The TRIUMPH project aims to initiate the **development of a future PV cell technology node**, based on an **advanced triple junction cell concept**, that is widely considered to be the **next technology node** to come **after tandems**.

Presently, there is considerable amount of **attention and research and development (R&D) activities devoted to Pk/Si tandems and already promising cell efficiencies**, reliability and outdoor performance results have been obtained. The **highest efficiency reported for a 2-terminal (2T) Pk/Si tandem is 33.7%,** which has already gone past the Auger limit of Si. Therefore, in TRIUMPH, **we plan to venture a step further than tandems by targeting TRIple junction devices**, that can add the **extra "OOMPH"** (hence the name TRIUMPH) needed to reach **efficiencies even >35%**. These 2T triple junction devices will be based on perovskites for the middle and top cells and silicon for the bottom cell and will build on the knowledge garnered in the field of Pk/Si tandems.

Additionally, cost-effective processing techniques that are industrially viable **will be selected for scale-up developments, with minimal upscaling performance loss and degradation during reliability testing and outdoor monitoring**.

As we enter the tera-watt (TW) era of PV deployment, using earth-abundant materials and enforcing circularity become necessities. Towards this objective, we **not only explore options that reduce critical raw materials (CRM) such as silver (Ag) and indium (In) in the triple junction devices, but also apply design for recycling principles to the triple junction modules**.

The consortium consists of **14 complementary partners from** both **research institutions and industry**, each bringing their best forte to the table, which will help to **establish the pathway and the value chain for future multi-junction modules**. In this way, **TRIUMPH would help the European Union (EU) to maintain its technological leadership in the PV domain** for the future generation of PV technologies.

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www.triumph-horizon.eu

Triple Junction Solar Modules Based on Perovskites and Silicon for High Performance, Low-cost and Small Environmental Footprint

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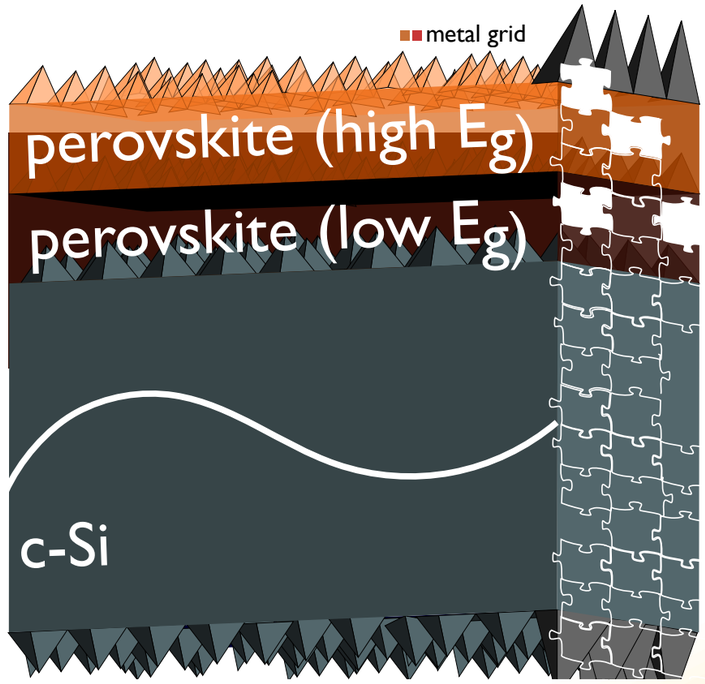
Duration: 42 months
Start date: 1 October 2022

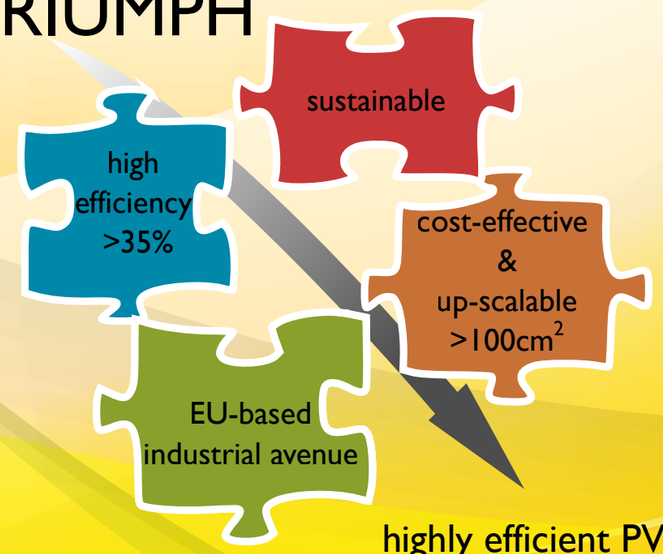
Project partners:

imec
Fraunhofer ISE
IPVF
TNO innovation for life
SALD Spatial ALD Innovators — Explore. Develop. Integrate. Together.
dyenamo
cnrs
UNI FREIBURG
Q CELLS Engineered in Germany
R|E|N|A|.
EPFL
csem
VON ARDENNE
ODTU GUNAM Center for Solar Energy Research and Applications



Overall Project Goal:

TRIUMPH



highly efficient PV
compatible with TW-scale deployment

The initiation and development of the N+3 node for terrestrial PV cell technologies reaching a TRL of 5, by realizing stable 2-terminal Pk/Pk/Si triple junction solar cells with high efficiencies >35%, upscaling them to large sizes ≥100 cm2 using cost-effective and industrially scalable processes, and establishing compatible module technologies, validated with indoor and outdoor testing. In preparing for the TW-era, attention will be paid towards design for sustainability and CRM resource efficiency.

1. Very high efficiencies and stability – Development of the building blocks (materials and processes) needed for triple junction devices to reach the targeted PCE >35% on 1 cm^2 with high stability.

2. Cost-effective and scalable technology – Demonstration of large-area (≥100 cm^2) 3J cells and encapsulated mini-modules using cost-effective and scalable cell processes and compatible module technologies, with minimal upscaling performance loss and degradation during reliability testing and outdoor monitoring.

3. Design for sustainability – Implement solutions that reduce or replace CRMs such as In and Ag, as well as concepts that allow easy recycling at end of life of the 3J modules.

4. Value chain buy-in – Establishing the value chain within EU for future multi-junction modules.