



Energy payback time for a high concentrated photovoltaic panel with optical micro-tracking

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HYBRID PHOTOVOLTAICS FOR EFFICIENCY RECORD USING INTEGRATED OPTICAL TECHNOLOGY

INNOVATIVE INDUSTRIAL PROCESS TO MANUFACTURE HIGHLY EFFICIENT HYBRID SOLAR MODULES

> 30% Solar PV record efficiency

+ 50% More energy than conventional modules

As easy to install and operate as conventional PV panels

- 16 Partners
- 10 Countries
- 10 590 511 € EU Funding
- 13 534 524 € Total Budget
- Almost 26 Full-Time Equivalents
- 48 Months



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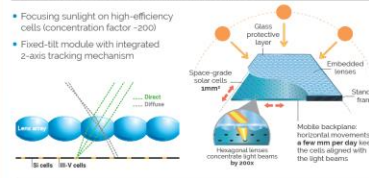
HYBRID PHOTOVOLTAICS FOR EFFICIENCY RECORD USING INTEGRATED OPTICAL TECHNOLOGY

HIPERION solar panels 50% more efficient
thanks to hybrid technology
As easy to install and operate as conventional modules

HYBRID APPROACH

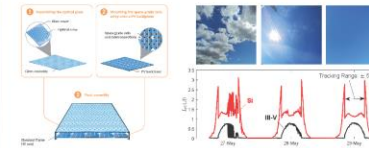
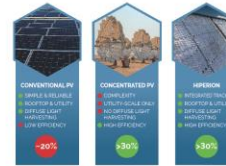
Planar micro-tracking: principles

- Focusing sunlight on high-efficiency cells (concentration factor ~300)
- Fixed-tilt module with integrated 2-axis tracking mechanism



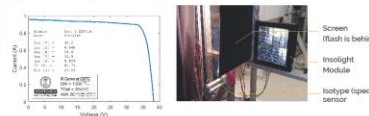
Hybrid Si/III-V architecture

- High efficiency III-V cells capture direct sunlight (concentrated)
- Low-cost Si cells capture diffuse sunlight (transmitted)
- Hybrid architecture with two cell technologies:
 - III-V cells on a glass substrate
 - Si cells as a backplane



Module performance (2018)

- Measured on a 0.1 m² module (574 Gain/PV/Gain/As/Ge 1 mm² cells)
- 29.0 % efficiency vs direct sunlight (indoor measurement @ C-STC)



THE HIPERION CONSORTIUM

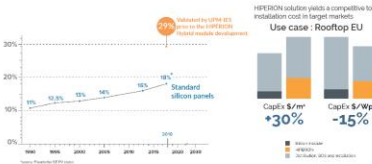
The HIPERION consortium, led by CSEM, comprises 16 partners covering the complete photovoltaic value chain.

| HIPERION project in numbers | |
|-----------------------------|---------------------------|
| 16 Partners | 10 590 511 € EU Funding |
| 10 Countries | 13 534 524 € Total Budget |
| 48 Months | 1 235 € Person-Months |



HIPERION OBJECTIVES

- Develop an industrial process to manufacture highly efficient hybrid solar modules which combine photovoltaic and concentrated photovoltaic technologies. This goal will be achieved by building a pilot production line in Neuchâtel (CSEM) and by developing tailored assembly techniques.
- Deliver unique and highly efficient solar modules capable of providing real-time record of energy generation. HIPERION modules are easy to install, with 25 years lifetime, converting direct sunlight at 30% efficiency and diffuse sunlight at 15% efficiency.
- Perform a technical and economical assessment of the blueprint solution, including qualification testing, performance and reliability validation at several commercial pilot sites across Europe.



HIPERION IMPACTS

- INNOVATIVE PRODUCTION PROCESS**
Trigger new investments in the European PV industry by establishing a pilot line capable of assembling the HIPERION module architecture through an industrial manufacturing process. Strengthen intellectual property on the process level in Europe and internationally.
- EQUIPMENT DEVELOPMENT FOR PV TECHNOLOGIES**
Trigger new investments in the European PV industry via tailored equipment development for mainstream PV technologies and integrate the latest photovoltaic silicon modules on the market with the III-V cells technology.
- PERFORMANCE & COST COMPETITIVENESS**
Bring cheaper solar electricity thanks to its high efficiency of more than 30%, optimise the bill-of-materials for the levelised cost of electricity and increase the return-on-investment of the full PV installation value chain.
- REGAIN MARKET SHARES**
Enable more PV applications (e.g. zero-energy buildings, electric vehicle stations and parking lots), provide added value for the rooftop market and improve the internal rate of return for homeowners. On the long term, HIPERION will reduce cost of electricity in the utility market.
- SECURE & SUSTAINABLE SUPPLY CHAIN**
Create a more secure and sustainable supply chain for the European PV market, preserve the European strategic position in this new field and strengthen the European expertise and know-how in several fields such as advanced optics, micro-mechanical components, multi-junction III-V solar cells and metrology.

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Project name: HYBRID PHOTOVOLTAICS FOR EFFICIENCY RECORD USING INTEGRATED OPTICAL TECHNOLOGY
Funding scheme: Innovation Action (IA)
Project coordinator: CSEM SA - Jacques Lévain
Management and dissemination: L'EP - Anamul Hoque, Sofia Sarti
Contact: contact@hiperion-project.eu
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Project end date: 31/08/2023

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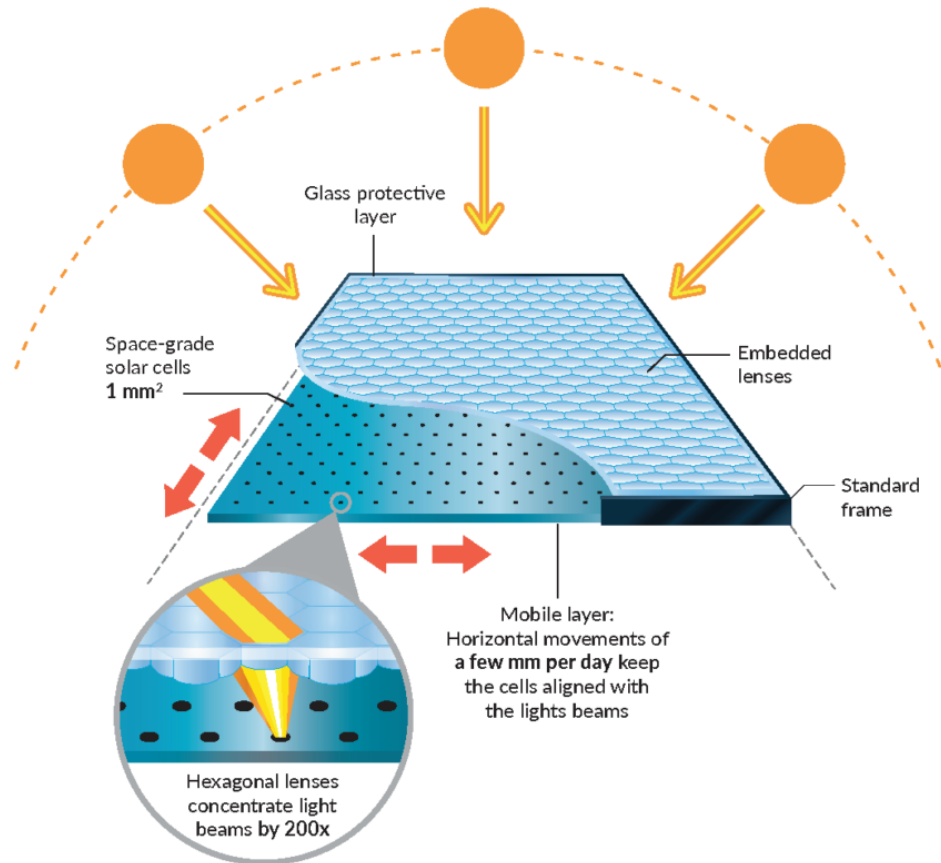
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Goal and scope definition

INSOLIGHT'S PHOTOVOLTAIC SYSTEM

Thanks to its novel optical design, Insolight brings space grade solar cell's power to the consumer market, reaching an efficiency of over 29%.

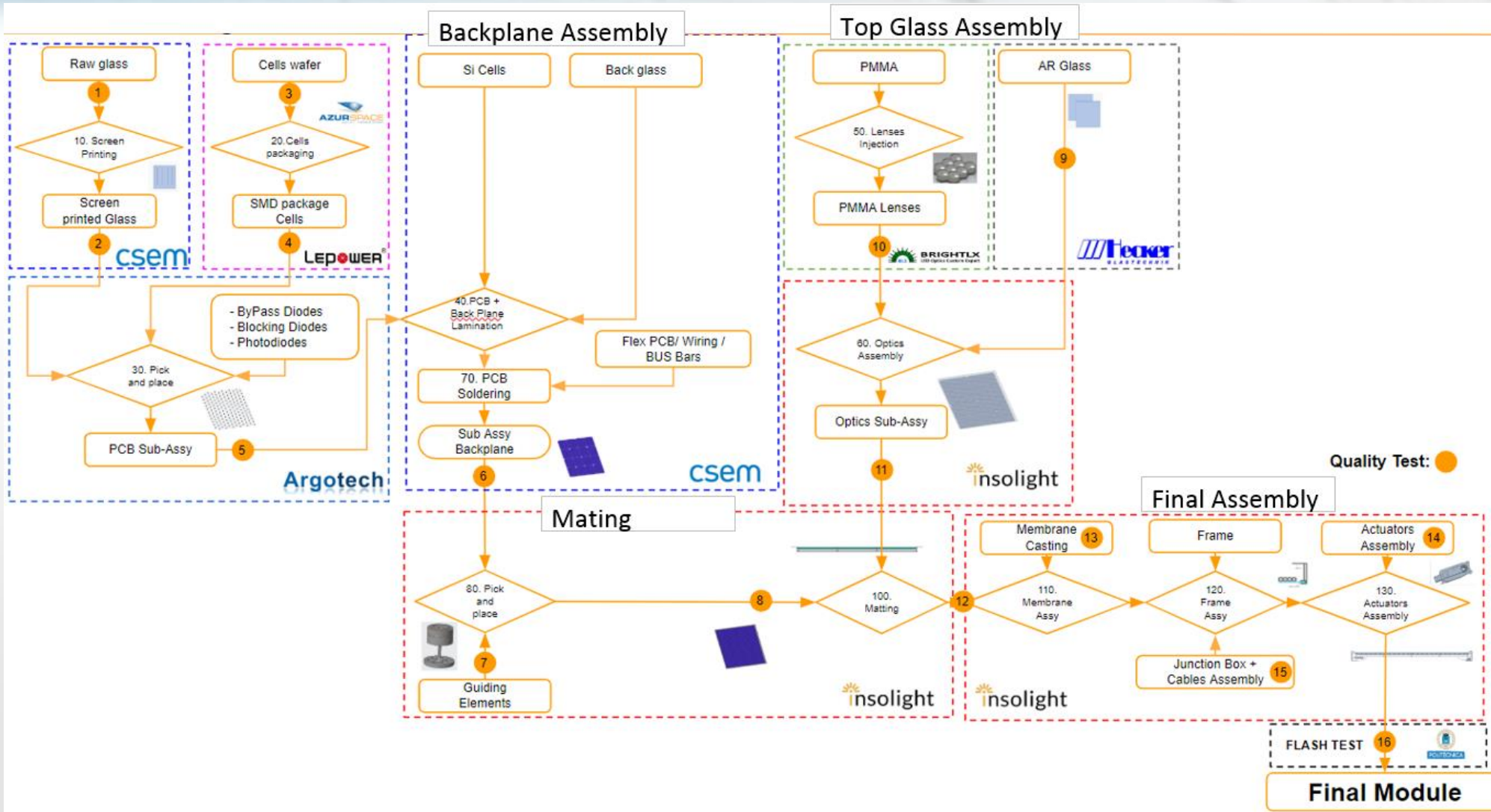


The functional unit (FU)

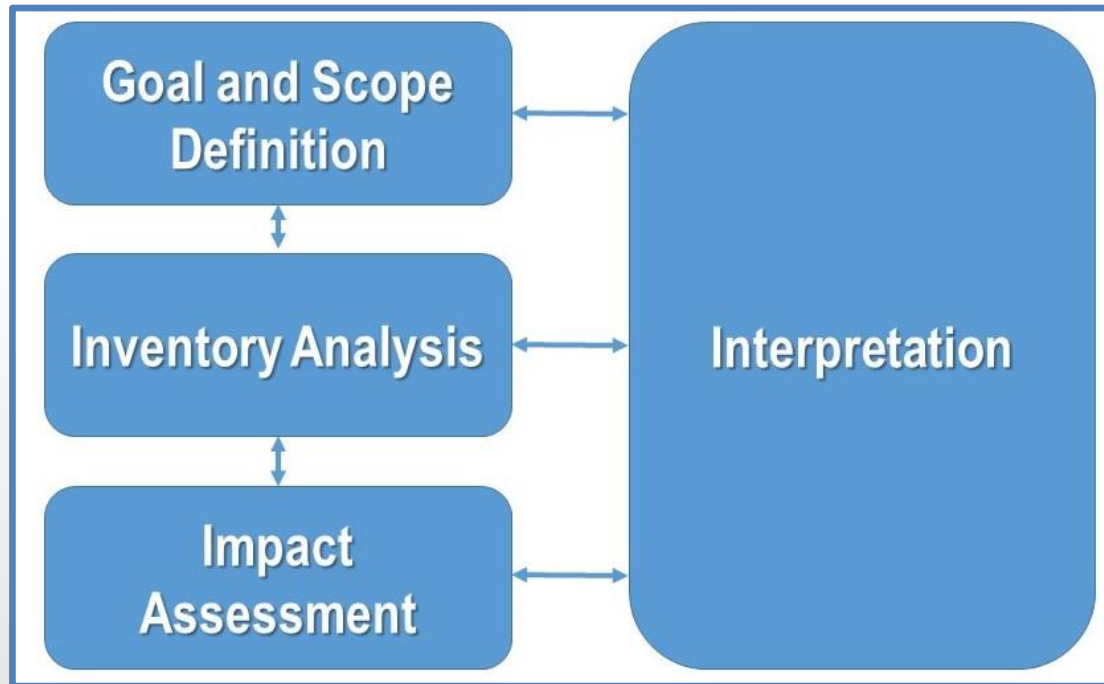
The FU is defined as **1kWh** of generated electrical energy over the lifetime of the module

Life time 25 years

System Boundary



Life Cycle Assessment - LCA



According to ISO 14040, the framework for LCA includes the following stages:

- ▶ Definition of goal and scope
- ▶ Life cycle inventory (LCI) analysis
- ▶ Life cycle impact assessment (LCIA)
- ▶ Interpretation

LCA system Boundaries

LCA of Gen2 for EU and out of EU supply chain; waste scenario, CO₂ kg eq/kWh over the lifespan

Function Unit: Full HCPV module

Software/ Database: SimaPro version 9.00.49 and Ecoinvent 3.7 database

Ecoinvent system model: APOS, market

Simapro Methodology: **IPCC(International Panel on Climate Change) 2022** *This method lists the climate change factors of IPCC with a timeframe of 100 years and expressed the LCA results in terms of kg CO₂-eq;*

Data: Collected by Insolight Based on GEN2

ENVIRONMENTAL PROFILE FOR GEN2 FOR UPGRADED DATA

Total carbon footprint of GEN2 module was estimated as 155 kg CO₂ eq.

PV cells produced decisive contribution to the environmental load of the module: 51.2 kg CO₂ eq. (33,1 %), due to large amount of the material covering 0.22 m² area of the module.

For GEN 2 module, the biggest load is generated by PV cells (51.2 kg CO₂ eq., 33.1%), structural elements (junction box) (33.8 kg CO₂ eq. 21,9 %), top glass (11.9 kg CO₂ eq., 7.73%) and frame (8.73 kg CO₂ eq., 5.65%).

Recycling of PMMA reduced environmental load by 25% (38.5 kg CO₂ eq.) and amount of kg CO₂ eq./ kWh.

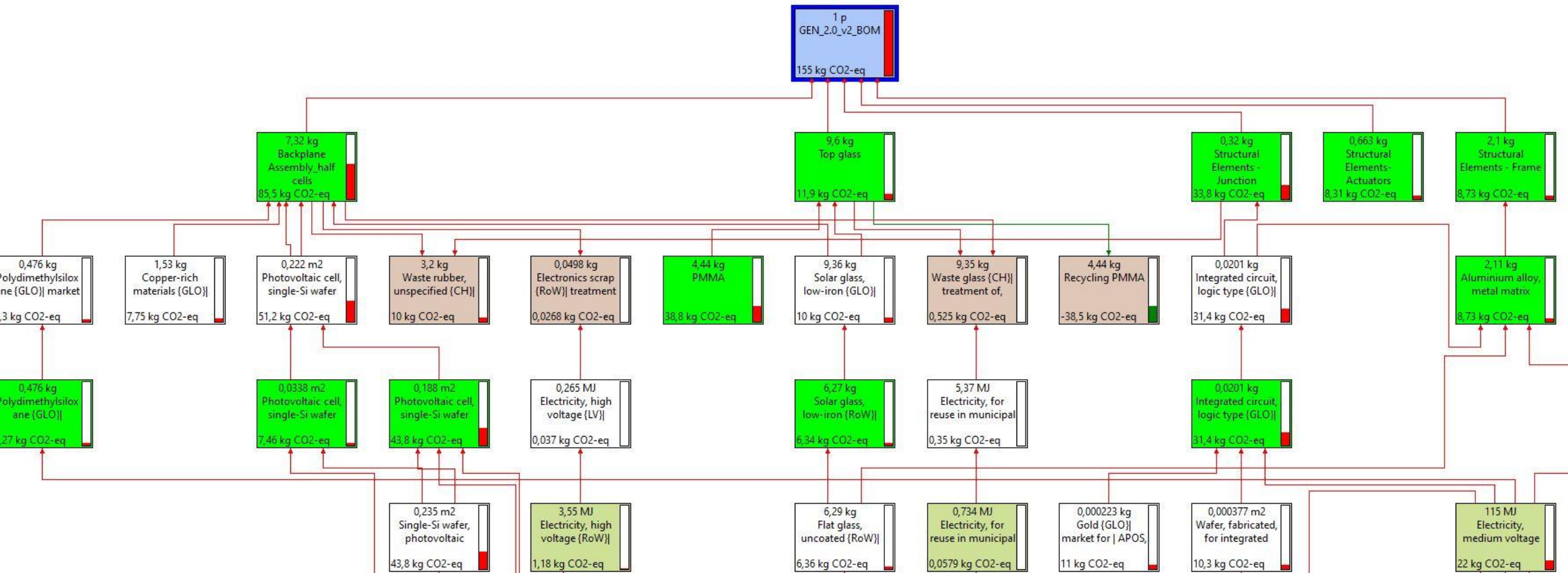
For location Madrid

$155\text{kg CO}_2/470\text{ kWh}/25 = 13.2\text{ g CO}_2/\text{kWh}$ (life span 25years)

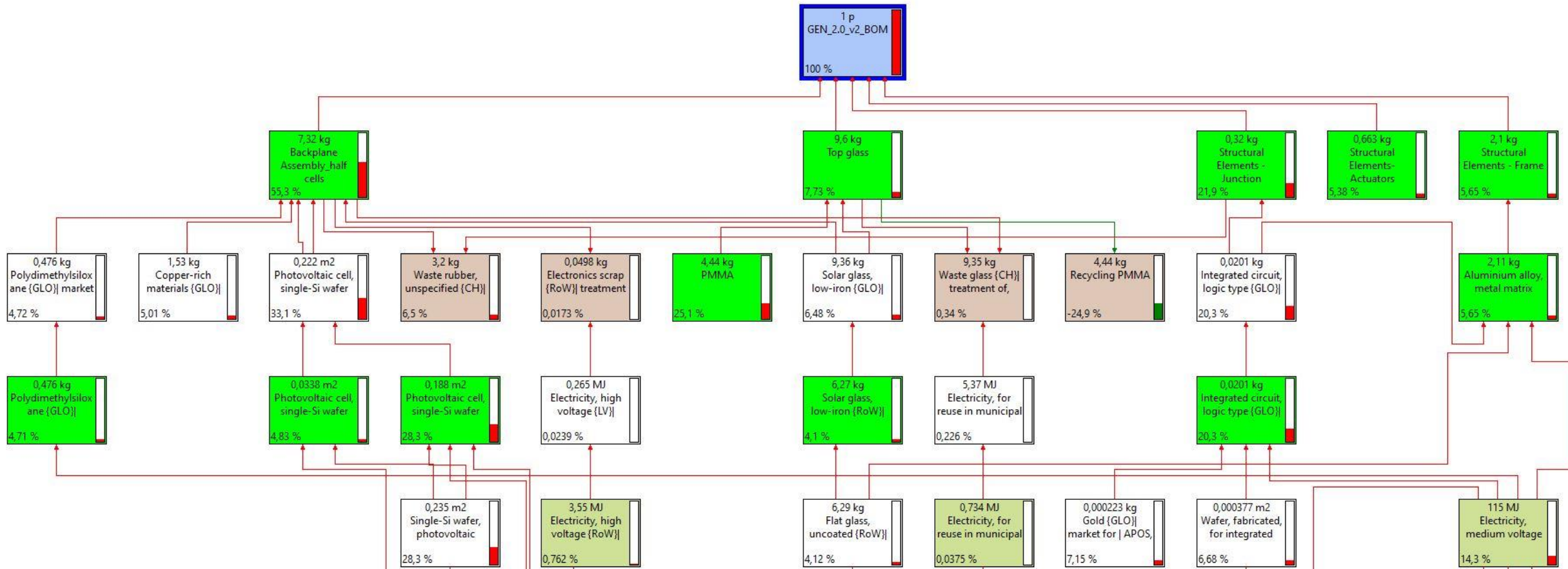
For location Lyon:

$155\text{ kg CO}_2/344\text{ kWh}/25 = 18.0\text{ g CO}_2/\text{kWh}$ (life span 25years)

PROCESS TREE



PROCESS TREE



ENERGY PAYBACK TIME

The energy payback time of the HCPV module was calculated by using the Cumulative Energy Demand (CED) method.

$$EPBT = \frac{CED_{mat} + CED_{manuf} + CED_{trans} + CED_{inst} + CED_{EOL}}{\left(\frac{E_{agen}}{\eta_G}\right) - CED_{O\&M}}$$

CED_{mat} : CED (in MJ) to produce the materials comprising the PV system,
 CED_{manuf} : CED (in MJ) to manufacture the PV system, CED_{trans} : CED (in MJ) to transport the materials during the life cycle, CED_{inst} : CED (in MJ) to install the system, CED_{EOL} : CED (in MJ) for end-of-life management,
 E_{agen} : mean annual electricity generation (in $kWh_{electric}$), $CED_{O\&M}$: CED (in MJ) for operation and maintenance, and η_G : grid efficiency, primary energy to electricity conversion at the demand side ($kWh_{electric}$ MJ).

The average η_G for Western Europe is approx. 0.31.

ENERGY PAYBACK TIME

The EPBT for the GEN2 module is in the range of **2.55** and **3.44** years, depending on the location and the related insolation factors (Madrid: 470 kWh/m², Lyon: 344 kWh/m²).

In the literature EPBT is in the range from 0.9 to 3.3 for different locations and irradiations. Impact of microinverters on EPBT is in the range of 2-3% which is similar as in the literature.

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