



Product Sustainability in Solar

LCAs, Carbon Payback, Recycling & Eco-Labels

Sept. 17, 2024 | IDEM P2 Conf. | Corporate Affairs – Sustainability



qcells

Qcells – Company Snapshot



No.1 Market Share

Top market share in both the U.S. residential and commercial segments.

*Wood Mackenzie US PV Leaderboard Residential & Commercial since 2018 and 2019 respectively.



Tier 1 Bankability

Tier 1 solar manufacturer backed by Hanwha Group, a Fortune Global 500 company and 7th largest conglomerate in South Korea.



USA Manufacturing

The only company to establish a fully-integrated, silicon based solar supply chain from raw material to finished panel in the US with the largest solar module factory of its kind in operation in the Western Hemisphere.*

* Applies to certain products



Top Technology

Robust 20+ year history of award-winning innovations and rated as a top module brand for 2 consecutive years in the US.



Quality Assurance

Strict quality testing standards that ensure outstanding durability and world-class performance as proven by top global institutions PVEL and TÜV Rheinland.



Best-in-class Warranty

Extended 25-year product and performance warranties* that reflect our commitment to quality products built to last.

* Applicable to select products



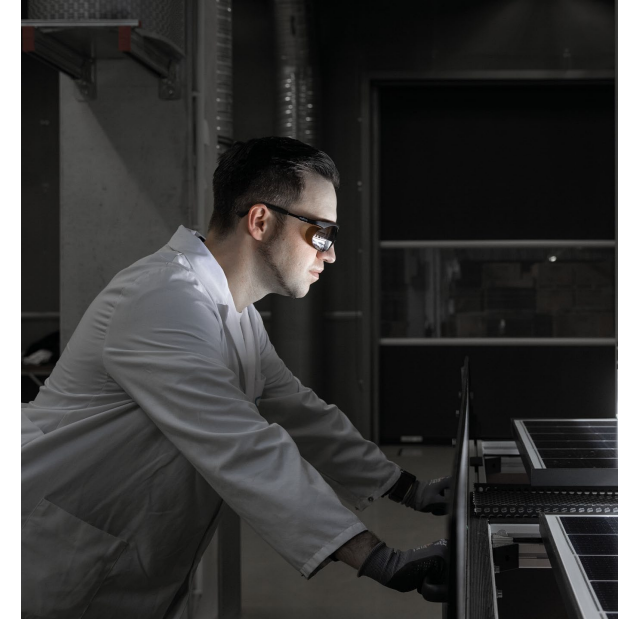
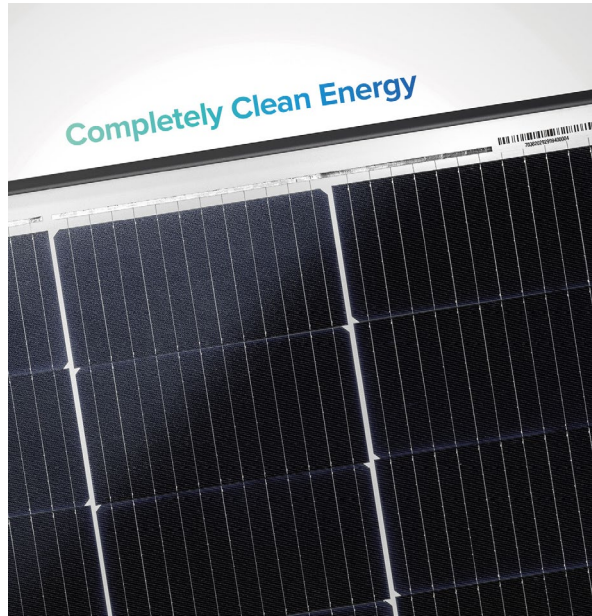
Leader in Low-Carbon Solar Manufacturing

- Largest U.S. solar investment, \$2.5 billion
- 1st solar manufacturer to build ingot, wafer, cell plant in the U.S.
- Sourcing polysilicon, a key raw material in solar panels, from hydro-powered plant in U.S.



Qcells Supply Chain Factory in Cartersville, GA, USA
Completion expected in 2024

Opportunities



Imbed Sustainability in Design

- Design for sustainability
- Learn, model, improve full life cycle
- Build circular economy capability

Measure to Manage

- Define, calculate, share baseline data
- Set and communicate goals
- Drive progress transparently

Integrated, Holistic Planning

- Beyond emissions – waste, water, biodiversity and employee health
- Environmental, Social, & Governance

Product Sustainability

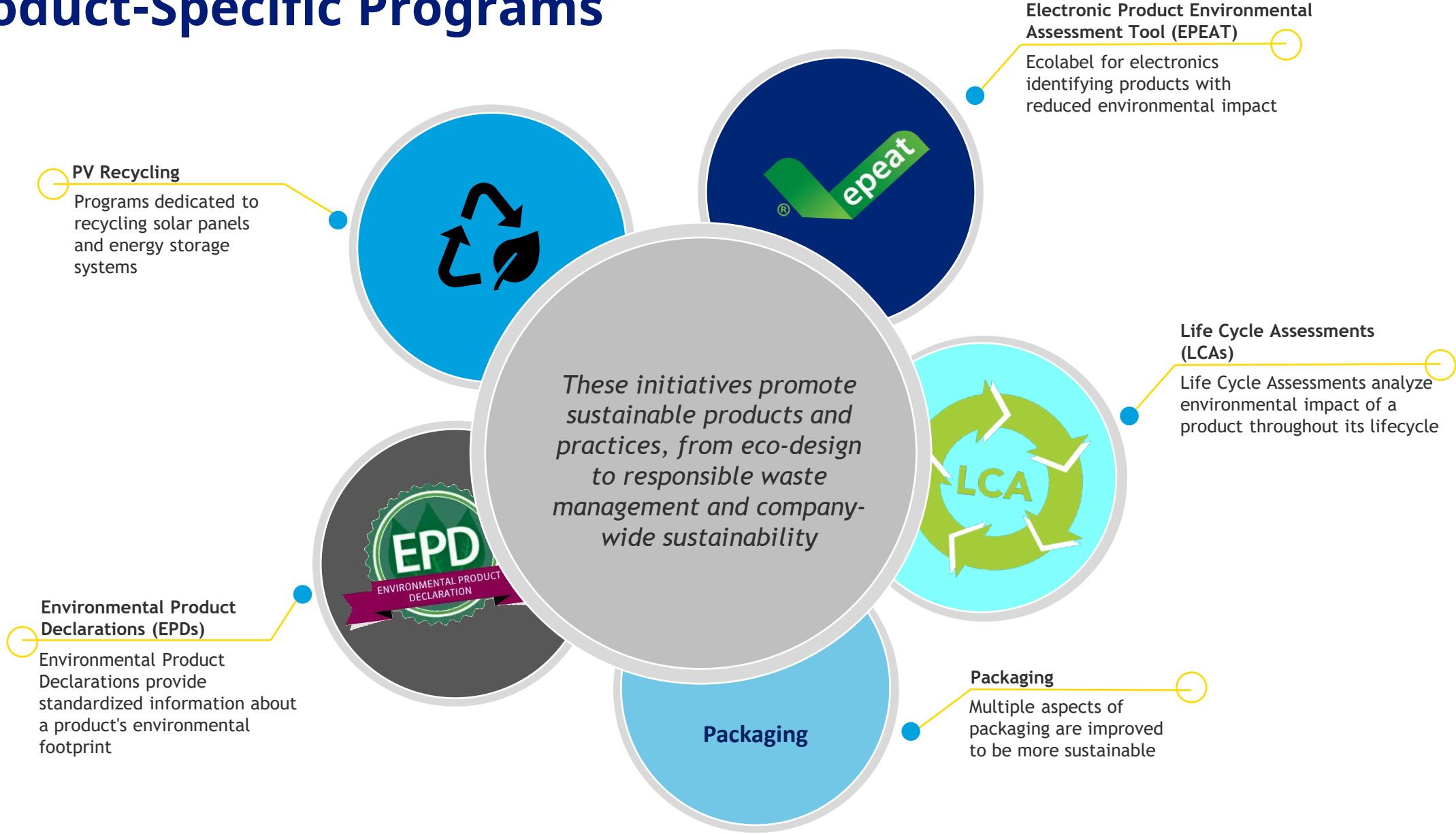
> Enterprise Sustainability: Emissions/Energy Measurement

- Scope 1 and 2 Emissions: Collected globally since 2018.
- Scope 3 Emissions: KR data collected starting 2019, Global data starting this year.
- Global Scope 1 and 2 Net Zero Goal by 2050, 35% reduction by 2030.
- KRE-100: 100% Renewable Energy in Korea by 2030 Commitment.

> Product Sustainability & Social Responsibility

- LCA: 1st Module Life Cycle Assessment (LCA) completed in 2023, 2nd completed 2Q24.
- EPEAT: 1st Polysilicon Module to receive EPEAT Certification in 2024. Register 2 more products this year.
- Internal Conflict Mineral traceability Policy implemented in 2024.
- Domestic panel recycling partnership with Solarcycle announced.
- Clean Energy Crew Formed: ES/GES Volunteer hours added benefit.
- Internal Donation process developed.

Product-Specific Programs



PV Recycling
Programs dedicated to recycling solar panels and energy storage systems

Electronic Product Environmental Assessment Tool (EPEAT)
Ecolabel for electronics identifying products with reduced environmental impact

Life Cycle Assessments (LCAs)
Life Cycle Assessments analyze environmental impact of a product throughout its lifecycle

Environmental Product Declarations (EPDs)
Environmental Product Declarations provide standardized information about a product's environmental footprint

Packaging
Multiple aspects of packaging are improved to be more sustainable

These initiatives promote sustainable products and practices, from eco-design to responsible waste management and company-wide sustainability

Lifecycle Assessments



Qcells Lifecycle Assessments (LCAs)

Previous LCAs (2019)

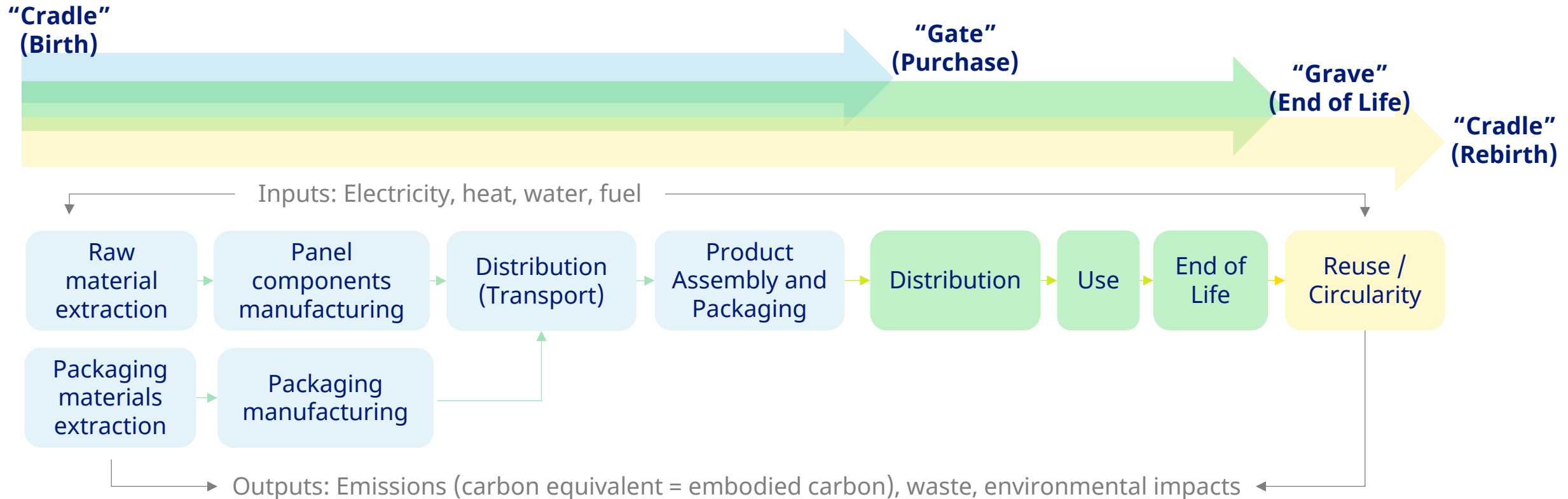
- Gate-to-Gate LCA
- Conducted by Pink (EU)
- 1 Korean Product
- Excluded frame, conducted in accordance with French Tender

New LCAs (2023-24)

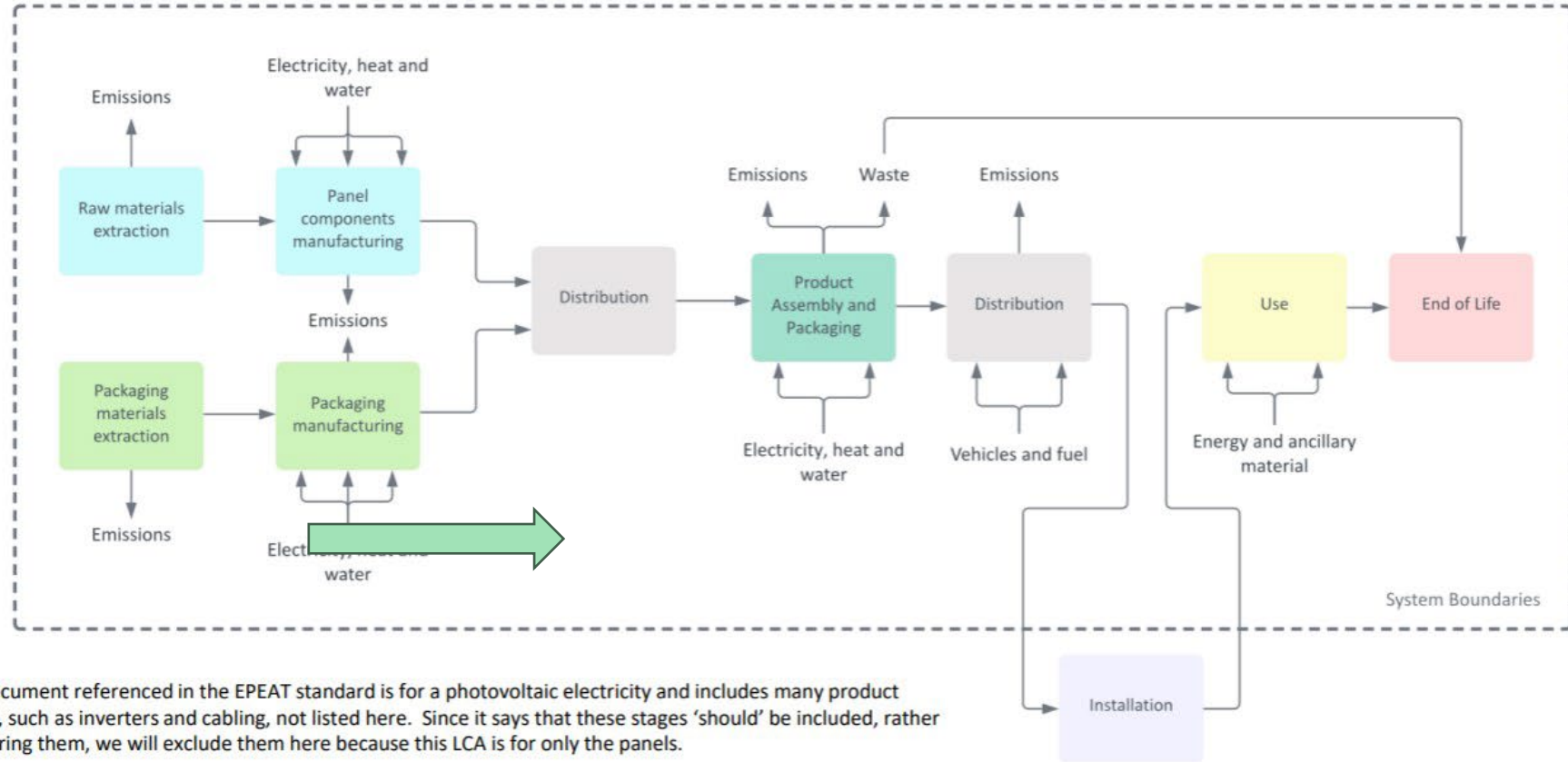
- Cradle-to-Grave
- Conducted by EarthShift Global
- 1 Korean panel
- 2 Dalton panels
- Includes product frame, conducted in accordance with EPEAT

Introduction to Life Cycle Assessment and Embodied Carbon

- Life Cycle Assessment (LCA) measures the environmental impact of a product through different phase of its life.
- One LCA output is the calculation of **embodied carbon**, expressed in weight of CO2 equivalent units (CO2e).
- Each product will have a unique embodied carbon depending on components, sourcing and assembly locations.



SYSTEM BOUNDARIES



The IEA document referenced in the EPEAT standard is for a photovoltaic electricity and includes many product categories, such as inverters and cabling, not listed here. Since it says that these stages 'should' be included, rather than requiring them, we will exclude them here because this LCA is for only the panels.

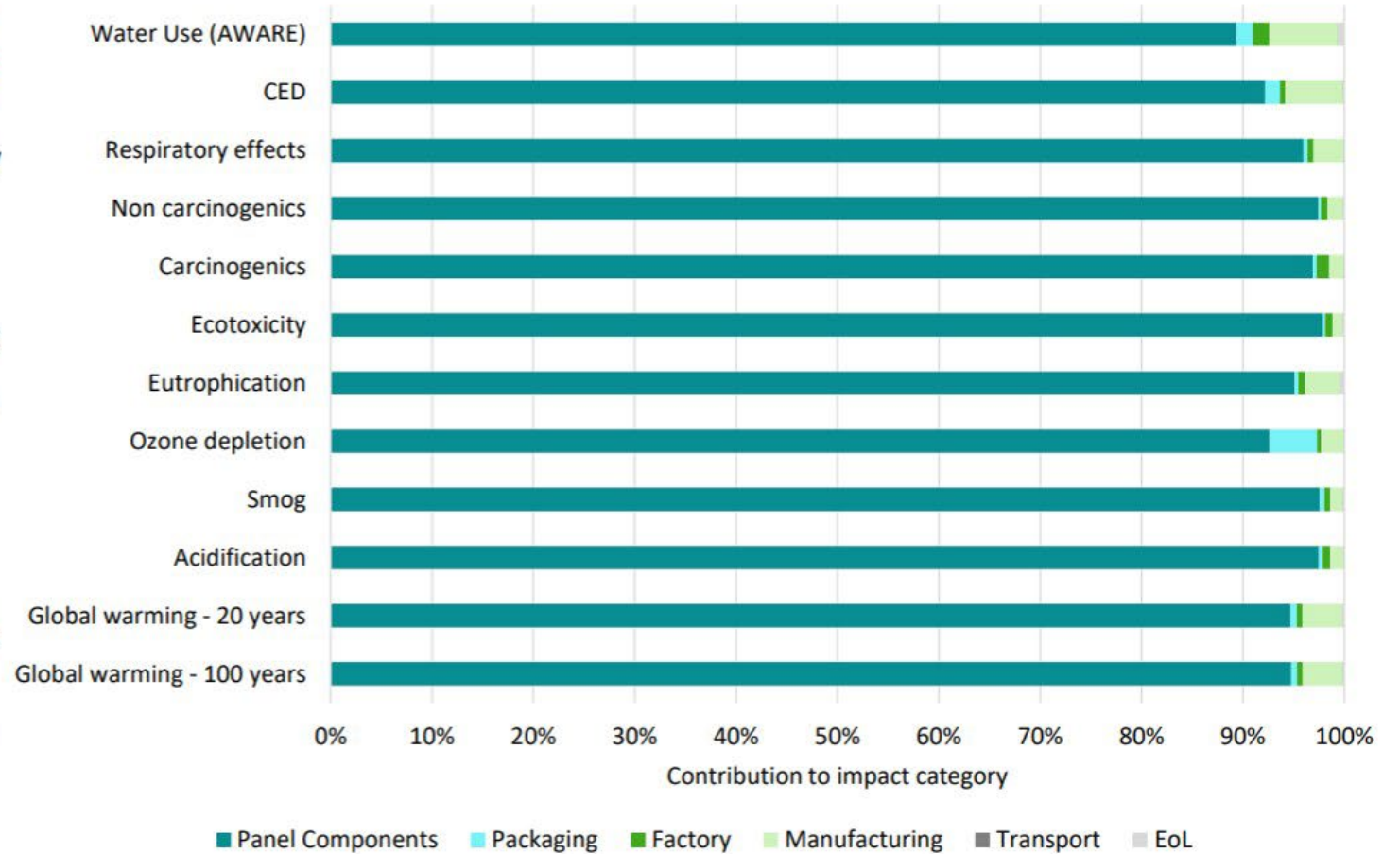
Product use should include:

- Auxiliary electricity demand
- Cleaning of panels
- Maintenance
- Repair and replacement, if any

LCAs

CONTRIBUTION ANALYSIS

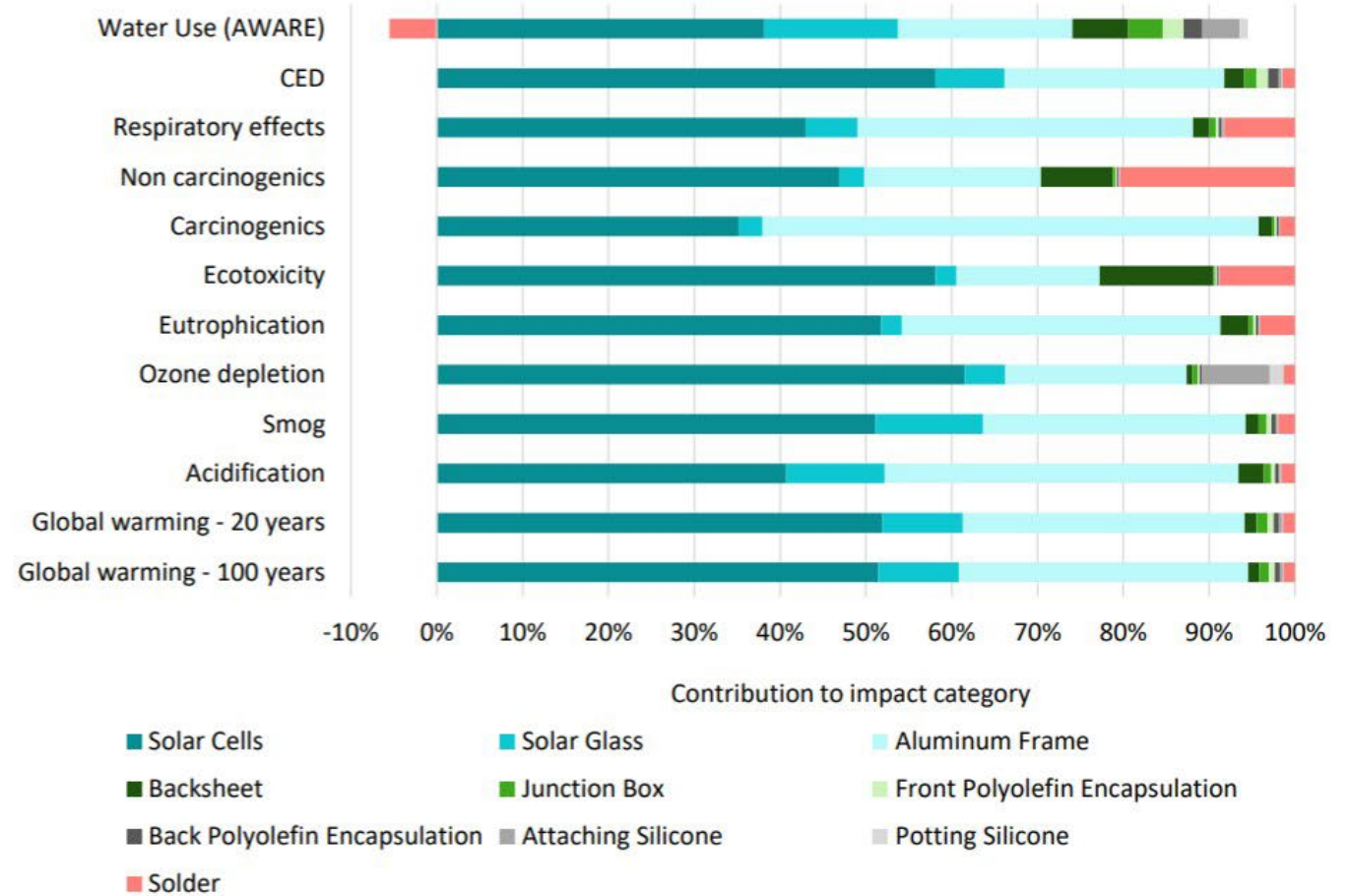
- The environmental impacts of the system in all impact categories are dominated by the **components of the panel** (89% - 98% contribution), with burdens mainly allocated to the solar cells.
- The **manufacturing** (assembly) of the panel is the secondary hotspot of the system, it accounts up to 7% of environmental impacts, due to the impacts of the electricity grid.
- Distribution, the factory infrastructure, packaging, and EoL all contribute to the lesser fraction of impacts, except for ozone depletion, where packaging is responsible for 5% of impacts due to the use of paper-based materials.



LCAs

PANEL COMPONENTS ZOOM IN

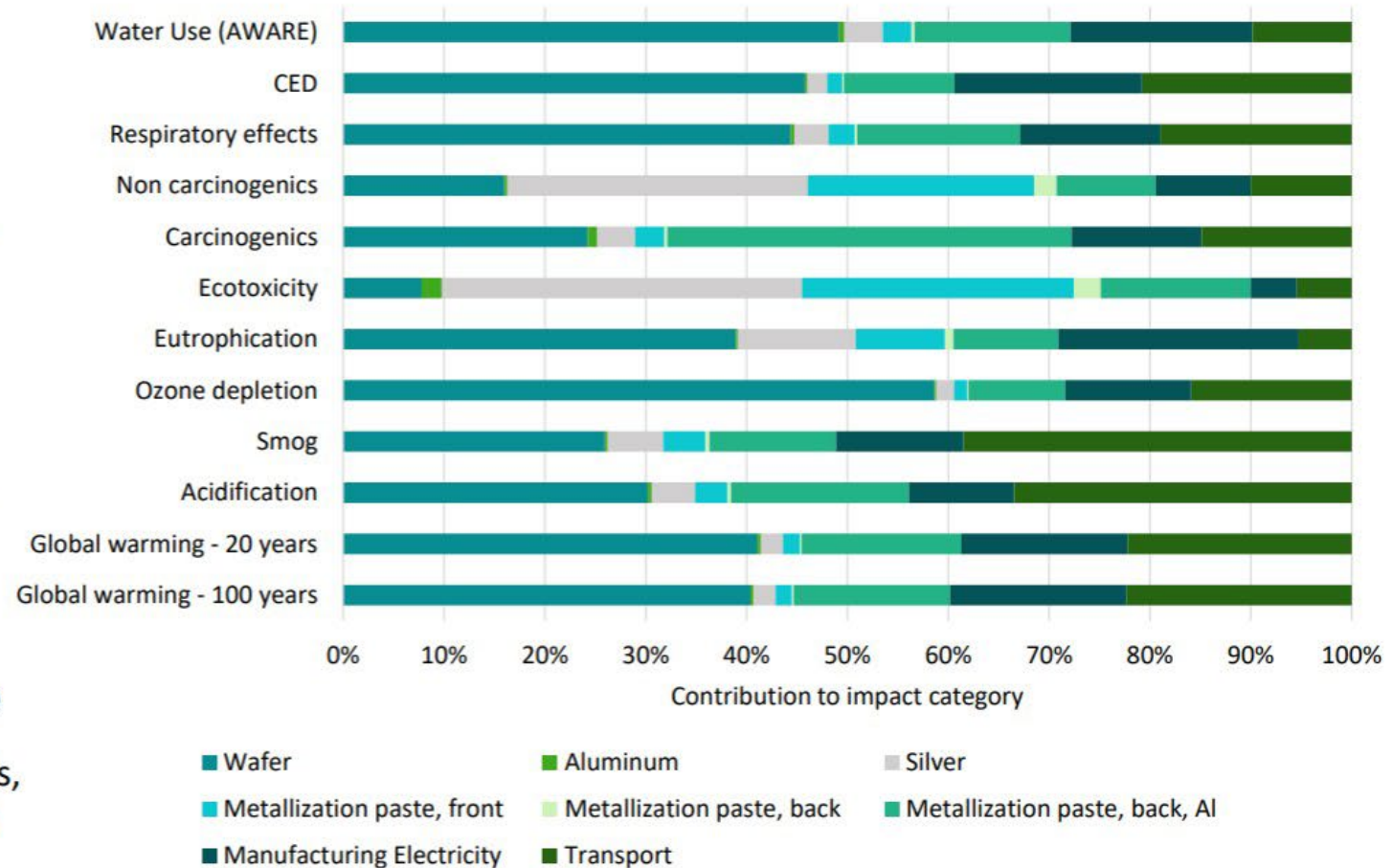
- The panel impacts are heavily driven by its **solar cells** (35% - 59% contribution).
 - Based on the IEA photovoltaic panel systems report, solar cell impacts are concentrated in the wafer manufacturing (main hotspot).
- The **frame** is the secondary driver of impacts (up to 58% contribution in carcinogenics) with environmental burdens mainly allocated on the production of the main material of the frame (virgin aluminum).
- The **solar glass** contributes to up to 18% of impacts, with the production of flat glass as the main driver of impacts.



LCAs

SOLAR CELLS ZOOM IN

- The cells' **wafer** is the main driver of impacts in 5 of the 12 analyzed impact categories.
 - Environmental burdens of the wafer are mainly allocated to energy consumption and the electricity grid used to power the manufacturing process.
- The **transport** and the **manufacturing electricity** are the secondary drivers of impacts:
 - Distribution accounts for 5% - 38% of impacts, due to the burdens associated to the heavy fuel oil production for the ship transport.
 - The electricity used during the manufacturing process contributes 4%-34% of impacts, because of the use of the coal used to generate this input.



EPEAT Ecolabel



What is EPEAT?

EPEAT is a **Type 1** sustainability ecolabel standard created by the Global Electronics Council (GEC)



EPEAT = Electronic Product Environmental Assessment Tool

- This is an individual product-level certification for a given country.
- Leading resource for differentiating sustainable electronic products.
- Strict, comprehensive criteria verified by an independent third party

EPEAT ecolabel is well known - required for 95% of US Federal Agencies electronics procurement

Eco-Label Appeal

- **Established:** US Government requires 95% electronics procurement be EPEAT registered
- **User-friendly:** simple 3-tier rating - no required expertise to understand
- **Credible:** Independent third-party reviews = very low risk of greenwashing
- **Stakeholder Value-add:** ESG rating benefits
- **Carbon Accounting Impact:** Reduces customer carbon emissions

EPEAT ecolabel provides reassurance to solar purchasers

EPEAT can be a valuable differentiator to customers



Federal Agencies

- FAR ([Federal Acquisition Regulation](#)) requires EPEAT procurement¹
 - Requires US Federal Agencies to procure 95% environmentally sustainable electronics under EPEAT standards
- Largest electricity purchaser in US 8.6GW (\$1B) solar estimated 23-26¹



Utilities

- Supports RE100 sustainability targets by reducing emissions for same power output
- Studies show 4-9% of customers signal a moderate willingness to pay for sustainability attributes (11% above cost)³



Corporations

As of June 2024, FAR requirement was met, 3 registered products from 2 different suppliers (Qcells & First Solar)

¹ Avascent Research, 2023; ² Reference 23.103A and 23.704; ³ [Clean Energy Buyers Institute \(CEBI\) Energy Customer Survey](#);

EPEAT Certification Requirements and Levels



- Manufacturers **MUST** meet **17 required** criteria for modules (only 30% of all US solar products anticipated to meet entry level)
- *This includes the Low-Carbon requirement¹*
- Manufacturers **MAY** meet **46 optional** points that define certification level



Bronze is the entry level, requiring no additional optional points

(KR Q.PEAK registered product has 10 optional points. Strategy today is to target Bronze status.)



Silver requires **50%** of the optional points



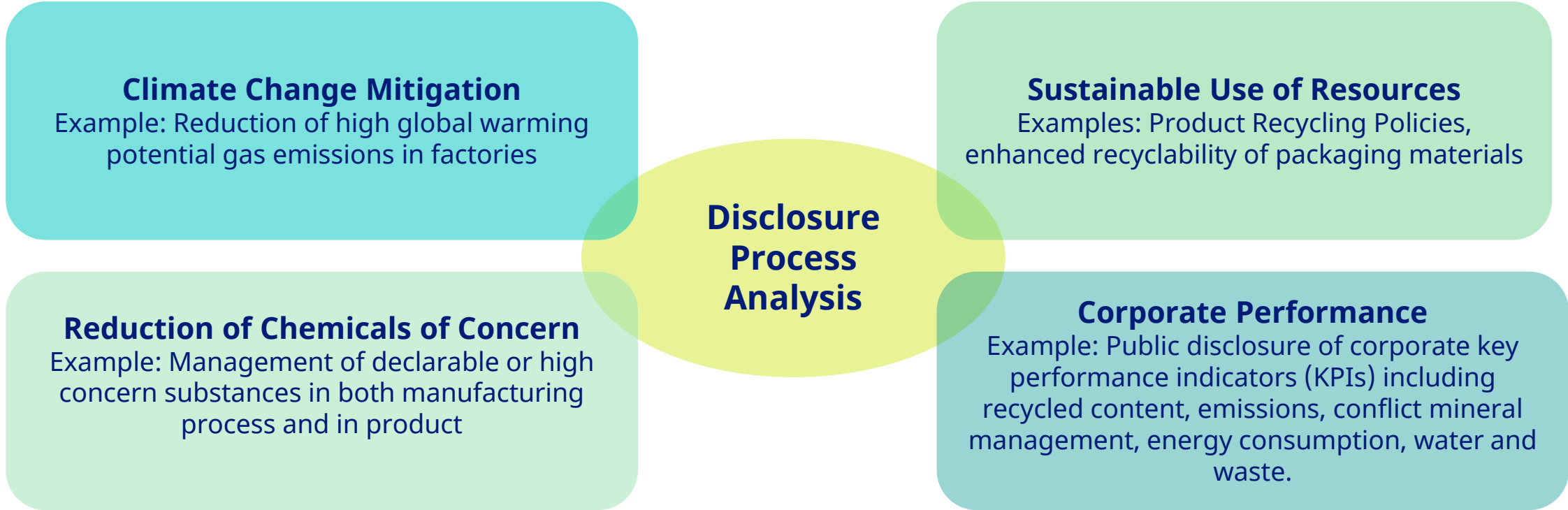
Gold requires **75%** of the optional points.

Q.PEAK DUO XL G11S.3/BFG Korea assembled module only		Q.TRON BLK M-G2+ Dalton assembled modules only		Q.PEAK DUO XL G11S.3/BFG Dalton assembled modules only	
February 2024		May 2024			

Today, Qcells is the only polysilicon-based PV manufacturer with an EPEAT registered solar product

¹ Implemented June 4, 2024

EPEAT Requirements for Manufacturers



EPEAT requires 1) evidence/disclosure of sustainable processes and 2) verified carbon footprint below threshold

Embodied Carbon

Is 630 kg CO₂/ kWp 'good'?



EPEAT Next Steps: Completing new Low Carbon Requirement

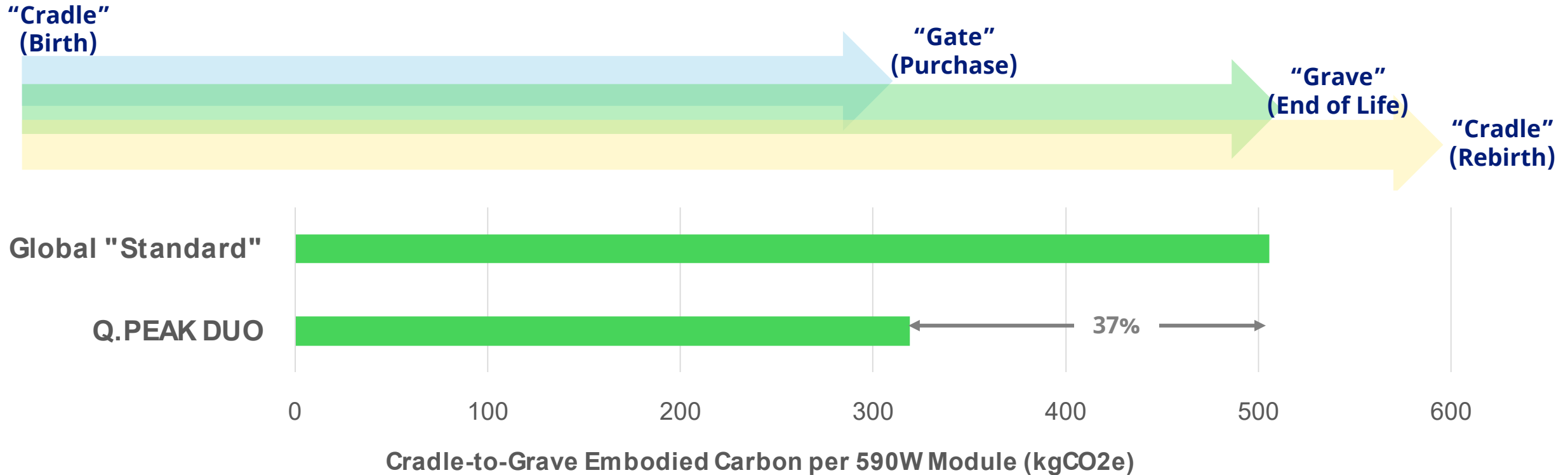
- In addition to the certification levels, there are now EPEAT **verified carbon footprint (VCFP) levels (June 4)**.
- Certified products must have a calculated and carbon footprint level below a threshold to meet this new requirement by **December 31, 2024**, or be removed from the registry until compliance can be shown.
- Depending on the carbon footprint, products fall into either the **low carbon** or the **ultra low carbon** levels.

Carbon Certification Level	Embodied Carbon Levels (Cradle to Gate, kgCO2e / kWp)	Comments
Global Industry "Standard" PV Module	~800-900	GEC Analysis (Heckman)
"Low Carbon" PV Module	630	25% less than "Standard"
"Ultra Low Carbon" PV Module	400	50% less than "Standard"

We are still in the process of completing this but anticipate being in the "Low Carbon" category

Qcells LCA data compared to global "standard" PV modules

LCA of Q.PEAK module has 37% lower embodied carbon than standard module at same peak power



Carbon Payback period for a single module

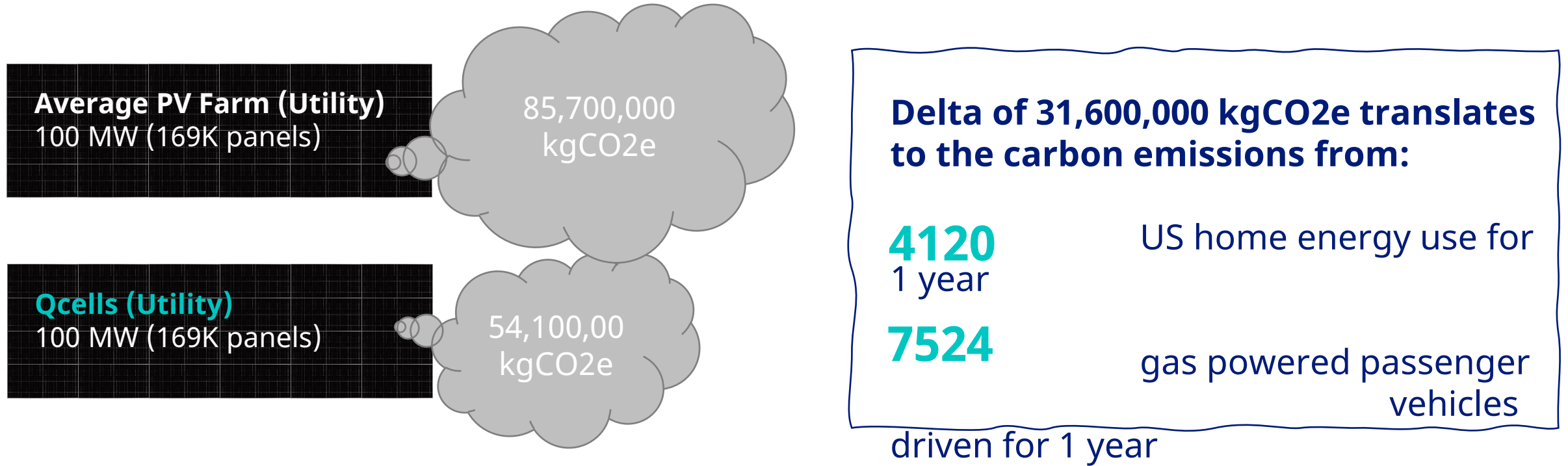
- Under standard conditions, a 590W panel like the Q.PEAK DUO XL G11S.3 can produce about **67.7 kWh/month**
- Comparing the **embodied carbon of one solar panel (590W)** to **grid energy emissions** to produce same energy allows us to compare module “carbon payback” periods for their cradle to grave life cycle

kgCO2e to make 67.7 kWh/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grid Emissions	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
“Standard” PV																		17.1						
Q.PEAK DUO G11												10.8												

By providing cleaner grid energy, Qcells Q.PEAK panels offset their embodied carbon in <11 months

Farm level carbon comparison using LCA data

When scaled to 100MW farm, this 37% emissions delta equates to significant environmental impacts for customers.

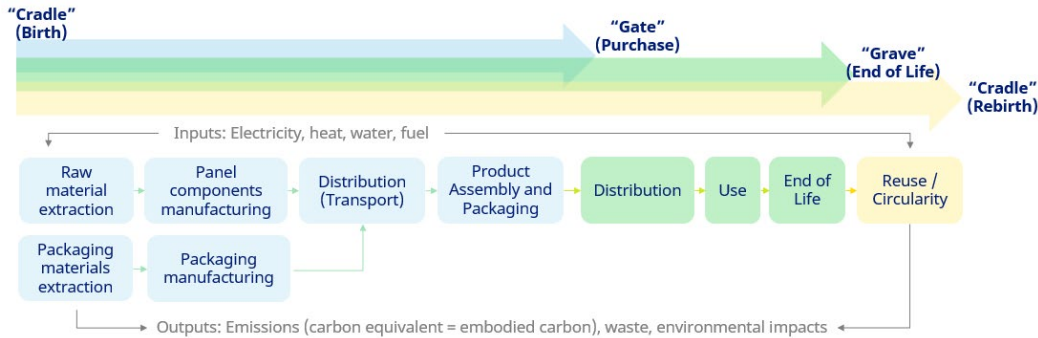


Not all solar is created equal! With Qcells modules, the same power output means 37% lower emissions

Difference between LCA and Verified Carbon Footprint (NEW)

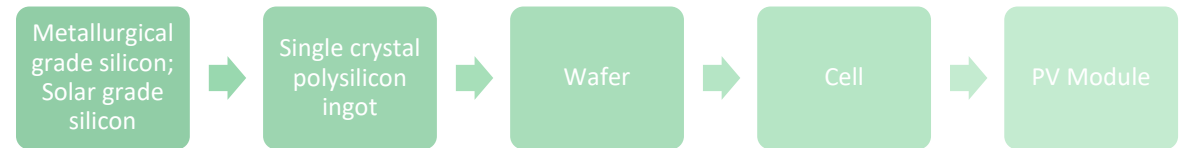
Life Cycle Assessment (LCA)

- LCAs measures the environmental impact of a product through different phase of its life.
- Each product will have a unique embodied carbon depending on components, sourcing and assembly locations.
- **Required for EPEAT registration (Criteria 7.1.1)**



Verified Carbon Footprint (VCFP)

- VFCP is based on French carbon tender process, this uses the same methodology as LCAs but with more constraining and specific input requirements.
- The EPEAT VCFP is an assessment of the energy flow of the most intensive processes to make a PV module, tracking key components in supply chain, their mass or area and country of origin (in addition to documentation and verification).
- **Required for EPEAT registration (Criteria 4.1)**



The output of both analysis is embodied carbon, but the calculation methods and assumptions differ

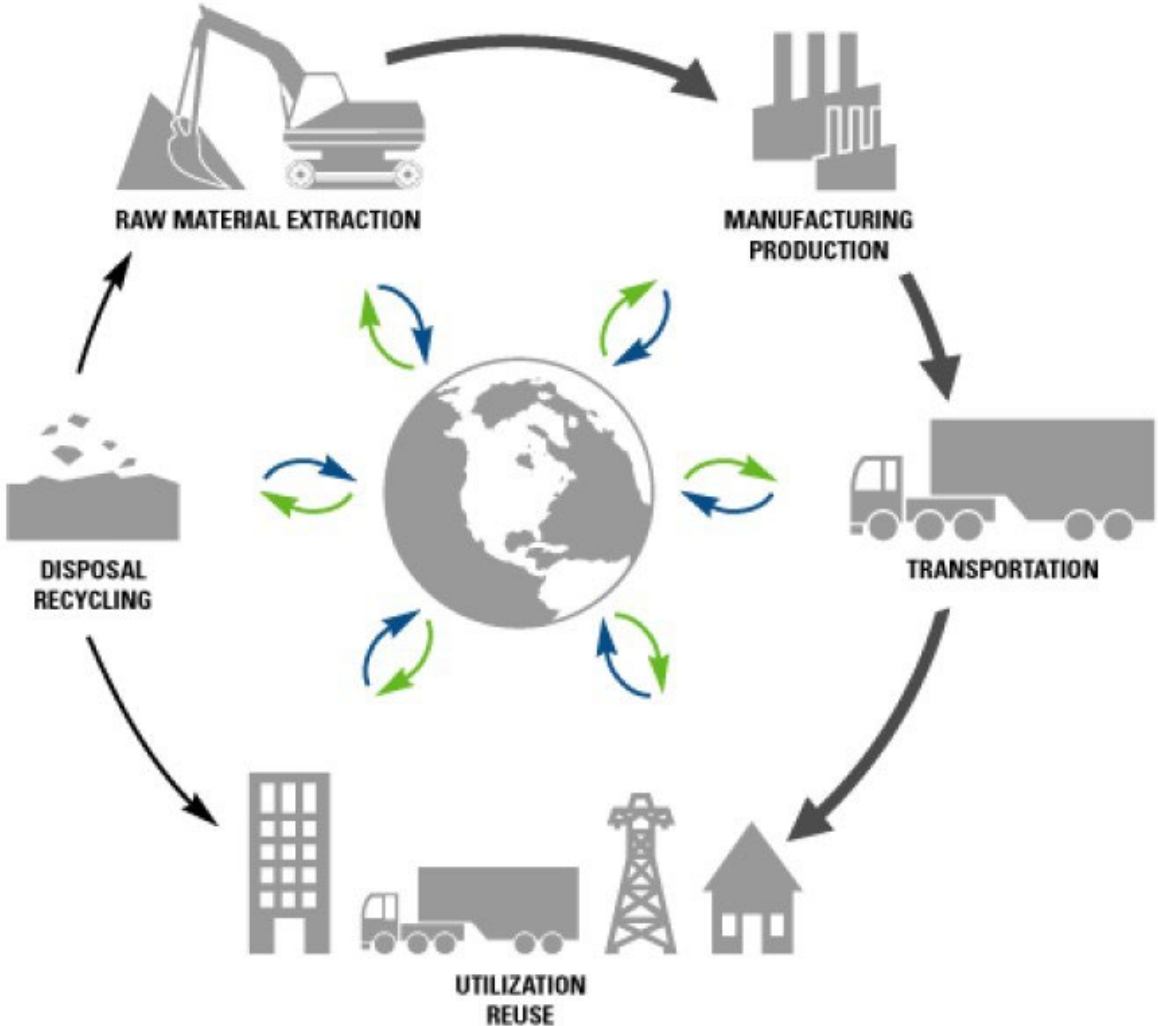
Solar PV Recycling



Linear Economy



Circular Economy



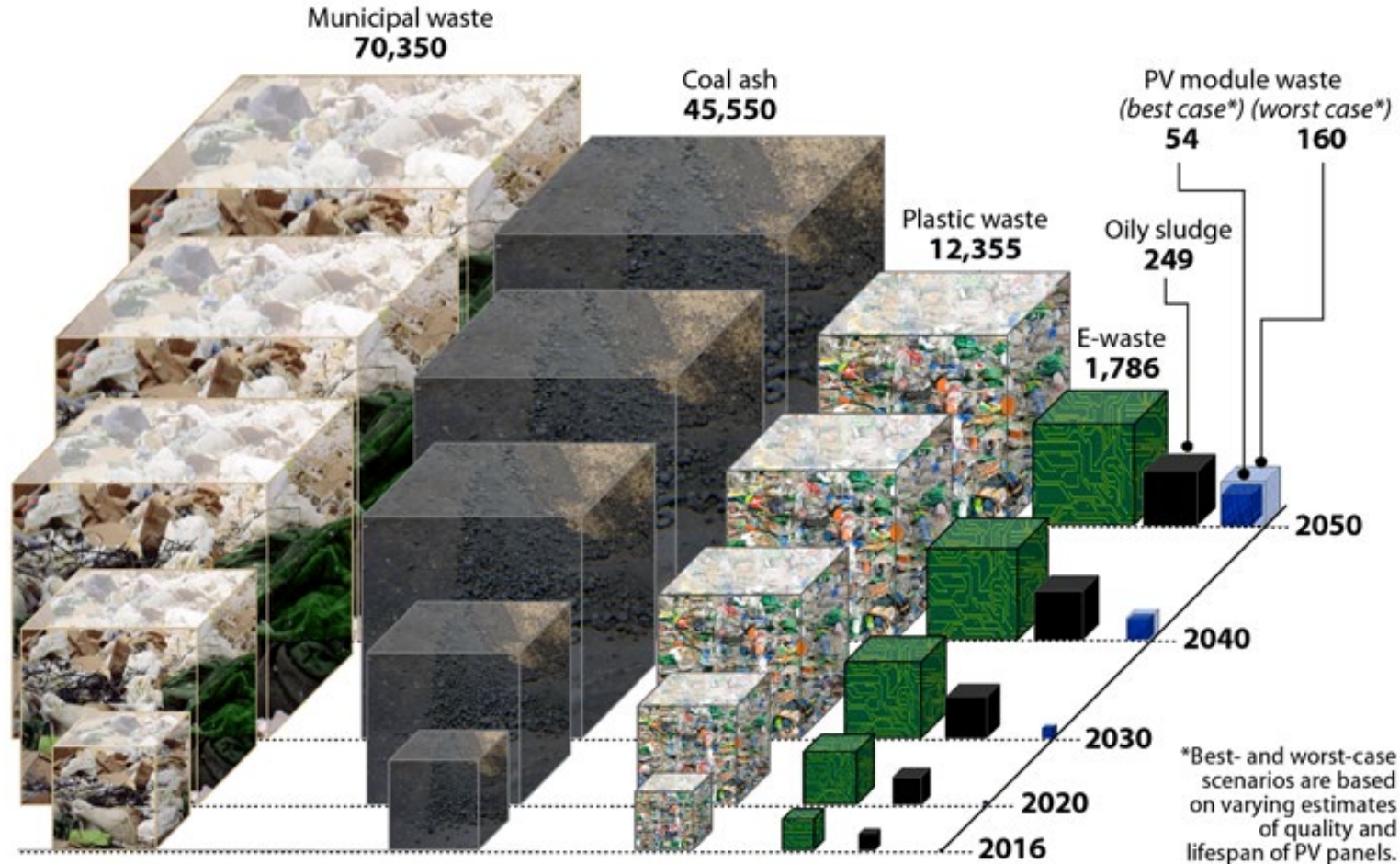
PV Recycling

Solar Panel Waste in Context

Researchers compared global waste estimates generated from landfills, fossil fuel production and e-waste. While waste from electronics and photovoltaic modules will certainly grow in the coming years, they will remain a fraction the amount of other sources.

GLOBAL CUMULATIVE WASTE





In millions of metric tons, 2016-2050



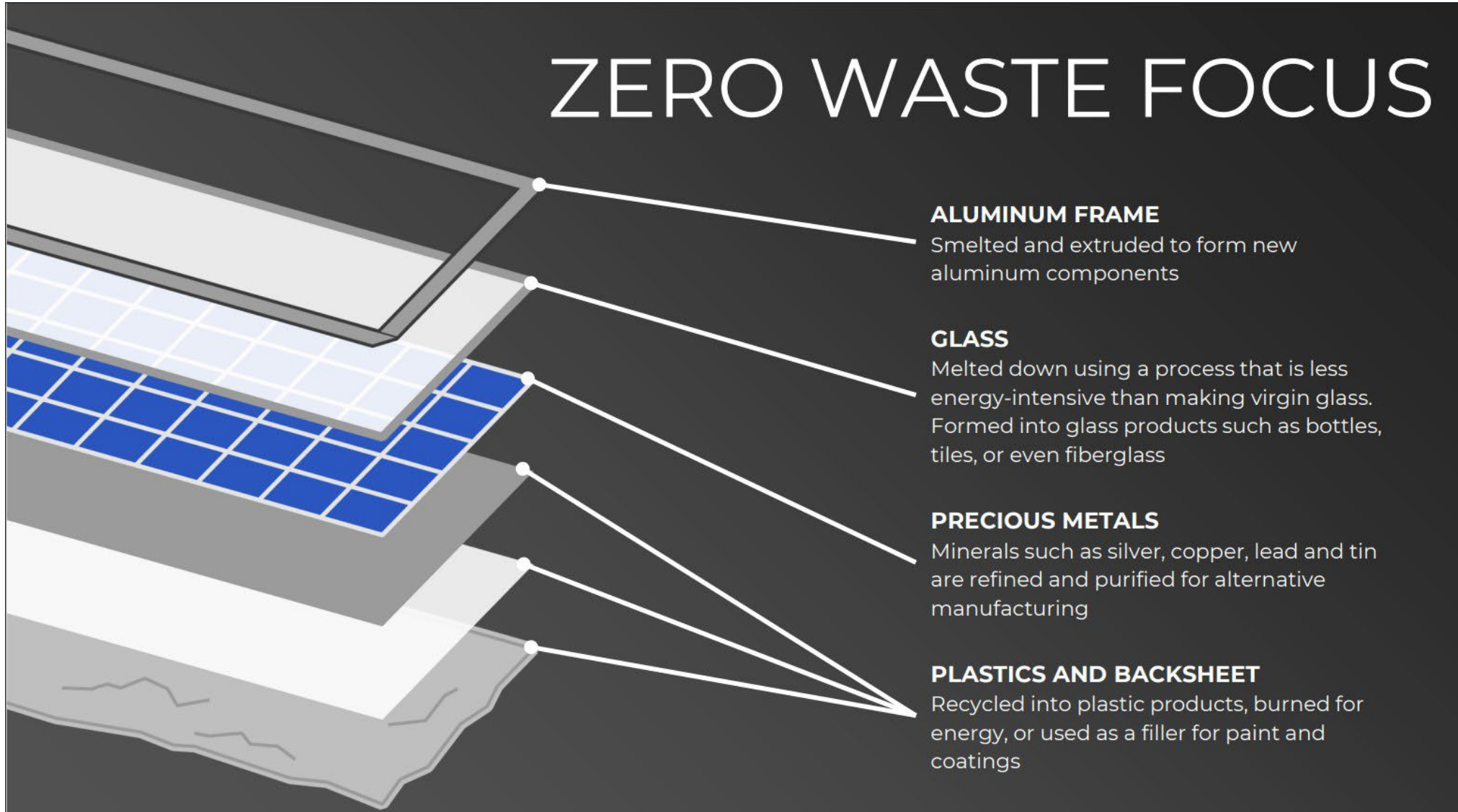
SOURCE: Heather Mirletz et al., *Nature*

Inside Climate News

PV Recycling Myth Busting

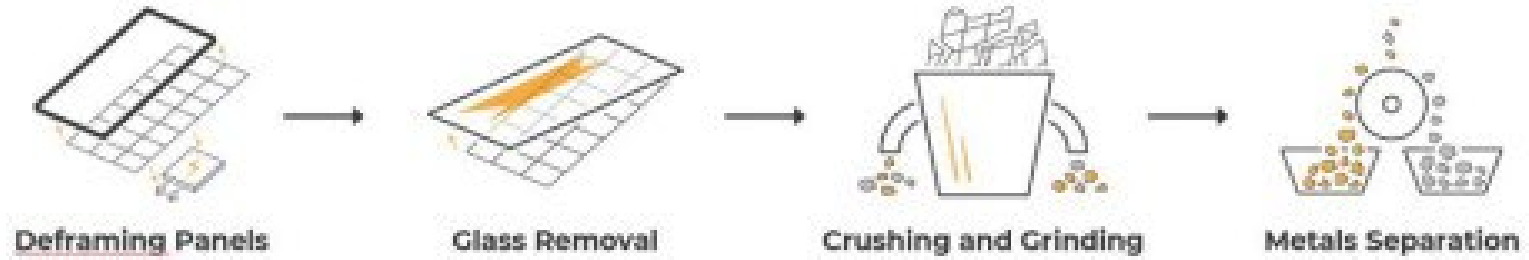
- “Tsunami” of waste 
 - Leaching chemicals 
 - Recycling isn’t possible 
 - Any recycling is good enough 
- Perspective of larger waste industry
 - NREL confirmed gross misinformation about what materials are in solar & most panels are crystalline and solid state
 - Recycling is already happening in the U.S., it’s just expensive still
 - Not all recyclers are equal. Where do materials end up?

PV Recycling



PV Recycling

Recycling Process

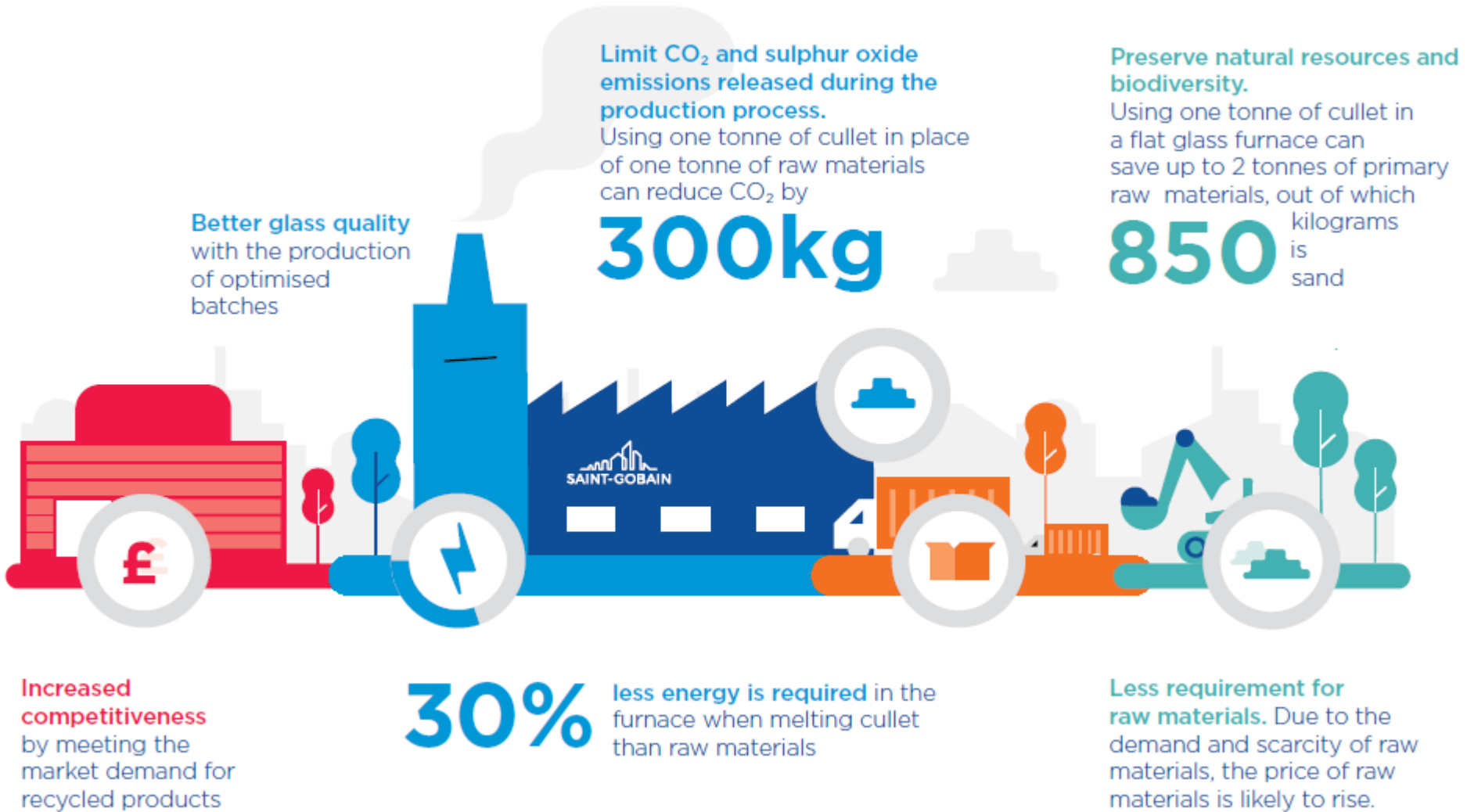


Material Outputs



Module material value	Weight%	Value USD/kg	% Value / PV Module	SCI Recovery Rate	Value Recovery
Glass	68	\$0.10	12.7%	99%	12.6%
Silver	0.03	\$500.00	28.1%	95%	26.7%
Silicon	3	\$2.40	13.5%	80%	10.8%
Copper	2	\$3.80	14.2%	98%	13.9%
Aluminum	12	\$1.40	31.5%	100%	31.5%
Balance (10%)	14.97	\$0.00	0.0%	0%	0.0%
				SUM	95.5%

PV Recycling



PV Recycling



- Meeting current EPEAT requirements
- Exploring new partnerships to diversify abilities
- Investigating building in-house capabilities
- Potential market differentiator

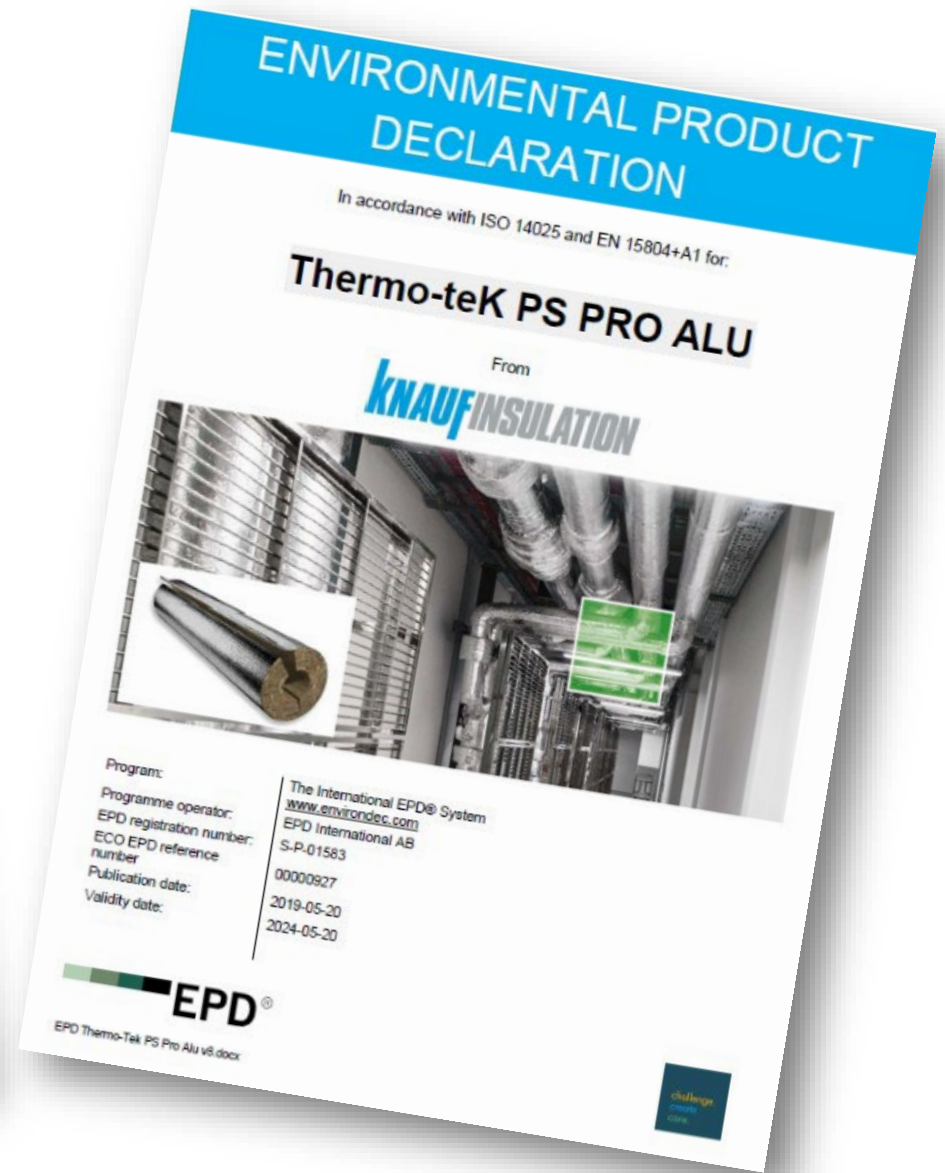
Environmental Product Declarations (EPDs)



EPDs



EPDs



Product Packaging



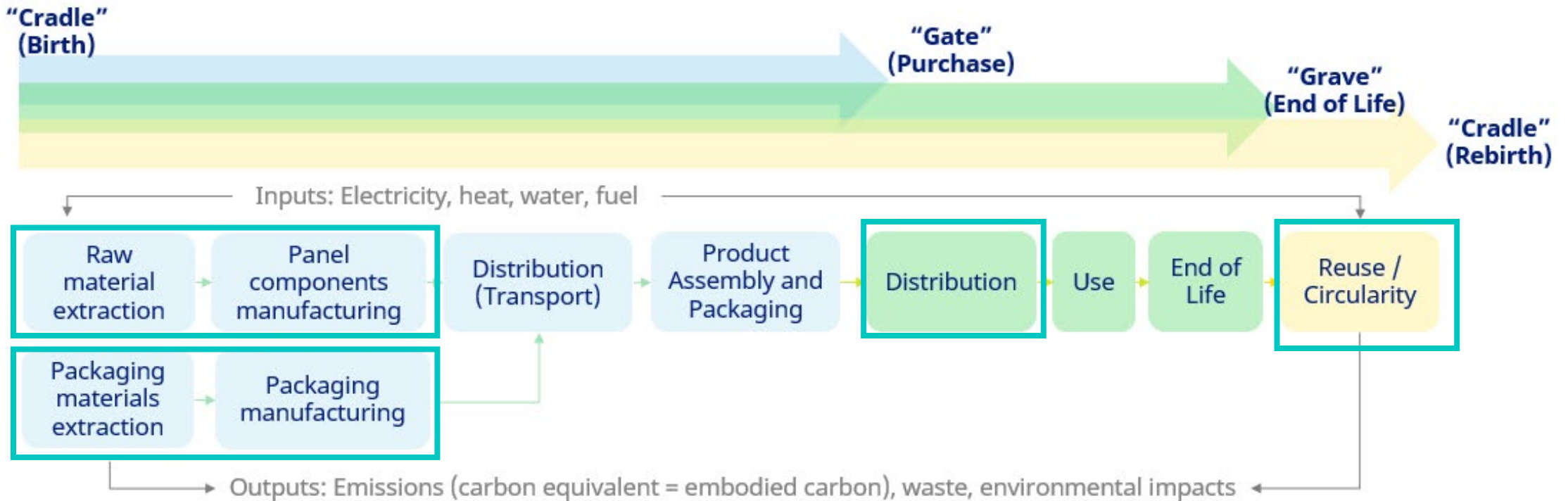
Product Packaging

No.	Material type	Material	Q'ty		Unit Weight (g)	Reusable components	Seperatability without tool
A	Wood pallet support steel slats	Wood + Steel	1	pc	26,500	Reusable	N/A (Reusable component)
B	Carton box	Corrugated cardboard	1	pc	22,400	Reusable	N/A (Reusable component)
C	Carton lid	Corrugated cardboard	1	pc	3,000	Reusable	N/A (Reusable component)
D	Carton pad	Corrugated cardboard	1	pc	1,400	Reusable	N/A (Reusable component)
E	Triangle paper protector	Paper	120	pc	192	Non-reusable	Seperable without tool
F	Paper protector (short)	Paper	8	pc	22	Reusable	N/A (weight < 25g)
G	Paper protector (long)	Paper	4	pc	12	Reusable	N/A (weight < 25g)
H	Fixing band	Paper + Tape	2	pc	0.1	Non-reusable	Seperable without tool
I	PET strap	Polyethylene terephthalate	16	M	10	Non-reusable	N/A (weight < 25g)
J	Plastic bag A	Polyethylene	2	pc	0.1	Non-reusable	N/A (weight < 25g)



Product Sustainability

- Example #1**
Developing technology to increase module efficiency so it requires less raw materials.
- Example #2**
Changing packaging corners from non-recyclable plastic to cardboard.
- Example #3**
Transport modules on a slow-moving cargo ship vs air freight.
- Example #4**
Designing the panels so that they can be easily recycled.



Closing

Conclusion



Thank You...

We are building a cleaner future together!

Questions?

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