LCA Practitioner in Renewable Industry

Dan LIU_ TÜV Rheinland_Shanghai,China

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Dan LIU: *UNSW Student to Project Manager*

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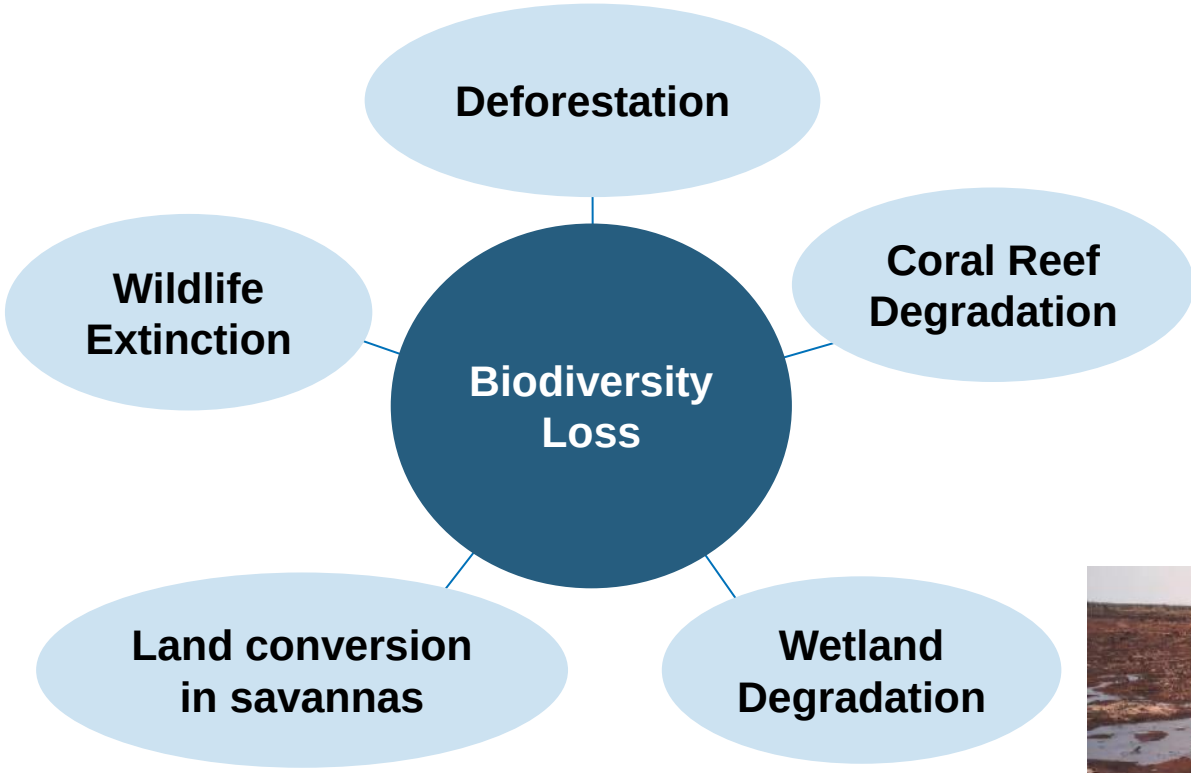
Content

1. Background

1.1 Enviromental Problems



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1. Background

1.1 Environmental Problems

LCA: Quantification

Human Consumption and Production Activities!

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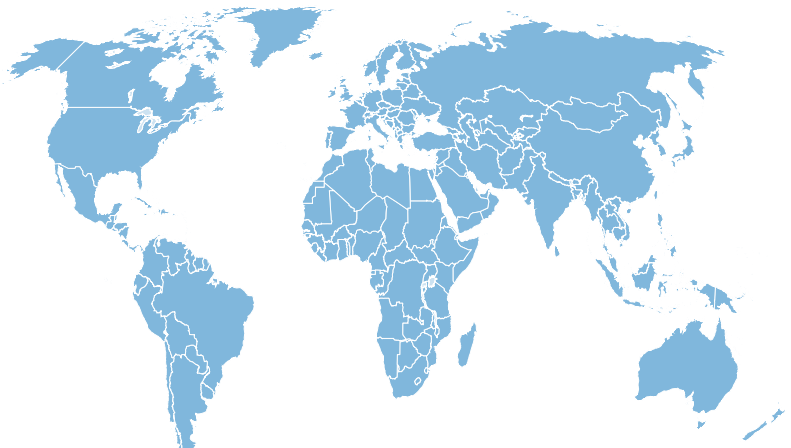
1. Background

1.2 Policy Orientation

Net Zero Target

- In Law
- In Policy Document
- Declaration/Pledge
- In discussion



GERMANY	2045	IN LAW
SWEDEN	2045	
JAPAN	2050	
FRANCE	2050	
UNITED KINGDOM	2050	
SOUTH KOREA	2050	
CANADA	2050	
SPAIN	2050	
IRELAND	2050	
CHILE	2050	
PORTUGAL	2050	
DENMARK	2050	
HUNGARY	2050	
NEW ZEALAND	2050	
LUXEMBOURG	2050	
FIJI	2050	
EUROPEAN UNION	2050	
RUSSIAN FEDERATION	2060	

MALDIVES	2030	IN POLICY DOCUMENT
FINLAND	2035	
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ANTIGUA AND BARBUDA	2040	
NEPAL	2045	
UNITED STATES OF AMERICA	2050	
ITALY	2050	
AUSTRALIA	2050	
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ROMANIA	2050	
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CROATIA	2050	
LITHUANIA	2050	
COSTA RICA	2050	
SLOVENIA	2050	
URUGUAY	2050	
LATVIA	2050	

Energy & Climate Intelligence Unit | Net Zero Scorecard (eciu.net)

2. LCA_ Life Cycle Assessment

2.1 Standards

14040-14049	ISO 14040:2006 - Environmental Management - Life Cycle Assessment - Principles And Framework ASQ/ANSI/ISO 14044:2006 - Environmental Management - Life Cycle Assessment - Requirements And Guidelines ISO 14045:2012 - Environmental management - Eco-efficiency assessment of product systems - Principles, requirements and guidelines ISO 14046:2014 - Environmental management - Water footprint - Principles, requirements and guidelines ISO/TR 14047:2012 - Environmental Management - Life Cycle Assessment - Illustrative Examples On How To Apply ISO 14044 To Impact Assessment Situations ISO/TS 14048:2002 - Environmental management - Life cycle assessment - Data documentation format ISO/TR 14049:2012 - Environmental Management - Life Cycle Assessment - Illustrative Examples On How To Apply ISO 14044 To Goal And Scope Definition And Inventory Analysis

INTERNATIONAL STANDARD **ISO 14040**

Environmental management — Life cycle assessment — Principles and framework

INTERNATIONAL STANDARD **ISO 14044**

Environmental management — Life cycle assessment — Requirements and guidelines

ISO

LCA (life cycle assessment)

compilation and evaluation of the **inputs, outputs** and the **potential environmental impacts** of a product system throughout **its life cycle**.

Method;
Quantification;

2. LCA_ Life Cycle Assessment

2.1 Standards

14020-14029	ISO 14020:2000 - Environmental Labels And Declarations - General Principles ISO 14021:2016 - Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling) - Amendment 1: Carbon footprint, carbon neutral ISO 14024:2018 - Environmental labels and declarations - Type I environmental labelling - Principles and procedures ANSI/ISO 14025:2006 - Environmental Labels And Declarations - Type III Environmental Declarations - Principles And Procedures ISO/TS 14027:2017 - Environmental labels and declarations - Development of product category rules ISO/TS 14029 - Mutual recognition agreements between Type III Environmental Declaration (EPD) Programme Operators -Principles and procedures

ISO 14024:2018
ENVIRONMENTAL LABELS AND DECLARATIONS — TYPE I ENVIRONMENTAL LABELLING — PRINCIPLES AND PROCEDURES

ISO 14021:2016
ENVIRONMENTAL LABELS AND DECLARATIONS — SELF-DECLARED ENVIRONMENTAL CLAIMS (TYPE II ENVIRONMENTAL LABELLING)

ISO 14025:2006
ENVIRONMENTAL LABELS AND DECLARATIONS — TYPE III ENVIRONMENTAL DECLARATIONS — PRINCIPLES AND PROCEDURES

2. LCA_ Life Cycle Assessment

2.2 Definitions

Life cycle

Functional unit

System boundary

Reference flow

Life Cycle Inventory Analysis: LCI

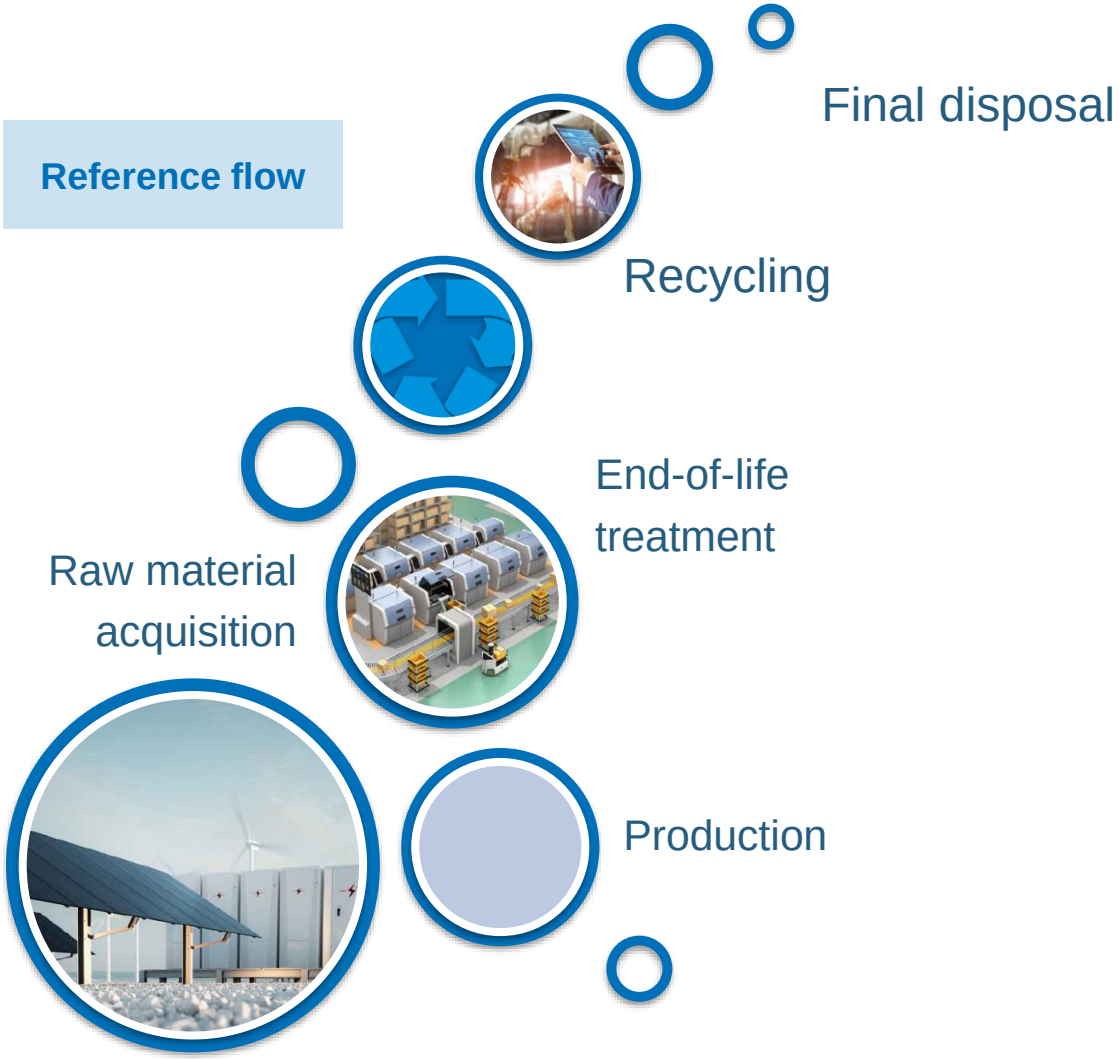
Unit process

Life Cycle Interpretation: LC interpretation

Life Cycle Impact Assessment: LCIA

Impact category

Product system



2. LCA_ Life Cycle Assessment

2.3 Methodological Framework

INTERNATIONAL STANDARD **ISO 14044**

Contents Page

Methodological Framework

Reporting

Critical Review

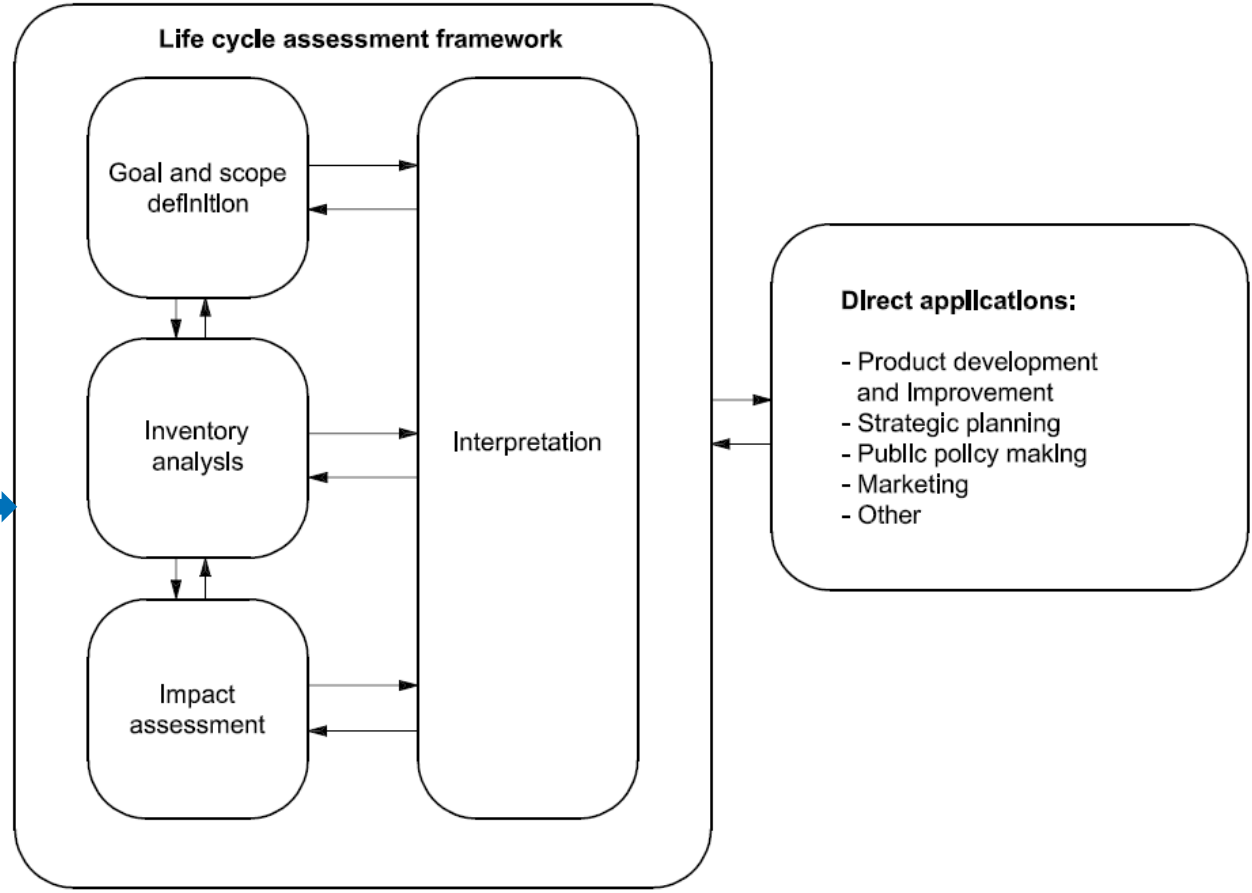


Figure 1 — Stages of an LCA

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2. LCA_ Life Cycle Assessment

2.4 LCIA Categories

- **Natural Resources**
  - Land use
  - Resource depletion
  - Desiccation, salination
- **Natural Environment**
  - Climate change
  - Acidification
  - Respiratory inorganics
  - Photochemical ozone formation
  - Ozone depletion
- **Human Health**
  - Eutrophication
  - Accidents
  - Ecotoxicity
  - Human toxicity
  - Noise
  - Ionizing radiation

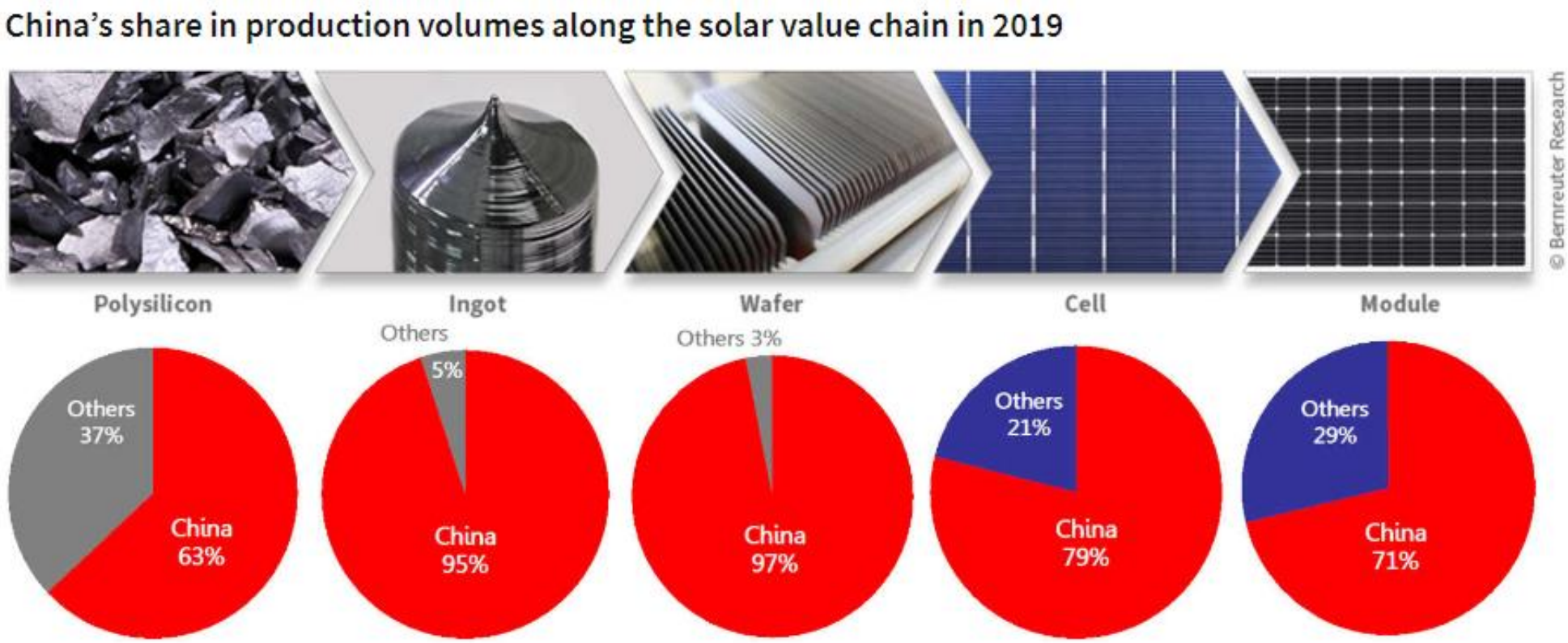
Quantification!

LCIA Categories	CRT TV		LCD TV (LED)
Climate change	1,319 kg CO_2 eq	>	755 kg CO_2 eq
Photochemical ozone formation	12 kg C_2H_4 eq		8 kg C_2H_4 eq
Eutrophication	2.5 kg PO_4^{3-} eq		5.8 kg PO_4^{3-} eq
Resource depletion	3,250 kg Sb eq	<	3,568 kg Sb eq
⋮	⋮		⋮

2. LCA_ Life Cycle Assessment

2.5 In practice

LCA of PV manufacturing?



China more or less dominates the solar value chain from polysilicon to panels – Sources: Bernreuter Research (polysilicon), Bloomberg New Energy Finance (ingot), China Photovoltaic Industry Association (wafer/cell/module); Graphic: Bernreuter Research

2. LCA_ Life Cycle Assessment

2.5 In practice

Project Phase			Leading Part	Deliverables	Time Management							
					Duration (day/week)		Jul	Aug	Sep	Oct	Starting Time (dd/mm)	End Time (dd/mm)
Part 1: Certification Process	1.1	Project setup	TUV Rh	Preparation files		Weeks						
	1.1.1	Order	TUV Rh & Client	Quotation&Order		Week						
	1.1.2	Quotation	TUV Rh & Client	Contract		Weeks						
	1.2	Kick-off meeting&Technical training	TUV Rh	Qualified trainees		Days						
	1.3	LCA	TUV Rh & Client	LCA report		Weeks						
	1.3.1	LCA inventory data collection assignment	Client	Template&Guidline		Days						
	1.3.2	LCA inventory data submission	Client	Result_draft		Weeks						
	1.3.3	LCA inventory dataset check	TUV Rh	Suggestions		Weeks						
	1.3.4	LCA inventory dataset correction	Client	Result		Week						
	1.3.5	Modelling in software	TUV Rh	LCA report		Weeks						
	1.3.6	LCA result and LCA report	TUV Rh			Weeks						
Part 2: Certificate	2.1	Report review&certification	TUV Rh	LCA certificate		Week						
Deliverables:Training+LCA Report+LCA Certificate+TUV Mark					Starting time: xx/xx/2022 ~ End time:xx/xx/2022							

2. LCA_ Life Cycle Assessment

2.5 In practice_LCI

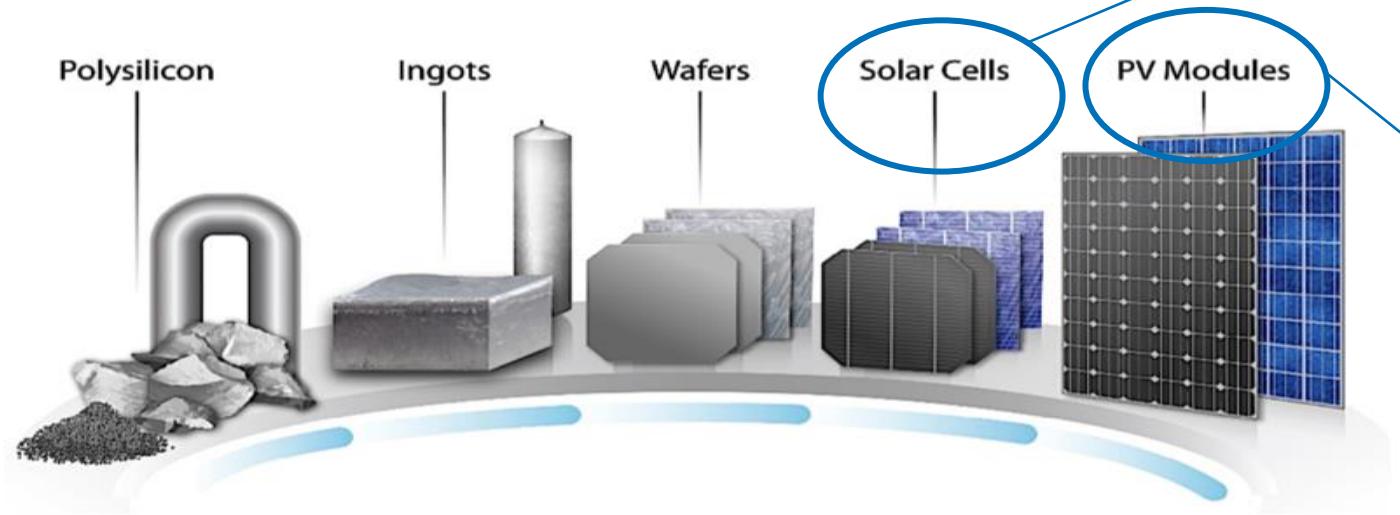
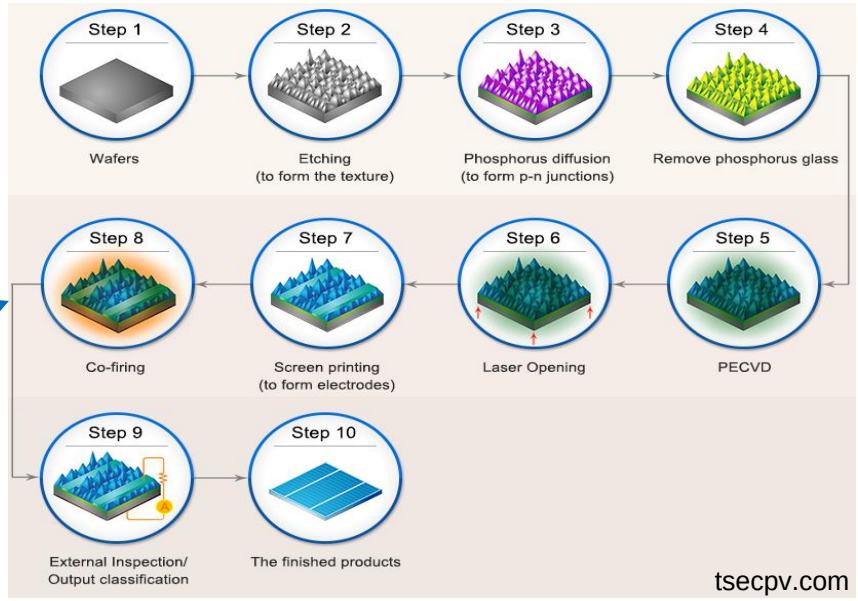
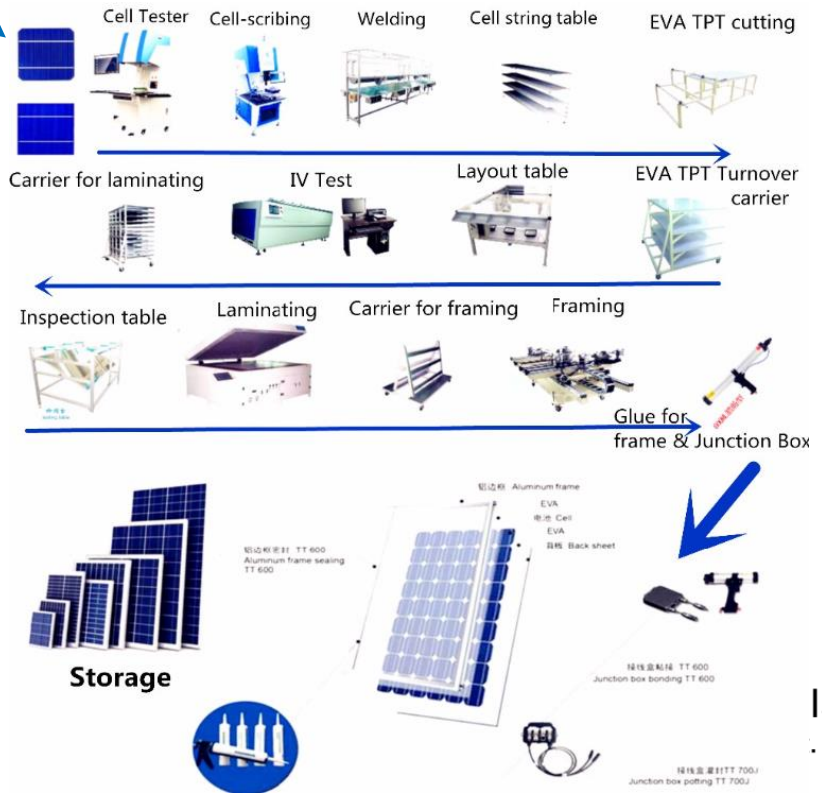


Figure 1. Schematic of c-Si PV module supply chain

researchgate.net





System Boundary

LCIA: Climate Change (GWP)

Simulation: PVsyst

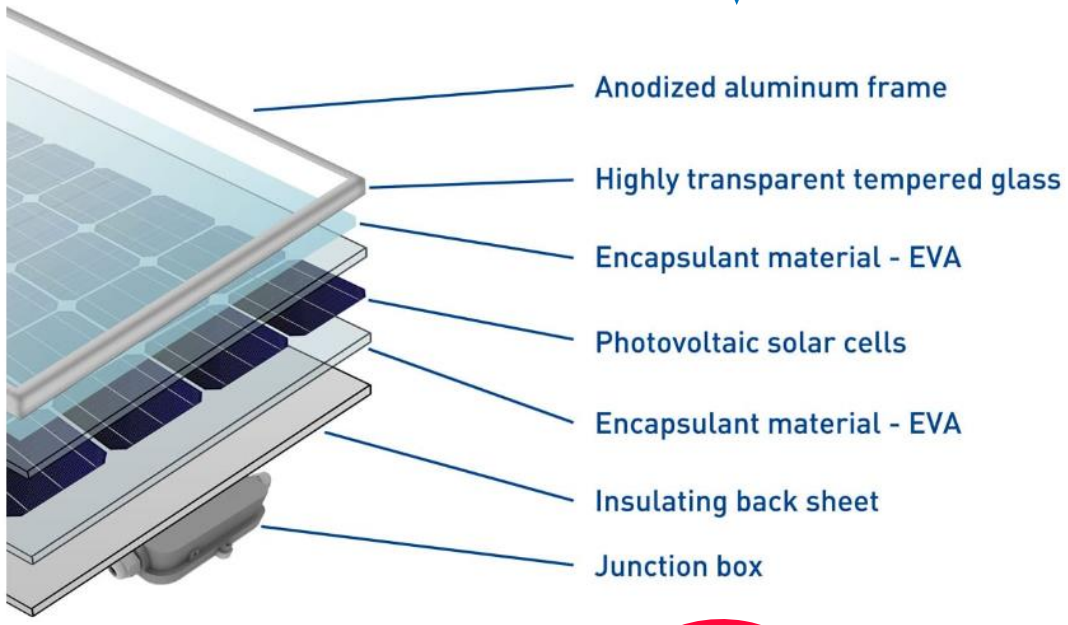
2. LCA_ Life Cycle Assessment

2.5 In practice_Data

Ingot Solar Cell PV Module

- **Material Stage**
  - Raw material input
    - Main Component
    - auxiliary materials
    - package materials for target product
  - Scraps/Residue
  - Transportation
- **Manufacture Process**
  - energy/ resource consumption
  - solid waste generation （waste water included）
  - pollution gas emission
  - process GHG emission
- **Relevant Evidence**
  - evidence for energy consumption
    - Electricity/ Water/Gas Bills
  - target product energy consumption allocation
  - summary of waste generation demonstration

weight
texture



Data Period

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2. LCA_ Life Cycle Assessment

2.5 In practice Result

Result:

DE09 series

Indicators / Stages	Unit	Total	Industrial silica fume		Polysilicon		Ingot		Cell		Module	
Impact Categories			material	Production Process	material	Production Process	material	Production Process	material	Production Process	material	Production Process
Acidification (fate not incl.)	kg SO_2 eq	2.31 E+00	4.49E-03	2.22E-01	6.29 E-03	5.80E-01	4.42E-04	2.58E-01	1.18 E-01	1.96E-01	8.19 E-01	1.03E-01
Eutrophication	kg $PO4^{3-}$ eq	5.60 E-01	1.17E-03	4.61E-02	1.51 E-03	1.08E-01	9.97E-05	5.46E-02	6.43 E-02	4.17E-02	2.20 E-01	2.26E-02
Global warming (GWP100a)	kg CO_2 eq	4.17 E+02	1.51E +00	5.08E+01	1.72 E+00	1.15E +02	9.55E-02	5.31E +01	1.12 E+01	4.04E +01	1.21 E+02	2.19E +01
Photochemical oxidation	kg NMVOC	1.47 E+00	1.29E-02	1.46E-01	6.23 E-03	3.65E-01	4.30E-04	1.68E-01	7.27 E-02	1.27E-01	5.02 E-01	6.74E-02
Abiotic depletion, elements	kg Sb eq	2.93 E-02	1.13E-06	1.47E-04	1.03 E-05	3.41E-04	5.84E-07	3.10E-05	9.89 E-03	2.46E-05	1.89 E-02	1.41E-05
Abiotic depletion, fossil fuels	MJ	4.28 E+03	2.50E +01	4.11E+02	4.64 E+01	1.10E +03	1.48E +00	4.74E +02	1.40 E+02	3.63E +02	1.53 E+03	1.92E +02
Water scarcity	m^3 eq	1.09 E+02	9.22E-01	5.01E+00	1.23 E+00	1.17E +01	1.90E-02	9.56E +00	7.35 E+00	2.11E +01	4.83 E+01	4.12E +00
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	1.27 E-05	2.44E-07	2.41E-07	2.11 E-07	5.85E-07	1.82E-08	4.54E-07	1.15 E-06	4.05E-07	9.08 E-06	2.82E-07

Certificate

Standard: **ISO 14040:2006, ISO 14044:2006**

Certificate Registr. No.: [redacted]

Report No.

Certificate Holder: [redacted]

Site: **Please see annex "sites verified".**

Scope:

Verification and Validation Body: TÜV Rheinland (China) Ltd.
- Process: Document review, interview, site visit and recalculation
- Review Criteria: ISO 14064-3:2006

Based on the information we have received and evaluated that:
- Programme: Voluntary scheme
- Product Category Rule: N/A
- Analysis method: EPD (2018) V1.03
  - LCA software or database: SimaPro Ver. 9.3.0.2/ Ecoinvent 3.8
  - Product and Model No.: PV module

[redacted]

- Boundary: Cradle to Grave
- Data period: 2021.04.01~2021.09.30
- Functional unit: one set (with packaging 6.6 Kg/pcs)
- Result: according to annex

Validity: This certificate is valid from 2022-05-20 until 2024-05-19.
This certificate only verified the target product, this verification does not include review of external communication.

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2. LCA_ Life Cycle Assessment

2.5 In practice_Impact contribution

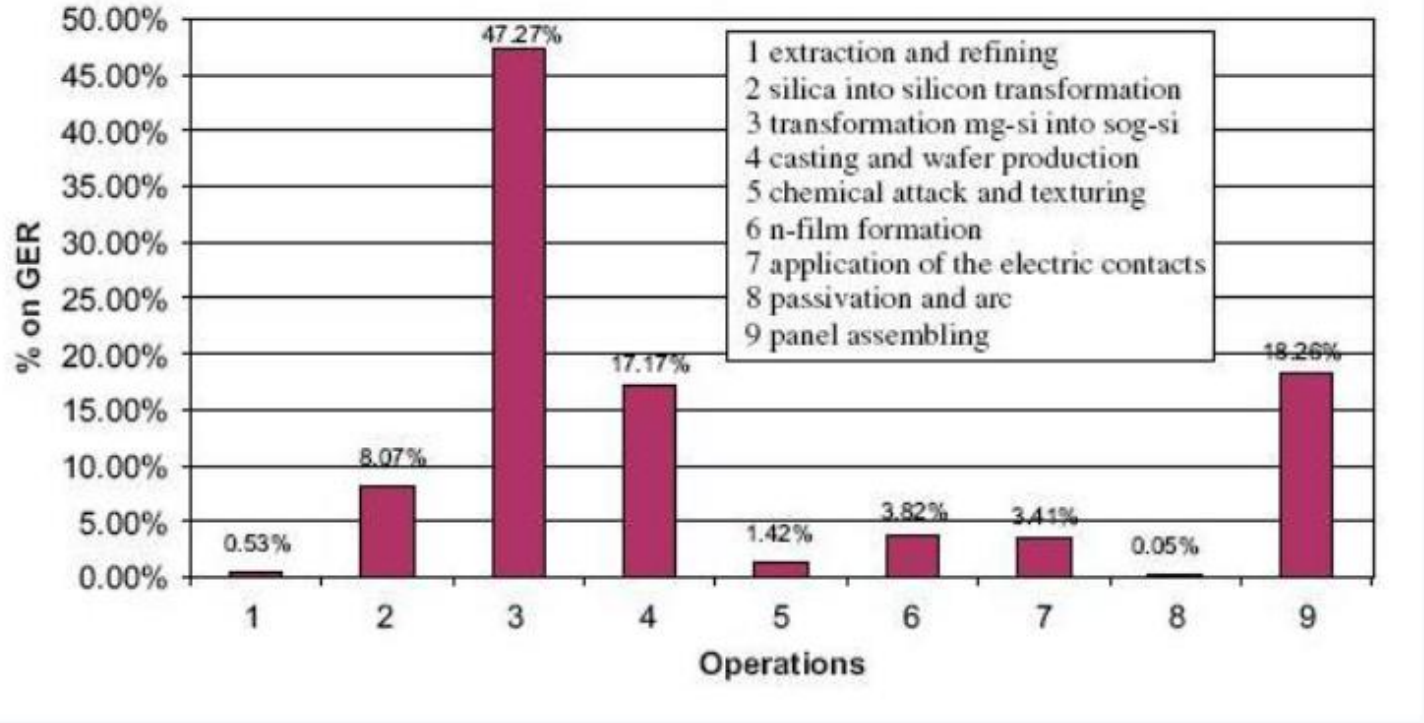


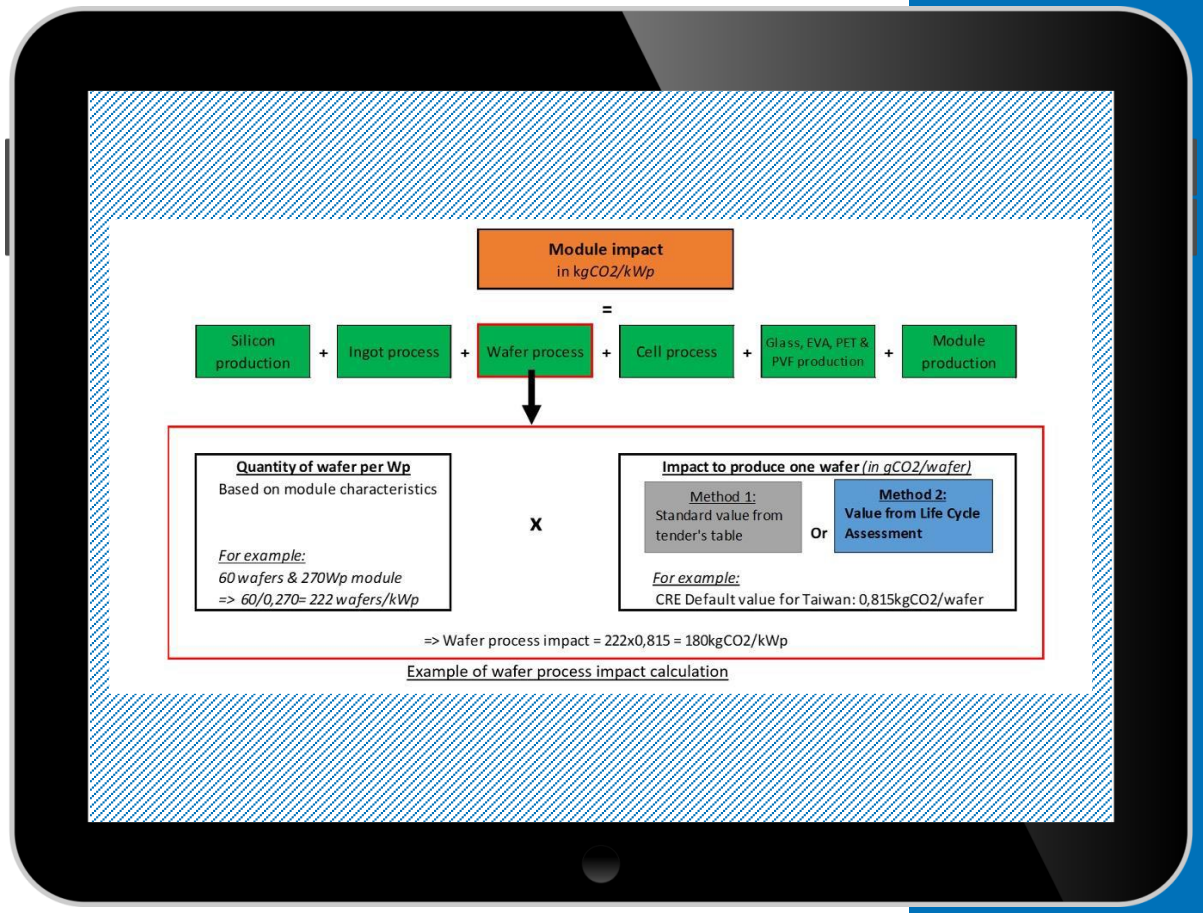
Figure 2: Energy requirements of production stages in the manufacturing of PV panels as percentages of the Gross Energy Requirement (GER) of 1494 MJ/panel (~ 0.65m2 surface).[4]

What is the dominant life cycle stage?

A. Silica to metallurgical silicon
B. Polysilicon production
C. Casting and wafer production
D. Solar cell manufacturing
E. Solar panel assembling

3. LCA Applications

3.1 Product Carbon Footprint_PCF/CFP



Example of wafer process impact calculation

Marketing Demand

Standard： ISO 14067， PAS 2060；

France：

1) >100kWp project;
2) ECS Evaluation Carbone Simplifié（ECS);
3) Evaluation: Certisolis；

3. LCA Applications

3.2 Type III_Environmental Product Declaration_EPD

EPD

- Default parameters;
- Based on LCA;
- Quantification;
- Comparison between different products which have the same function

Standard

- ISO14040；ISO14044；ISO14025
- Product Category Rules（PCR）

Marketing Demand

- Italy, Sweden(International), Norway

EPD ITALY

epd-norway
Global Program Operator

EPD®
THE INTERNATIONAL EPD® SYSTEM

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3. LCA Applications

3.3 Service Flow_EPDItaly

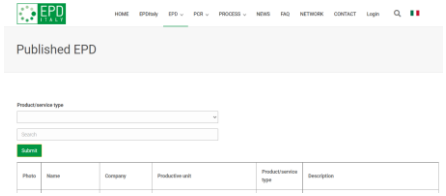
TUV Rh: PCR → **TUVRh&Client: LCI Data** → **TUV Rh: Report** → **EPDItaly: Audit** → **EPDItaly: Publication**

Deliverables

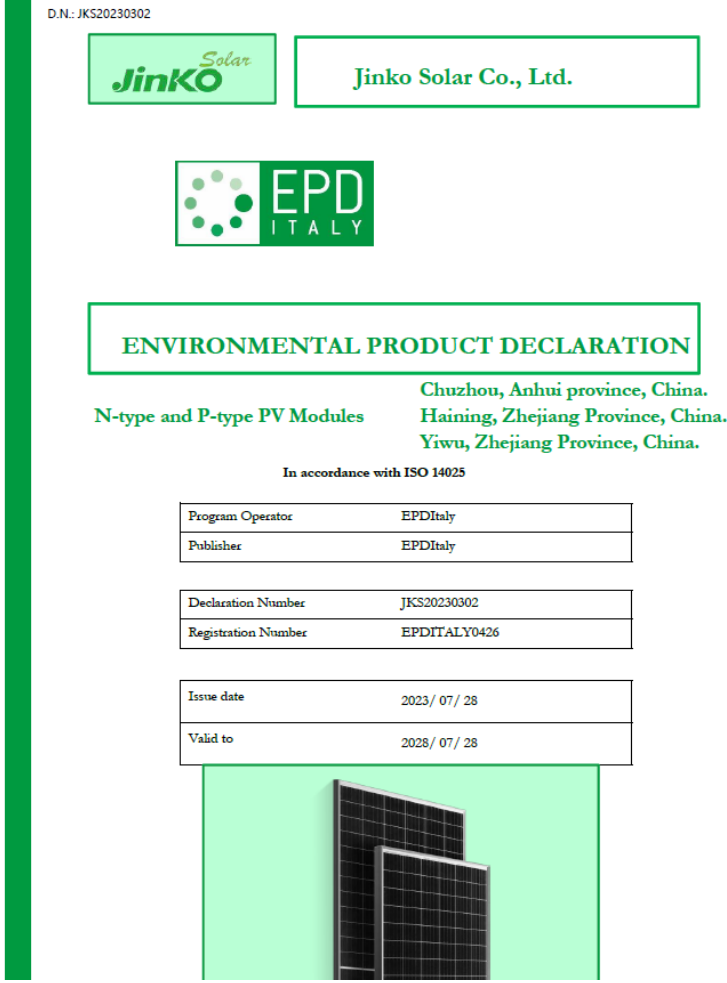
LCA Report

EPD Report

TUV Mark



Published EPD



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3.典型市场需求

3.4 Ecodesign

- **30/03/2022: Ecodesign for Sustainable Products Regulation;**
- **2022-2024:new energy-related products**
- Smartphones ;
- Tablets ;
- **Solar panels;**
- Fastest-growing waste stream


EUROPEAN COMMISSION

COMMUNICATION FROM THE COMMISSION

Ecodesign and Energy Labelling Working Plan 2022-2024

(2022/C 182/01)

European Commission

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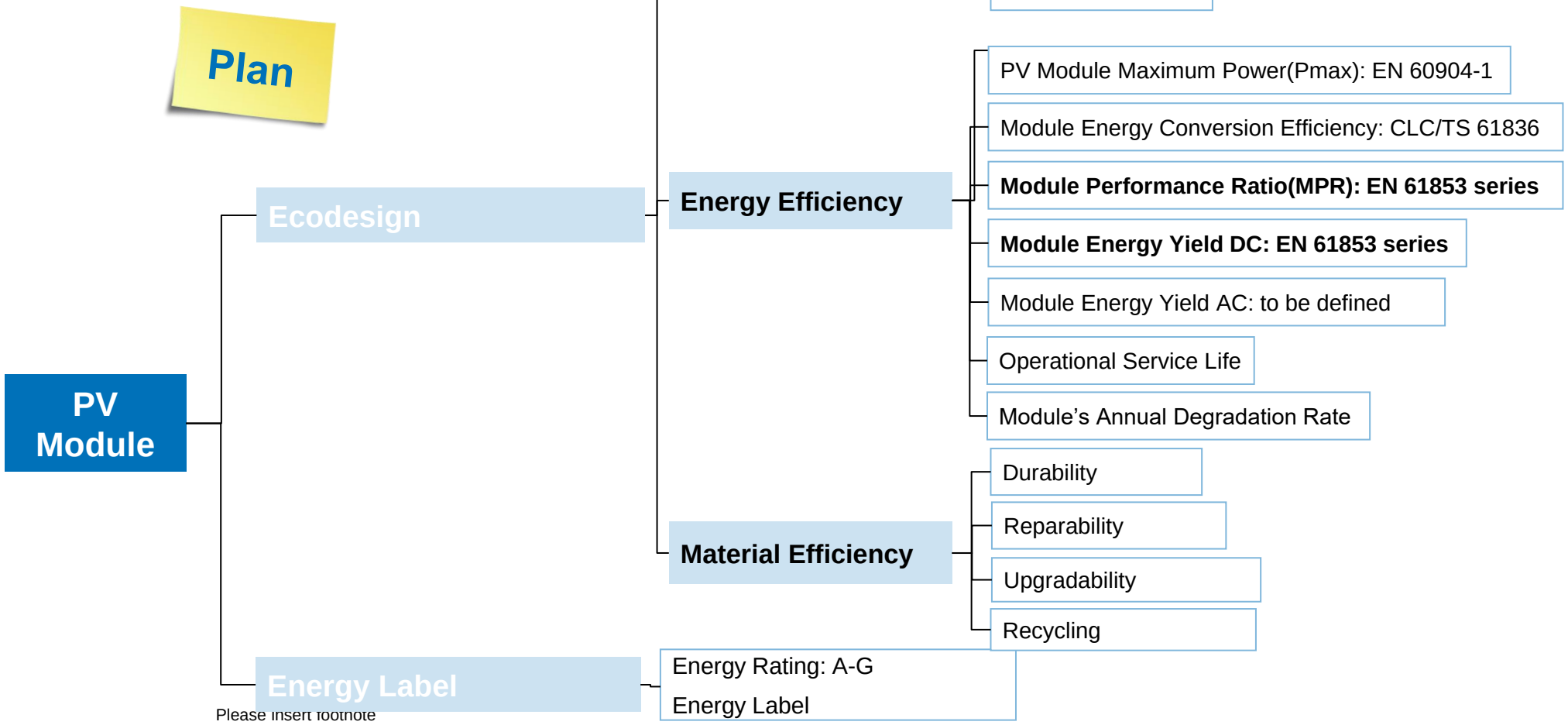
3.典型市场需求

3.4 Ecodesign

Plan



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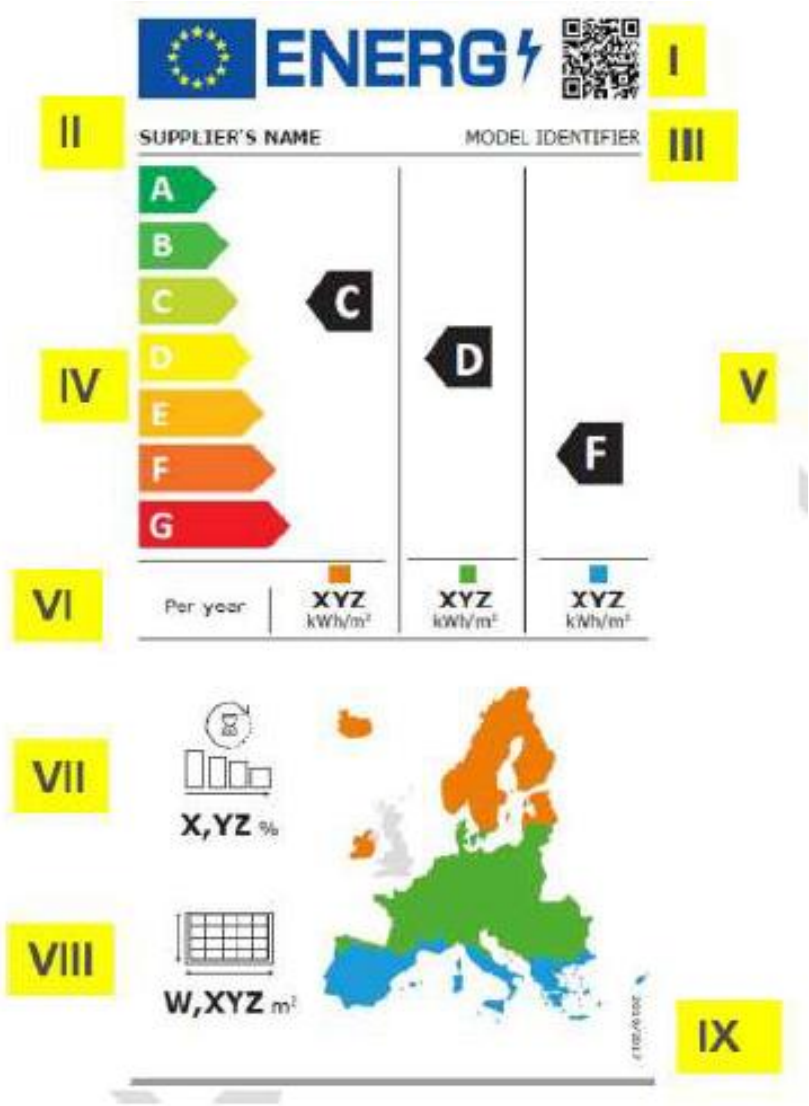
3. LCA Applications

3.3 Energy Label



I QR code;
II Name/Trade Mark
III Model Identifier
IV Energy Eff Class:A-G
V Energy Eff Class: under 3 climate conditions
VI Energy Efficiency Index: kWh/M^2
VII Degradation Rate
VIII Module Area
IX Regulation Number: 2022/XXX

IEC 61853 series

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3. LCA Applications

3.4 Type I_EPEAT

EPEAT_Type 1 ecolabel

Electronic Product Environmental Assessment Tool

- The Global Electronics Council (GEC) manages the EPEAT ecolabel.
- ISO 14024
- 2019: NSF/ANSI 457_PV Modules &Inverters

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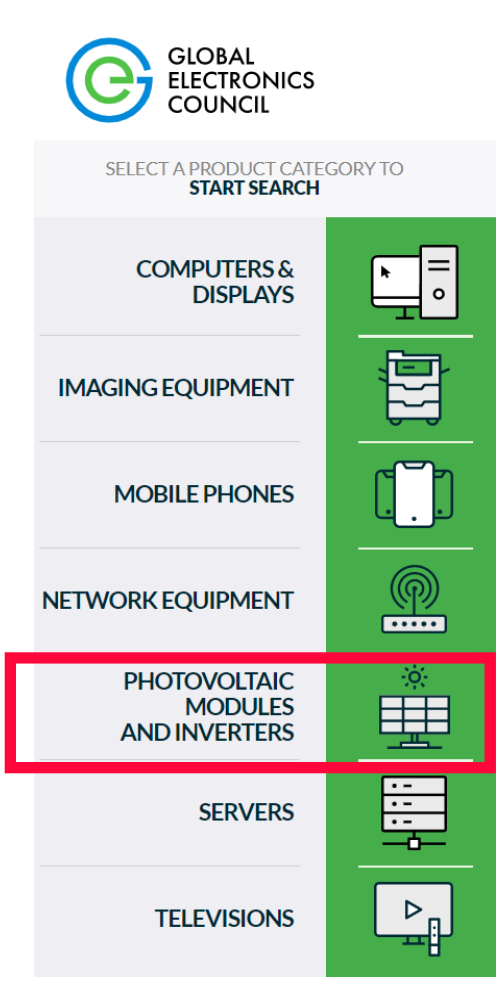
3. LCA Applications

3.4 Type I_EPEAT



Clause	Criteria	PV module	
		Required	Optional
5	Management of substances	4	7
6	Preferable materials use	1	1
7	**Life cycle assessment(LCA)**	1	4
8	Energy efficiency and water use	1	5
9	End of life management and design for recycling	1	3
10	Product packaging	3	2
11	Cooperated responsibility	5	5
		16	**27**

Tiers of EPEAT	NSF457-PV module	
	Required	Optional
	16	27
Bronze	16	≥0
Silver	16	≥13
Gold	16	≥20

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3. LCA Applications

3.5 Carbon Neutral

International Organizations

- **CDP:** Carbon Disclosure Project
- **SBTi:** Science Based Targets
- RE 100 Renewable Energy 100%
- **C4C:** Caring for Climate Business Forum

CDP DRIVING SUSTAINABLE ECONOMIES

SCIENCE BASED TARGETS DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

EP100: EV 100 Energy Productivity 100%

EV100: EP 100 Electric Vehicle 100%

GOOD ENVIRONMENTAL CHOICE AUSTRALIA GECA CERTIFIED

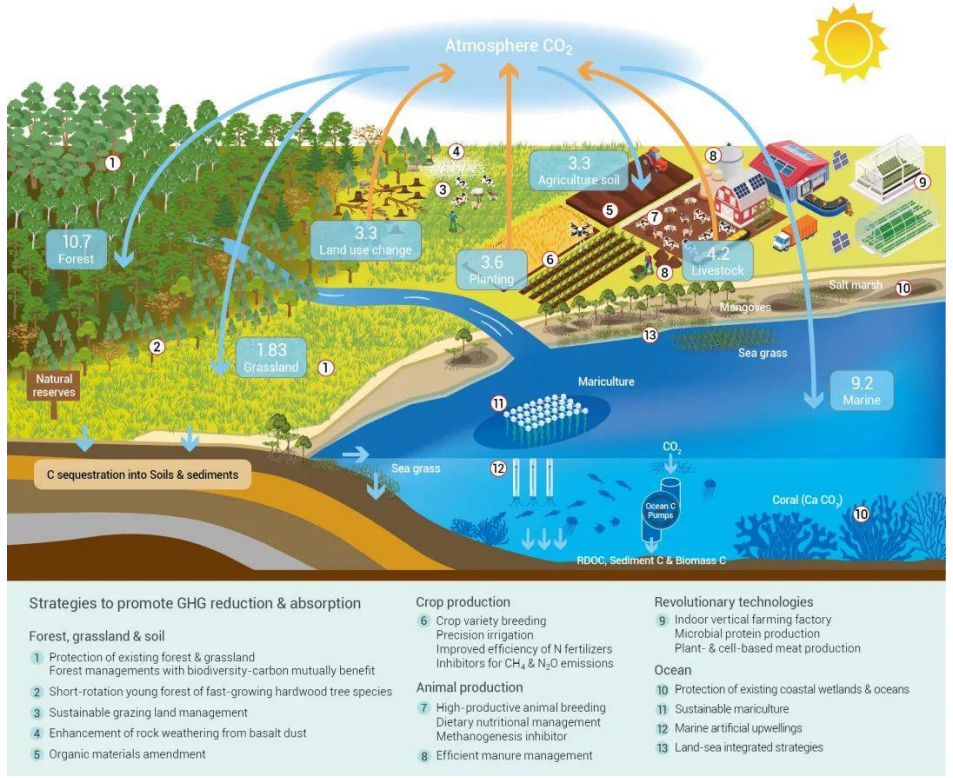
Caring for Climate

THE GLOBAL COMPACT UNEP

4. We Can Do More

4.1 Strategies to promote GHG reduction & absorption

Strategies to promote GHG reduction & absorption				
Forest, grassland & Soil	**Crop production**	**Animal production**	**Revolutionary technologies**	**Ocean**
① Protection of existing forest &grassland; Forest managements with biodiversity -carbon mutually benefit; ② Short-rotation young forest of fast-growing hardwood tree species; ③ Sustainable grazing land management; ④ Enhancement of rock weathering from basalt dust; ⑤ Organic materials amendment;	⑥ Crop variety breeding; Precision irrigation; Improved efficiency of N fertilizers; Inhibitors for CH4&N2O emissions;	⑦ High-productive animal breeding; Dietary nutritional management; Methanogenesis inhibitor; ⑧ Efficient manure management;	⑨ Indoor vertical farming factory; Microbial protein production; Plant- and cell-based meat production;	⑩ Protection of existing coastal wetlands and oceans; ⑪ Sustainable mariculture; ⑫ Marine artificial upwellings; ⑬ Land-sea integrated strategies;



4. We Can Do More

4.2 CO2 Capture/Utilization/Storage

CO2 Capture

Source:
1. Biomass
2. Fossil fuel
3. Air

Current capture technologies
1. Post-combustion
2. Pre-combustion
3. Oxy-combustion

Innovation technologies
1. Chemical looping
2. Polygeneration+CCS
3. BECCS/fossil + BECCS

Transportation

CO2 Utilization

Technology: 1. Photochemical conversion
2.Thermochemical conversion
3.Electrochemical conversion

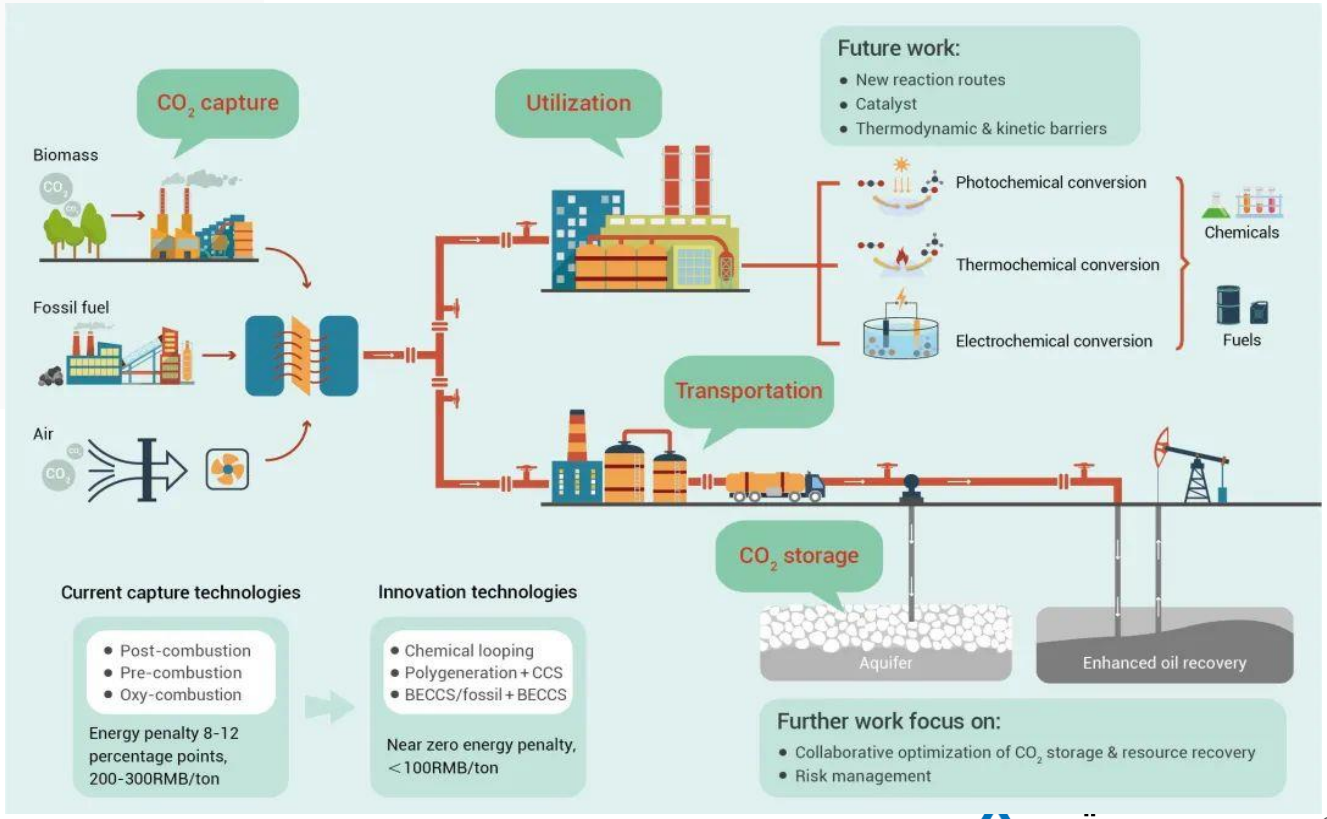
Future work:
1. New reaction routes
2. Catalyst
3. Thermodynamic&Kinetic barriers

Product
1. Chemicals
2. Fuels

CO2 Storage

Technology: 1. Aquifer;
2.Enhanced oil recovery;

Future work:
1. Collaborative optimization of CO2 storage & resource recovery
2. Risk management



Q&A

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Dan.liu@tuv.com

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