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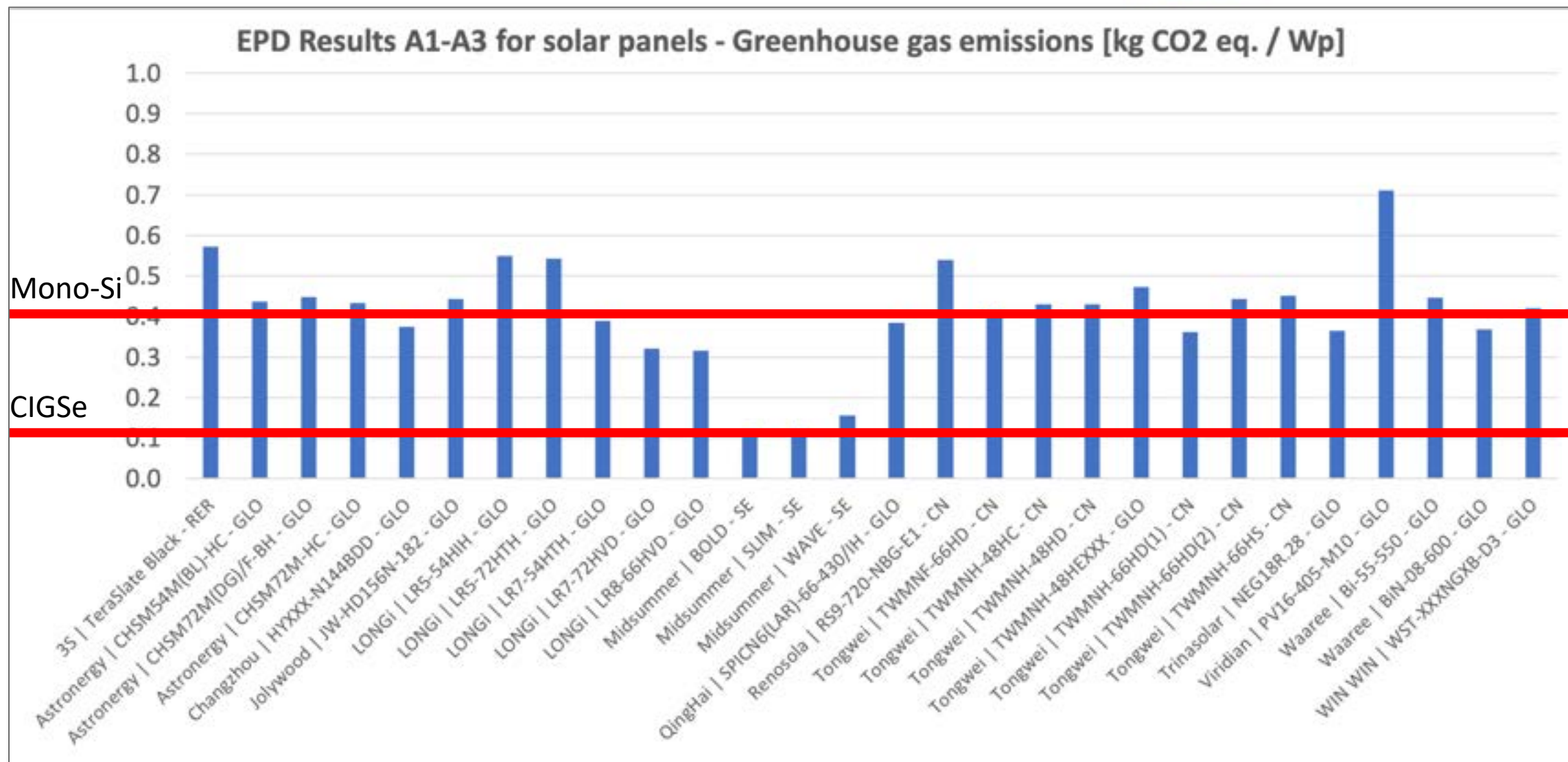
Product Category Templates (PCTs)

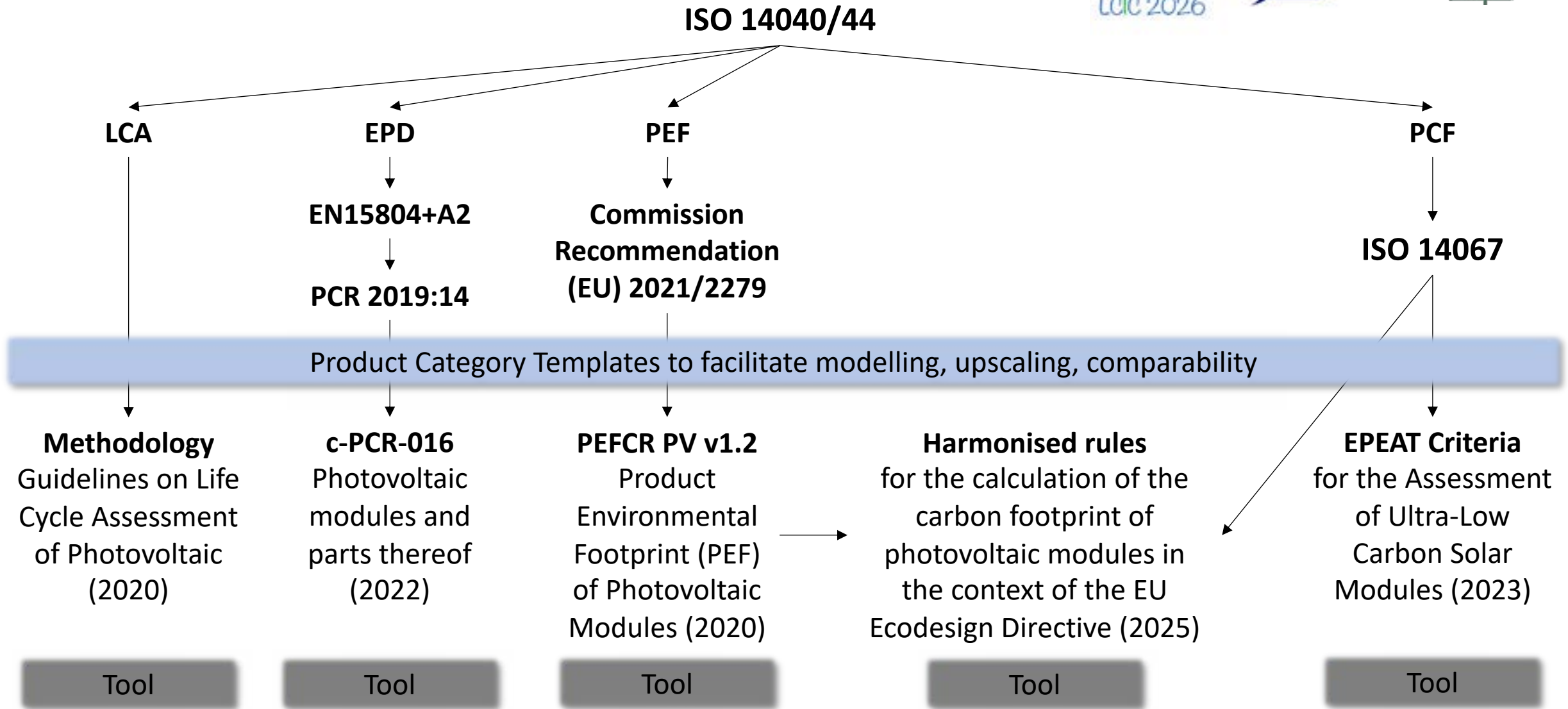
Conformance layers for upscaling life cycle models of the same product group
(Photovoltaic systems as an example)

Conrad Spindler, GreenDelta GmbH

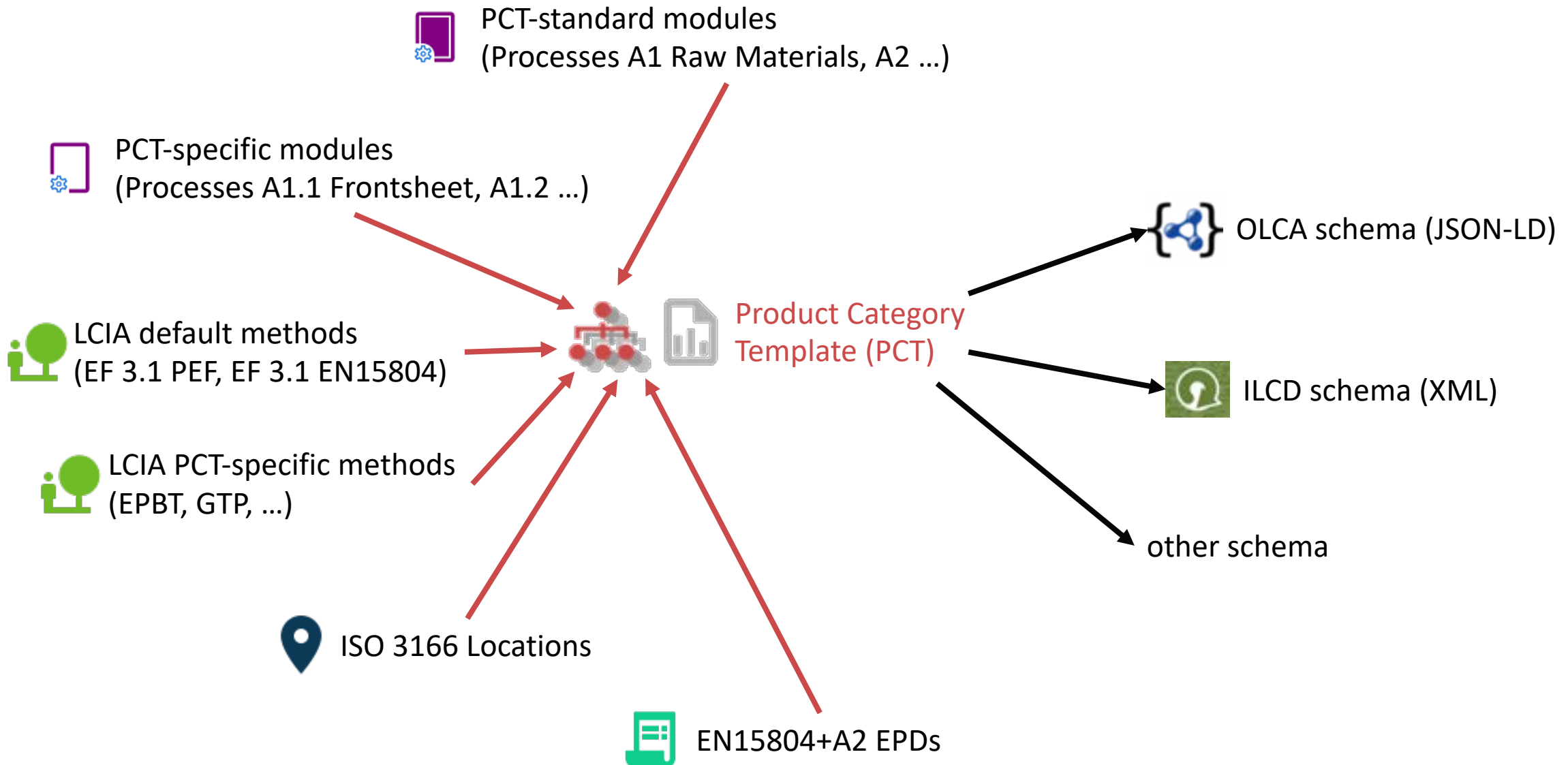
LCIC 2026, Berlin

- Horizon Europe project Hi-BITS
“High-efficiency bifacial thin-film chalcogenide solar cells”
- There is many ways on modelling photovoltaic systems or solar panels according to a given standard/guideline
 - Is the solar inverter and mounting included?
 - Is infrastructure (machinery, factory lighting and air conditioning ...) included?
 - Functional unit of 1 kWh of AC electricity delivered to the grid
 - Declared unit of 1 W_p of nominal power for the solar panel only
 - Which installation location during the use phase? (solar irradiation varies)
- We also want to check or use result from different compliances, e.g. from already existing, verified EPDs





Specific tools for one “end-point”, similar to e.g. GCCA tool, PEFCR tools, PCF tools for certain chemicals



How would a normal workflow with PCTs look like?

1. Download the latest PCT in the right format (OLCA or ILCD) and the right reference system (BAFU 2026, ecoinvent 3.12, etc.)

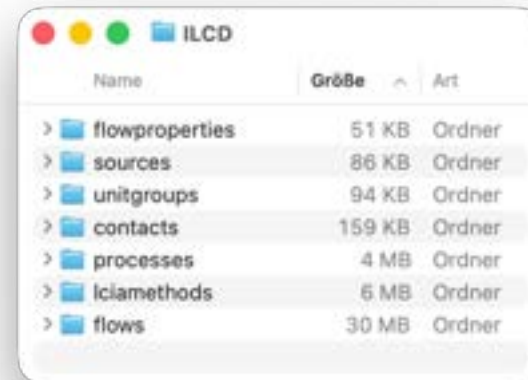
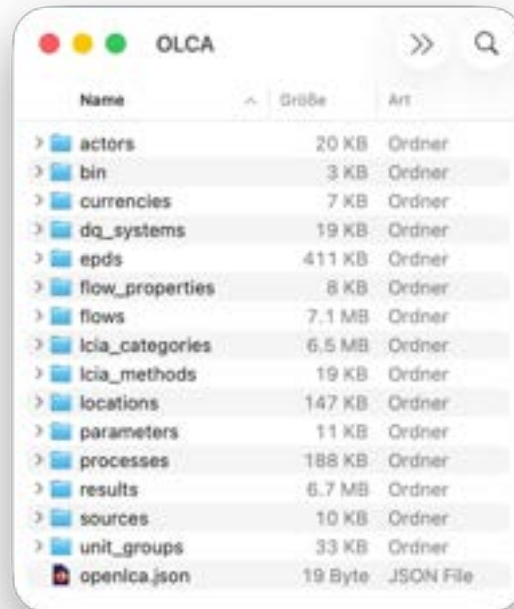
Example: “PCT Photovoltaics v1.0 – Nexus ecoinvent 3.12 (OLCA).zip”

2. Import the PCT into the background database
3. Set values for the minimum necessary parameters

How would a normal workflow with PCTs look like?

4. If needed, calculate parameters with the integrated calculators
(e.g. the average annual specific yield can be automatically calculated from solar irradiation, bifacial gain, first and subsequent yearly degradation rates)
5. Fill the template with your primary or secondary data with a fixed reference flow
6. Set the additional / optional parameters if needed
7. Calculate the product system with the correct method, depending on your compliance needs

**Approximately 10MB zip-file with data elements in ILCD or OLCA format
(background database is not included on purpose)**



PCT Photovoltaics v0.7 – Nexus ecoinvent 3.12 Nexus (ILCD).zip
PCT Photovoltaics v0.7 – Nexus ecoinvent 3.12 Nexus (OLCA).zip
PCT Photovoltaics v0.7 – Nexus BAFU 2025 (ILCD).zip
PCT Photovoltaics v0.7 – Nexus BAFU 2025 (OLCA).zip

Minimum for flow properties and unit groups needed

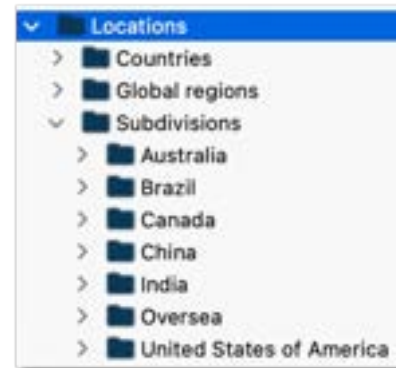


- Can be taken e.g. from ILCD units
- More units and flow properties can come from background databases
- Necessary to keep compliance between results from the same PCT

Locations from ISO 3166-1, ISO 3166-2 and UN M49



- Background database like ecoinvent typically add more locations for background data (aluminium industry, etc.)
- For the PCT foreground, only a “compliant” minimum of countries, global regions and its subdivisions needed



Data quality systems for the standards/guidelines used

General information - PCR Data Quality System

General information

Name: PCR Data Quality System

Category: - none -

Description: Data quality level and criteria of the UN Environment Global Guidance on LCA database development.
Table E.1 in EN 15804:2012 + A2:2019.

Version: 03.12.002 Last change: 2026-06-17 11:35:40 UUID: 36b9988a-f5d5-43cb-9179-4c7f150da37ee

Tags:

Source:

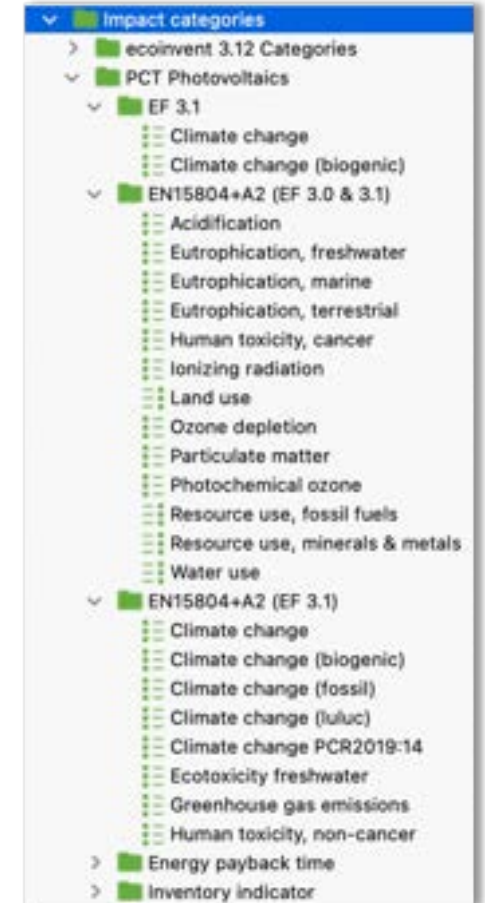
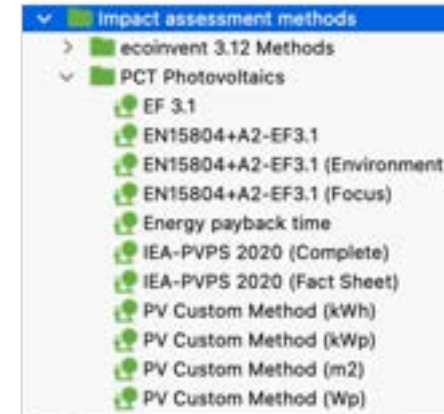
Indicators & Scores

	Very good	Good	Fair	Poor	Very poor	
Geographical representativeness	The processes included in the data set are fully representative for the geography stated in the "location" indicated in the title.	The processes included in the data set are well representative for the geography stated in the "location" indicated in the title.	The processes included in the data set are sufficiently representative for the geography stated in the "location" indicated in the title.	The processes included in the data set are only partly representative for the geography stated in the "location" indicated in the title.	The processes included in the data set are not representative for the geography stated in the "location" indicated in the title.	Add score Remove indicator
Technical representativeness	Technology aspects have been modelled exactly as described in the title and metadata, without any	Technology aspects are very similar to what described in the title and metadata with need for limited improvements.	Technology aspects are similar to what described in the title and metadata but merits improvements.	Technology aspects are different from what described in the title and metadata. Requires major improvements.	Technology aspects are completely different from what described in the title and metadata. Substantial.	Remove indicator
Time representativeness	Data are not older than 5 years as expressed in the ILCD field "data set valid until" and the difference	Data are not older than 5 years as expressed in the ILCD field "data set valid until" and the difference	Data are not older than 6 years as expressed in the ILCD field "data set valid until" and the difference	Data are not older than 10 years as expressed in the ILCD field "data set valid until" and the difference	Data are older than 10 years as expressed in the ILCD field "data set valid until" and the difference between the	Remove indicator
	Add indicator Remove score	Remove score	Remove score	Remove score	Remove score	

- Data quality systems**
- ☐ ecoinvent Data Quality System
 - ☐ ILCD Data Quality System
 - ☐ PCR Data Quality System

LCIA methods for the different standards/guidelines

- LCIA methods compatible to specific reference system
- PCTs available for different background databases
- Availability for different background database allows to also set some default product/waste flows
- Different LCIA methods for different standards
 - EN15804+A2 (EF 3.1) for EPDs
 - EF 3.1 for PEF and standards LCA
 - IEA-PVPS 2020 is EF 3.1 plus NR-EPBT
 - IPCC 2021 (incl. biogenic CO₂) for PCF, ISO 14067
 - Custom methods to focus on few relevant indicators



PCT specific impact method to e.g. automatically calculate the PV energy payback time

$$EPBT = \frac{CED_{mat} + CED_{manuf} + CED_{trans} + CED_{inst} + CED_{EOL}}{\left(\frac{E_{year}}{\eta_{grid}}\right) - CED_{use}} \approx CED_{tot} \frac{\eta_{grid}}{E_{year}}$$

Characterization factors - Energy payback time

▼ Characterization factors

Flow	Category	Factor	Unit Uncertainty
✓ Coal, brown	Elementary flows/Resource/in ground	9.9 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/kg none
✓ Coal, hard	Elementary flows/Resource/in ground	19.1 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/kg none
✓ Energy, geothermal, converted	Elementary flows/Resource/in ground	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Energy, gross calorific value, in biomass	Elementary flows/Resource/biotic	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Energy, gross calorific value, in biomass, primary forest	Elementary flows/Resource/biotic	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Energy, kinetic (in wind), converted	Elementary flows/Resource/in air	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Energy, potential (in hydropower reservoir), converted	Elementary flows/Resource/in water	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Energy, solar, converted	Elementary flows/Resource/in air	1.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/MJ none
✓ Gas, mine, off-gas, process, coal mining	Elementary flows/Resource/in ground	40.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/m3 none
✓ Gas, natural	Elementary flows/Resource/in ground	40.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/m3 none
✓ Oil, crude	Elementary flows/Resource/in ground	46.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/kg none
✓ Peat	Elementary flows/Resource/biotic	9.9 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/kg none
✓ Uranium	Elementary flows/Resource/in ground	560000.0 / 3.6 * Grid_Efficiency / (Annual_Specific_Yield / 1000)	year/kg none

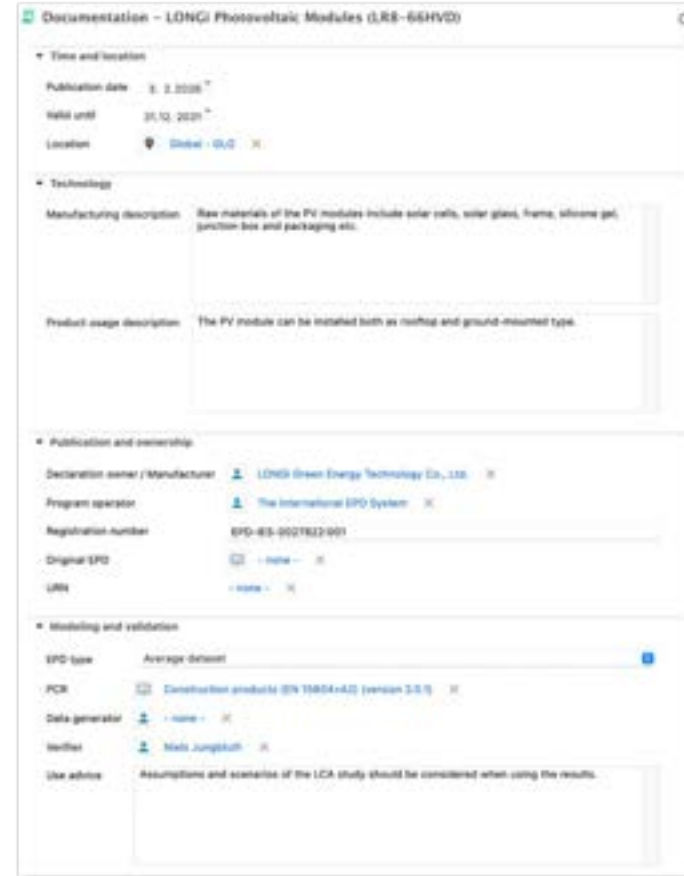
Example here for declared unit of 1 Wp and an annual specific yield given in kWh/kWp/year

Parameterized calculation of PV energy yield to fulfil different standards

$$E_{RSL} = \eta_M A_M I_{STC} P_R Y_{rad} (1 - r_1) \left(1 + \sum_{n=1}^{L-1} (1 - r_x)^n \right) = \eta_M A_M I_{STC} E_{PV} L_{RSL}$$

E_{RSL}	Total energy yield in the reference service life [kWh]
E_{PV}	Specific average annual PV system energy yield [kWh/kW _p /year]
Y_{rad}	Specific annual solar energy yield [kWh/kW _p]
η_M	Module efficiency [relative]
A_M	Module area [m ²]
I_{STC}	Irradiance at standard test conditions, usually AM1.5 with 1000 W/m ² [kW/m ²]
P_R	Performance ratio [relative]
r_1	Degradation rate first year [relative]
r_x	Degradation rate subsequent years [relative]
L_{RSL}	Reference service life [year]

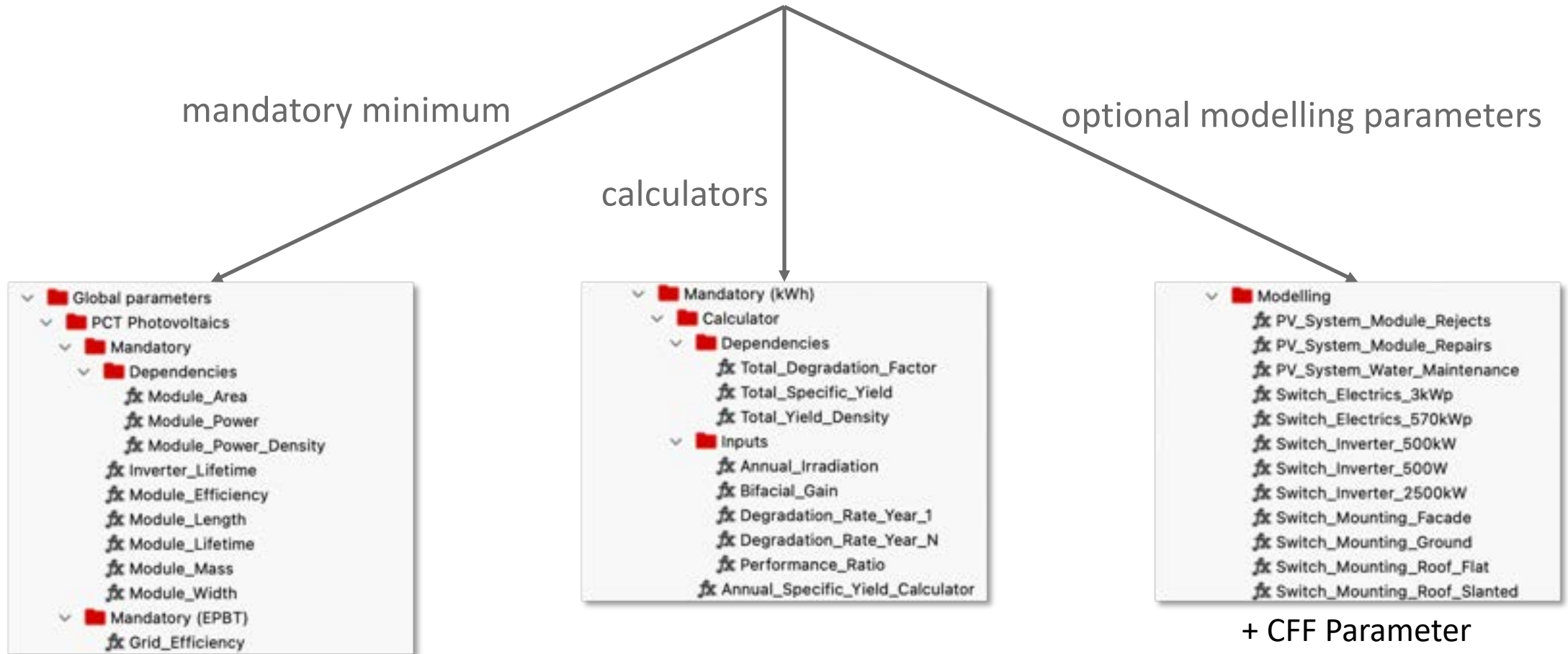
All existing digital EPDs for photovoltaics can be used (modules, inverters, solar glass)



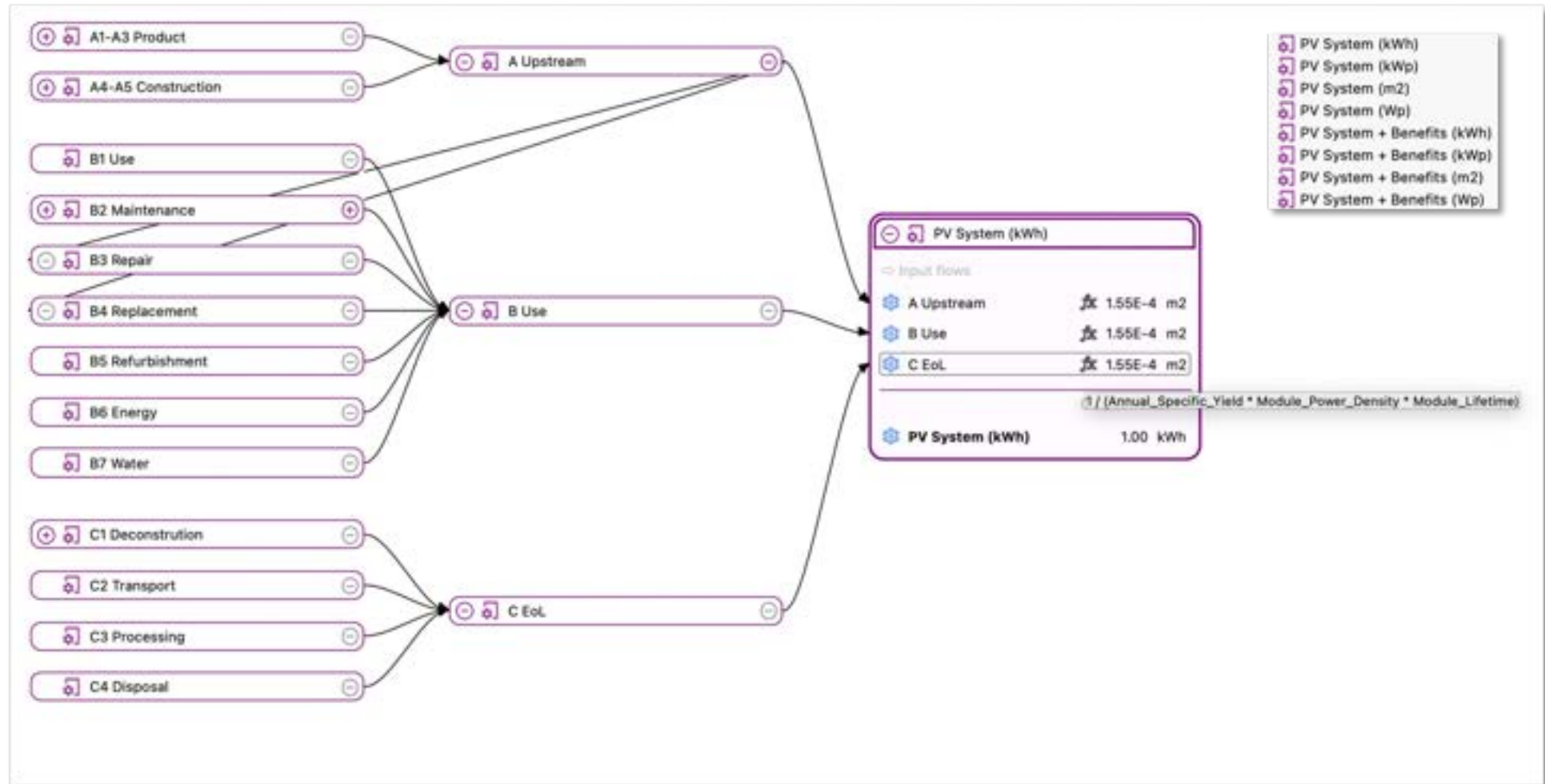
Unfortunately most digital EPDs not allowed to be freely distributed

→ direct import of EPDs into openLCA over the soda4LCA API

Global parameters for automatic calculations (the less the merrier)

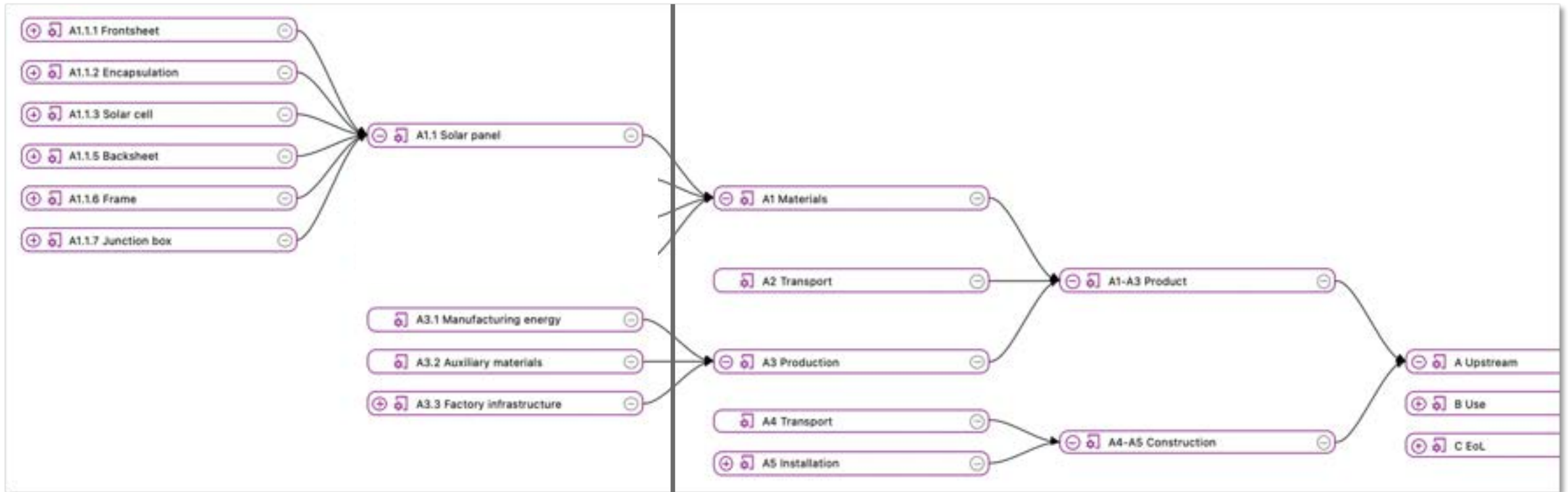


Base modules (taken from EPDs) and conversions for declared or functional unit

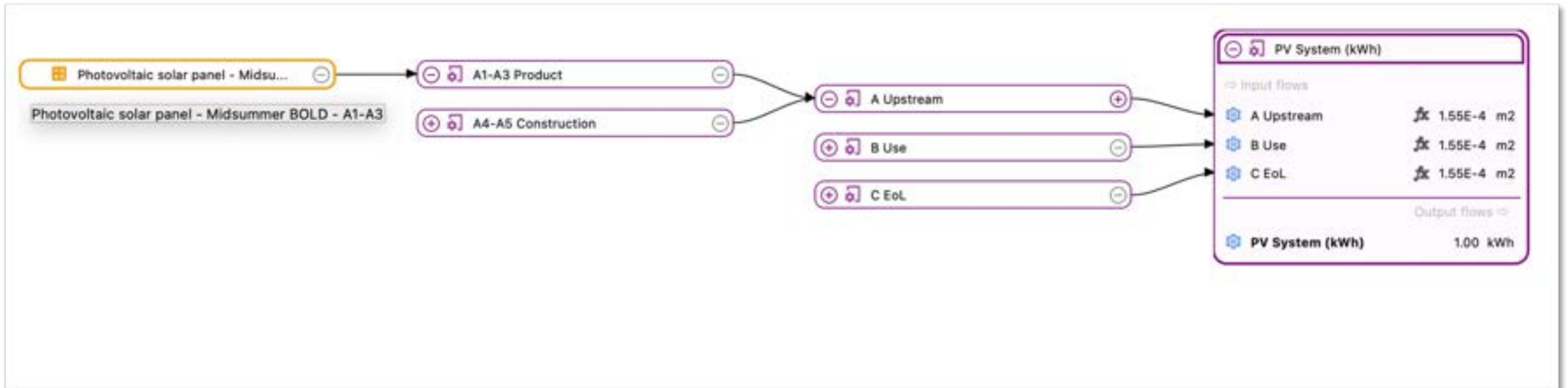


PCT specific modules (left) to guide the modeller and to simplify analysis groups

Modules can be easily removed depending on the system boundaries of the needed standard/compliance



Depending on the goal & scope or the supplier data, user can also connect EPDs



How does it differ from already existing, more specific tools?

- Open-source templates that can be verified/improved/corrected by the community (not proprietary, since all modules included are simply unit processes)
- Open data formats like OLCA (JSON-LD) or ILCD (XML) format
- All needed database elements are included in one package, except background data
- Wish of ongoing and dynamic system for updating and distributing PCTs (Product Category Templates) that is similar to e.g. the ongoing and dynamic developments of PCRs (Product Category Rules) for EPDs



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Thank you for your attention!

Dr. Conrad Spindler
Sustainability Researcher & Consultant
GreenDelta GmbH
spindler@greendelta.com



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UNIVERSITET



MARTIN-LUTHER-UNIVERSITÄT
HALLE-WITTENBERG



How does it differ from already existing tools or compliance packs?

Inputs/Outputs – PV Panel | CIGSe | Hi-BITS Standard

▼ Inputs

Flow	Category	Amount	Unit	Provider
A1.1 Frontsheet	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 2.0mm Custom - RER
A1.2 Encapsulation	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 2.0mm Custom - RER
A1.3 Cell	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 2.0mm+AR Custom - RER
A1.4 Backsheet	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 3.2mm Custom - RER
A1.5 Diode	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 3.2mm+AR Custom - RER
A1.6 Frame	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 4.0mm Custom - RER
A1.7 Auxiliary	PCT Photovoltaics	1.00000	m2	Frontsheet Glass 4.0mm+AR Custom - RER
A3.1 Energy	PCT Photovoltaics	1.00000	m2	Energy CIGSe ecoinvent 3.11 - RER
A3.2 Infrastructure	PCT Photovoltaics	1.00000	m2	Infrastructure Generic ecoinvent 3.11 - GLO

▼ Outputs

Flow	Category	Amount	Unit	Provider
PV Panel	PCT Photovoltaics	1.00000	m2	

- Specific tools usually limit already the possible providers
 - less freedom to model
 - usually only 1 compliance
- PCTs are step before this, so that different compliances can be modelled
 - more modelling tasks
- PCTs could also be limited further to create a specific tool if wanted