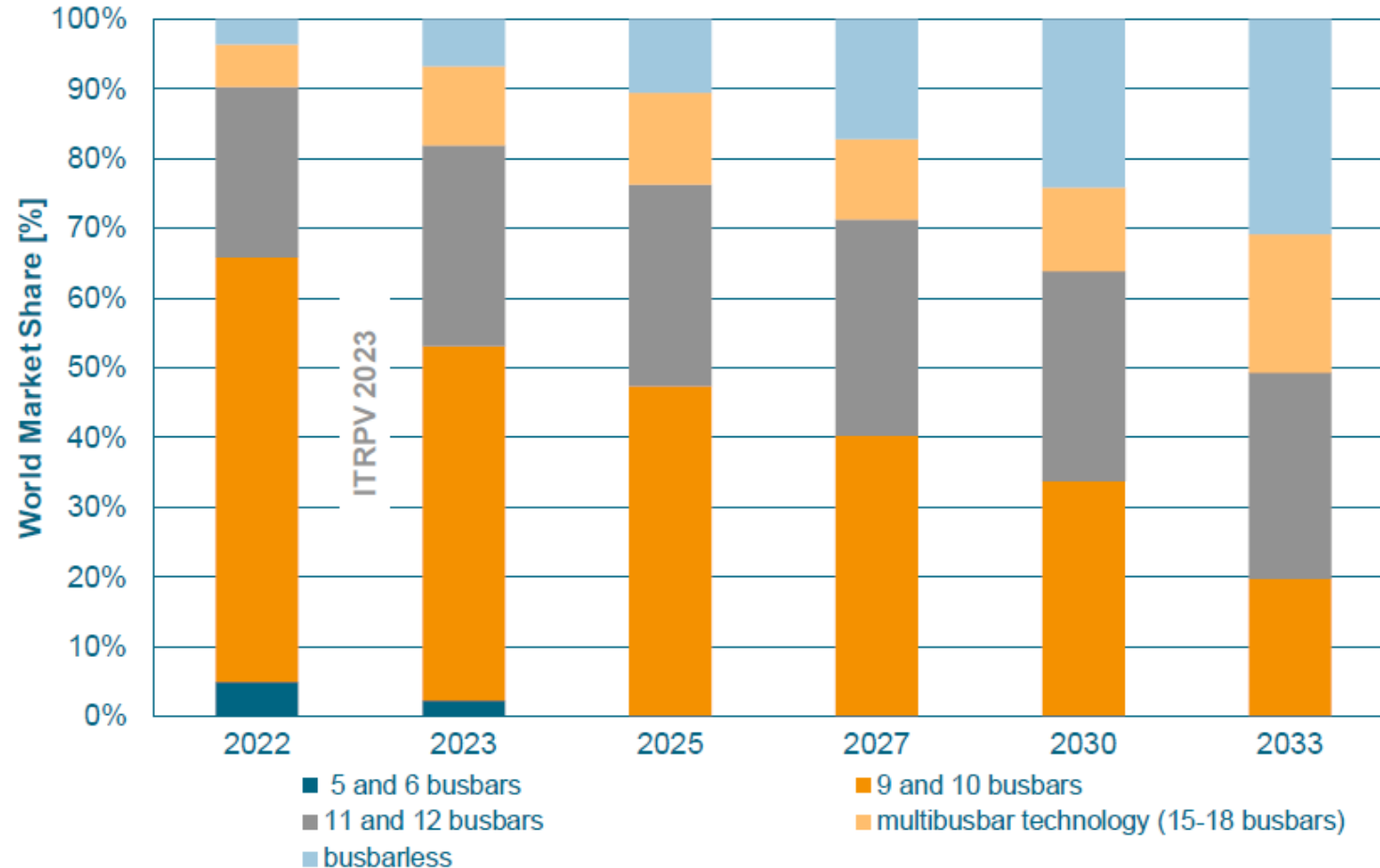
Module Efficiency

Module efficiency trend for modules in mass production with different c-Si based cell technologies



Busbar number (M10)

For double side contacted cells in new and upgraded lines for = M10



- Research and Technology Organisation (RTO) non-for profit

1984
FOUNDED

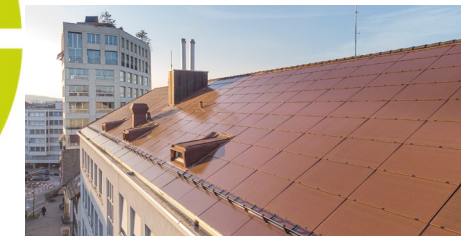
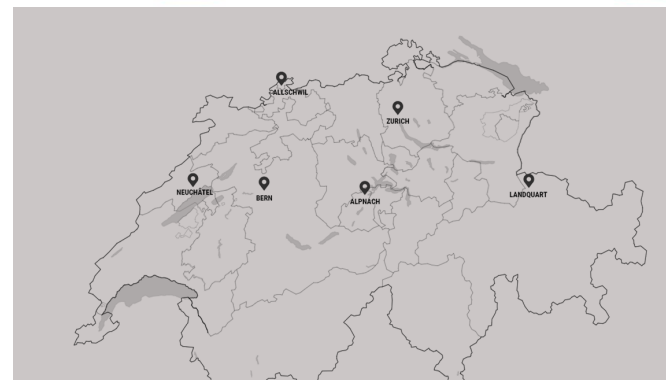
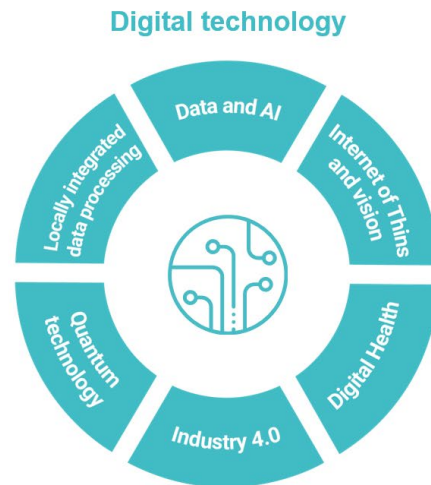
205
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6
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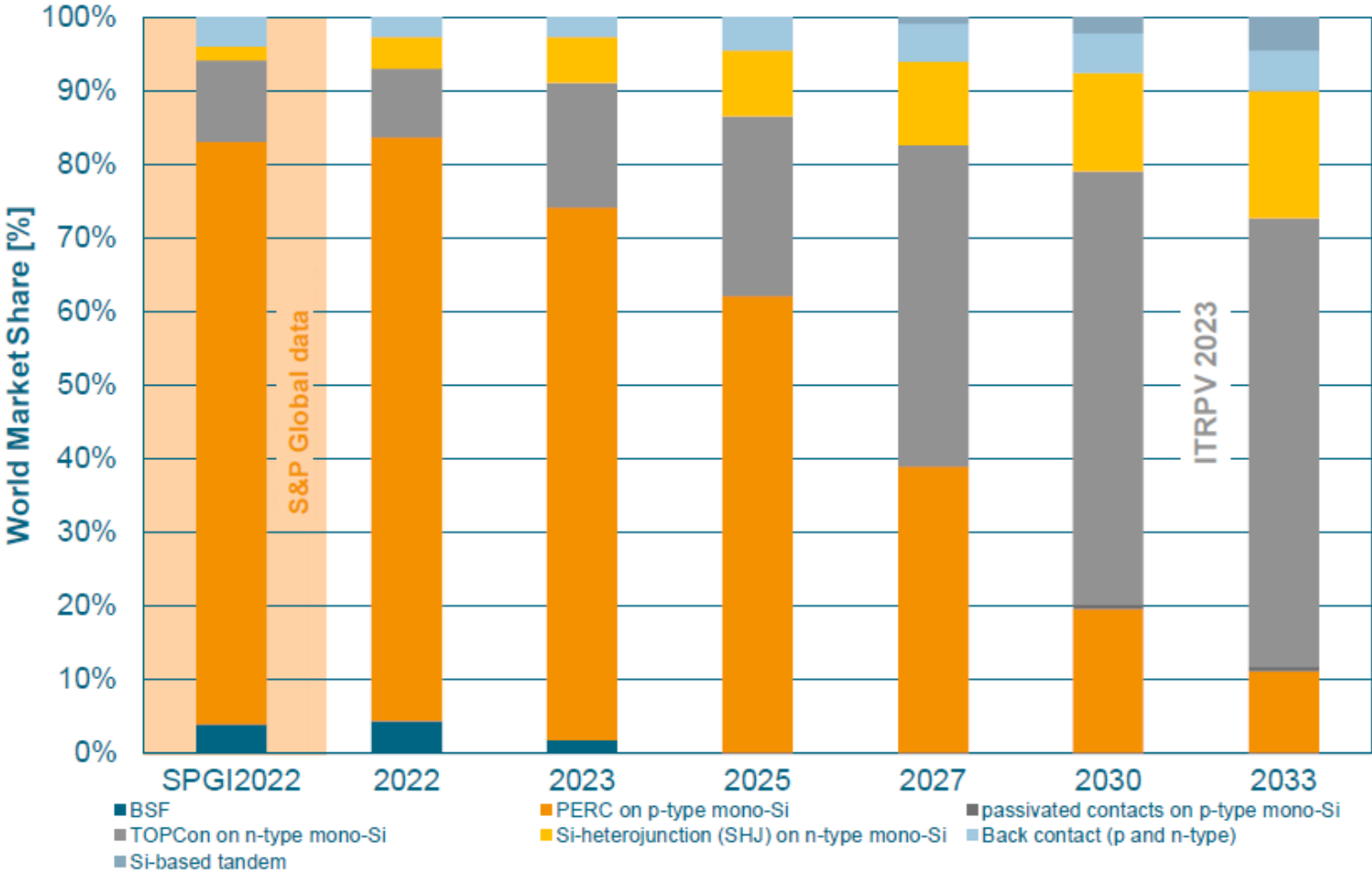
44
SPIN-OFFS

89.2
CHF Mio
INCOME

225
INDUSTRIAL
CLIENTS / YEAR



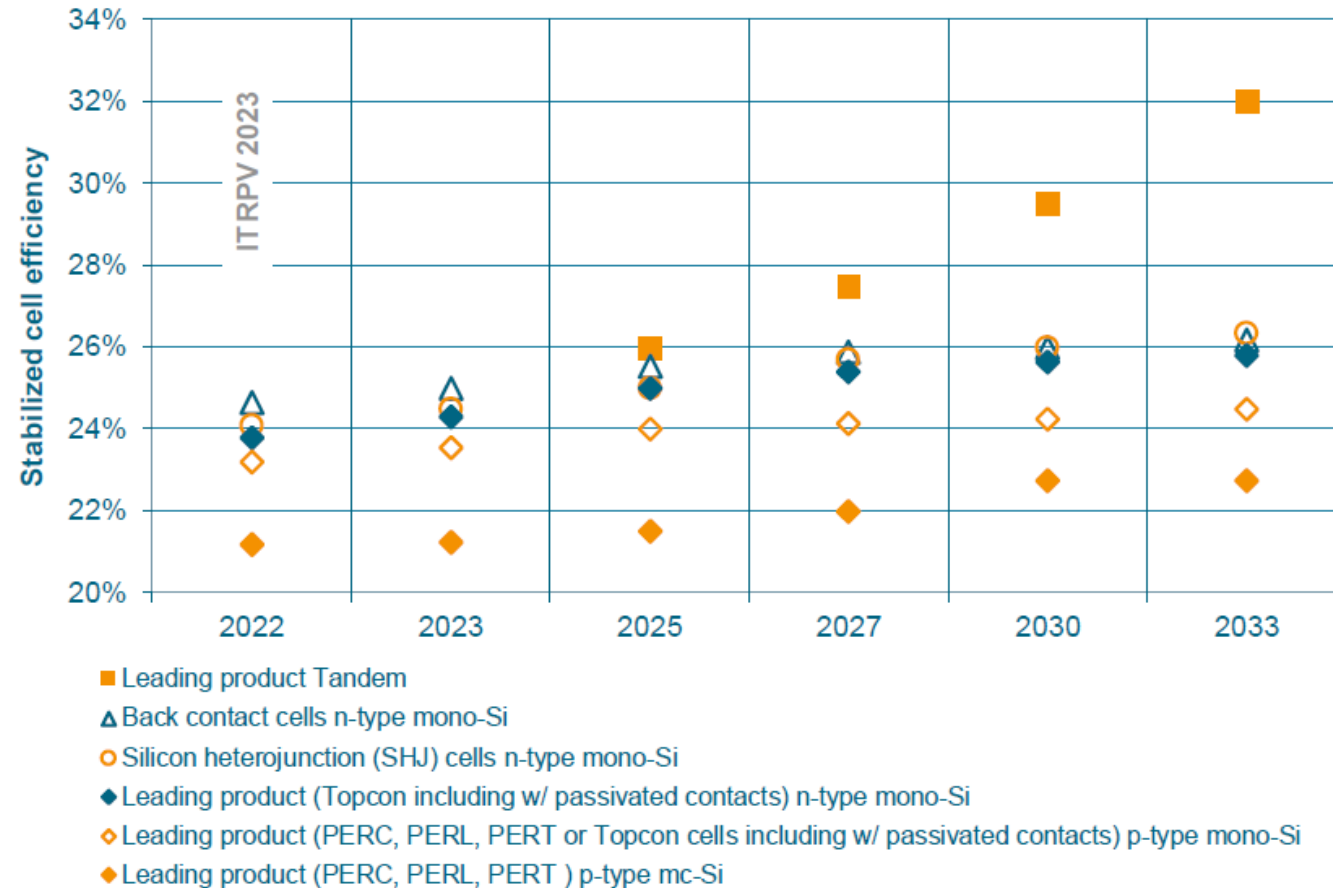
Cell Technology



Cell Efficiency

Average stabilized efficiency values for Si solar cells in mass production

Measured with busbars (no BB-less measurement) and front side STC



Plating versus Screen-printing

Plating will represent 7.5% of front metallization in 2033

