Supporting Information

The Cost of Ownership and Minimum Sustainable Price of POLO BJ Cells Produced in Germany

Gomez Trillos, Juan Camilo; Buddana, Viswa Harinath; Papantoni, Veatriki; Min, Byungsul, Junge, Sebastian, Kähler, Jan-Dirk; Schneider, Friedrich; Brendel, Rolf; Vogt, Thomas*

Contents

The following sections present the key assumptions made for the analysis as well as some additional details on results obtained after the CoO, MSP and LCOE calculations made in the in this study.

S1. Key Assumptions

The following section presents key assumptions made for the calculation of the Cost of Ownership (CoO) and Minimum Sustainable Price (MSP) of POLO BJ and PERC PV cells. Several inputs for the calculation of the CoO of the considered cell types were collected from project partners and deemed as confidential. Other secondary sources, from which data was also collected, are also mentioned in Table S1, Table S2, Table S3, Table S7, Table S8 and Table S9.

S1.1. Cell Production

Table S1. Tool costs, throughput and footprint assumptions for the production sequences of POLO BJ-W and POLO BJ-L cells. Source: Own table

Step	Description	Tool unitary price [USD]	Tool throughput [Wafer*h^{-1}]	Footprint [m^2]	Productive time [h*a^{-1}]	Source
0	Wafer inspection and load	672,000	3,200	2.5	8551	Chang et al. 2018 [1]
1	Cleaning, wet chem, SiOx	Confidential	7,000	63.1	8551	Confidential (Project partners)
2	LCPVD poly-Si insitu n+ type	Confidential	6,240	9.2	8551	Confidential (Project partners)
3	Thermal Oxidation	Confidential	6,360	9.2	8551	Confidential (Project partners)
4[a)]	One-side oxide removal, full-surface	Confidential	7,000	25.9	8551	Confidential (Project partners)
4[b)]	Laser ablation	Confidential	7200	20.0	8551	Confidential (Project partners)
5	Texturing, cleaning	Confidential	7,000	59.0	8551	Confidential (Project partners)
6	PECVD passivation AlOX/SiNy, front-side	Confidential	6,000	27.6	8551	Confidential (Project partners)
7	PECVD passivation	Confidential	6,000	27.6	8551	Confidential (Project partners)

	SiNy, rear-side					
8	Laser Contact Opening	Confidential	3,200	20.0	8551	Confidential (Project partners)
9	Metallization, screen printing	670,000	3,200	10.1	8551	Chang et al. 2018 [1]
10	Firing	287,000	3,200	20.0	8551	Chang et al. 2018 [1]
11	I-V Measurement	766,000	3,200	2.5	8551	Chang et al. 2018 [1]

[a)] Considered in the POLO BJ-W production sequence

[b)] Considered in the POLO BJ-L production sequence

Table S2. Tool costs, throughput and footprint assumptions for the additional step in the production sequence of PERC cells. Source: Own table

Step	Description	Tool unitary price [USD]	Tool throughput [Wafer*h^{-1}]	Footprint [m^2]	Productive time [h*a^{-1}]	Source
2	POCl Difussion	Confidential	11,100	31.8	8551	Confidential (Project partners)

A mechanical yield of 99.9% and optical/electrical yield of 99.9% was assumed in all the manufacturing steps considered in all the production sequences.

Table S3. Material, utility and waste disposal costs for the production of POLO BJ-W, POLO BJ-L and PERC cells. Source: Own table

Material	Price	Unit	Comment	Source
p-Type Silicon Wafer, M12	0.18	Piece	Spot price	[2]
Hydrofluoric Acid (HF)	Confidential	USD*l^{-1}	Original price per liter, converted to mass	Confidential (Project partners)

			assuming density of 1.14 kg/l (38% solution)	
Hydrochloric Acid (HCl)	Confidential	USD*l^{-1}	Original price per liter, converted to mass assuming density of 1.19 kg/l (30% solution)	Confidential (Project partners)
Potassium hydroxide (KOH)	Confidential	USD*kg^{-1}	Original price per liter, converted to mass assuming density of 1.19 kg/l (30% solution)	Confidential (Project partners)
Water (Reverse Osmosis)	1	USD*m^{-3}	Assumption	Assumed
Nitrogen (N2, >= 4.0)	Confidential	USD*kg^{-1}	Density of N_2 at 0°C and 300bar: 327,53 kg/m3	Confidential (Project partners)
Silane (SiH_4)	Confidential	USD*kg^{-1}		Confidential (Project partners)
Phosphine (PH_3)	Confidential	USD*kg^{-1}	Original data provided in 10% mixture in hydrogen	Confidential (Project partners)
Oxygen (O_2)	Confidential	USD*kg^{-1}		Confidential (Project partners)
Texturing additive	Confidential	USD*kg^{-1}		Confidential (Project partners)
Ammonia (NH_3)	Confidential	USD*kg^{-1}		Confidential (Project partners)
Nitrous oxide (N_2O)	5.62	USD/kg		[3]
Trimethylaluminium (TMA)	2970	USD/kg	Originally sold per 100g	[4]

Solar Back Silver Paste (Al)	684.16	USD*kg^{-1}		[5]
Front silver paste, Main grid (Ag)	1029.06	USD*kg^{-1}		[5]
Front silver paste	1035.93	USD*kg^{-1}		[5]
Electricity	0.1986	USD*kWh^{-1}	Electricity prices for non-household consumers	[6]
Compressed air	0.15	USD*m^{-3}		[7]
Cooling water	0.24	USD*m^{-3}		[8]
DI-Water	Confidential	USD*m^{-3}		Confidential (Project partners)
Process Waste Water HF-Concentrated	Confidential	USD*m^{-3}		Confidential (Project partners)
Process Waste Water HF- Diluted	Confidential	USD*m^{-3}		Confide Confidential (Project partners)
Industrial Waste Water	Confidential	USD*m^{-3}		Confidential (Project partners)
Labour costs	Confidential			[9]

In addition to the tools and material costs, also other facility costs such as clean room, industrial hall area and land area costs were also included in the analysis. A summary of these costs can be found in Table S4.

Table S4. Clean room, building and land costs. Source: Own table

Item	Cost	Unit	Comment	Source
Clean room area costs	3,276.60	USD*m^{-2}	Assumed originally as 3000 EUR*m^{-2}. Average between 1000-5000 EUR*m^{-2}	[10]

Industrial hall area costs	1965.96	$USD*m^{-2}$	Assumed originally as 1800 $EUR*m^{-2}$	[11]
Land area costs	38.23	$USD*m^{-2}$	Assumed originally as 35 $EUR*m^{-2}$. Assumed as percentile 75% of average values for available locations in komsis	[12]

Table S5. Summary of tax and WACC, depreciation and net working capital assumptions. Source: Own table

Item	Value	Comment	Source
Federal Corporate Income Tax	15.00%	In German “Körperschaftsteuer”	[13]
Solidarity surcharge	0.83%	In German, “Solidaritätsbeitrag”; 5.5% of Federal Corporate Income Tax	[13]
Local Trade Tax	15.75%	In German “Gerwebesteuer”. This tax is calculated as 3.5% times a multiplier between 250% and 580%. Used 450% as average value.	[13]
Depreciation period facility	20 years	Linear depreciation; useful life of lightweight construction halls 14 years. Other types of halls assumed as 20 years. Assumed conservatively 10 years	[14]
Depreciation period tools	7 years	Linear depreciation; useful life of machines mostly between 6 and 8 years. Assumed 7 as a conservative assumption	[15]
Net working capital	3 months	3 months’ worth of the sum of variable costs and operating expenses	[16]

S1.2. Plant upscaling

The costs, originally assumed for a pilot plant with a capacity of 330 $MWp*a^{-1}$, were upscaled according to Equation S1. [17]

Equation S1:

$$q_{mn}(VR_i) = q_{mn}(VR_{i,ref})\left(\frac{VR_i}{VR_{i,ref}}\right)^b$$

Where q_{mn} is the price of the cost element m referenced to the production volume VR_i, $VR_{i,ref}$ is the production reference production volume and b is the exponent of the power function used as scaling function. The scaling factors considered by Nold et al. 2019 were used for scaling up the cost of equipment, chemicals, gases, waste disposal, wafers, and electricity and area-specific acquisition costs for buildings and infrastructure, accordingly.[17]

Table S6. Scaling exponent assumed for different items involved in the production of PV cells. Source: Nold, 2019 [17]

Item	Exponent scaling function (b)
Frontside Ag-paste	-0.009
Backside Al and Ag paste	-0.021
Chemicals	-0.099
Gases	-0.068
Material logistics and disposal	-0.180
Wafer	-0.050
Electricity	-0.067
Process Equipment Acquisition Costs	-0.150
Area-specific acquisition costs for building and infrastructure	-0.100

Based on this, and considering the values for the pilot plant of 330 MWp*a^{-1} as reference level, the prices of the chemicals used for the production of the PV cells would have a reduction after considering a production of 5 GWp*a^{-1} of around 23.6% compared to those of the original plant.

S1.3. Operating expenses

The ratio between the operating expenses (sales and marketing, general administrative expenses, research and development, financial expenses) of sales were obtained from the Form 20-F or financial statements of different PV manufacturing companies between 2020 and 2023. Some lag in the data reporting exists as these statements are filed yearly. A comparison of the ratio between the cost of revenue and the revenue is shown in Figure S1. In addition, the ratio between operating expenses and revenue is shown in Figure S5. A ratio of 12.5% was assumed conservatively for the calculations made in this study.

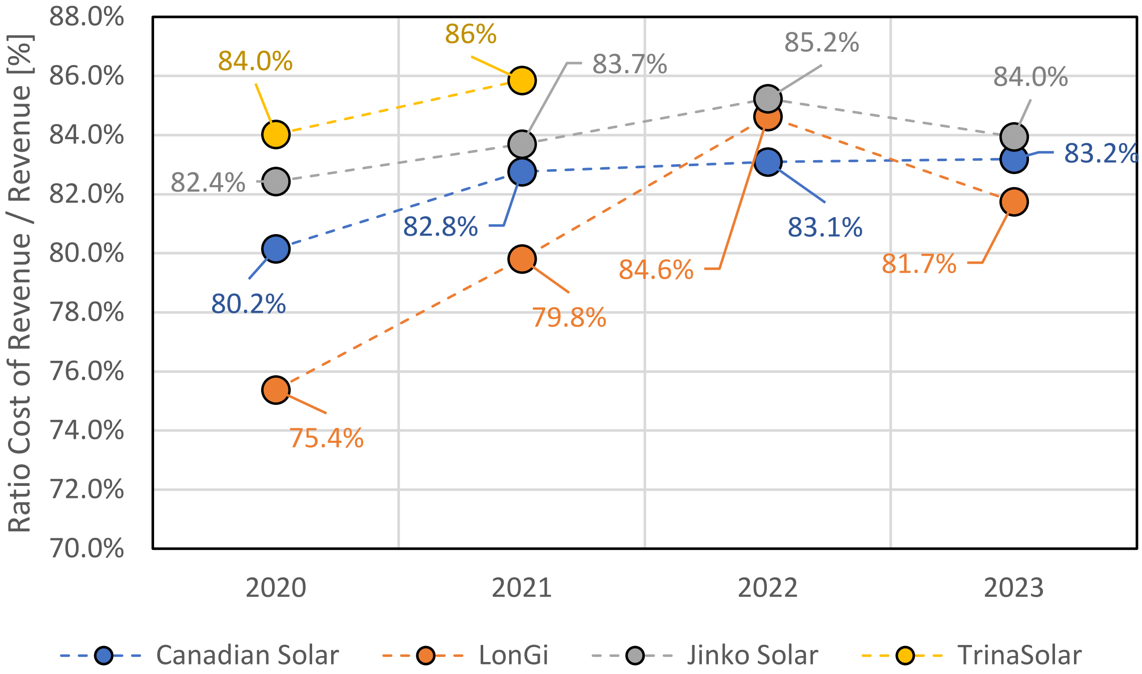

Figure S1. Summary of the ratios between cost of revenue and revenue for selected PV manufacturers. Source: Own figure with data extracted from Forms 20-F of the different companies or financial statements.

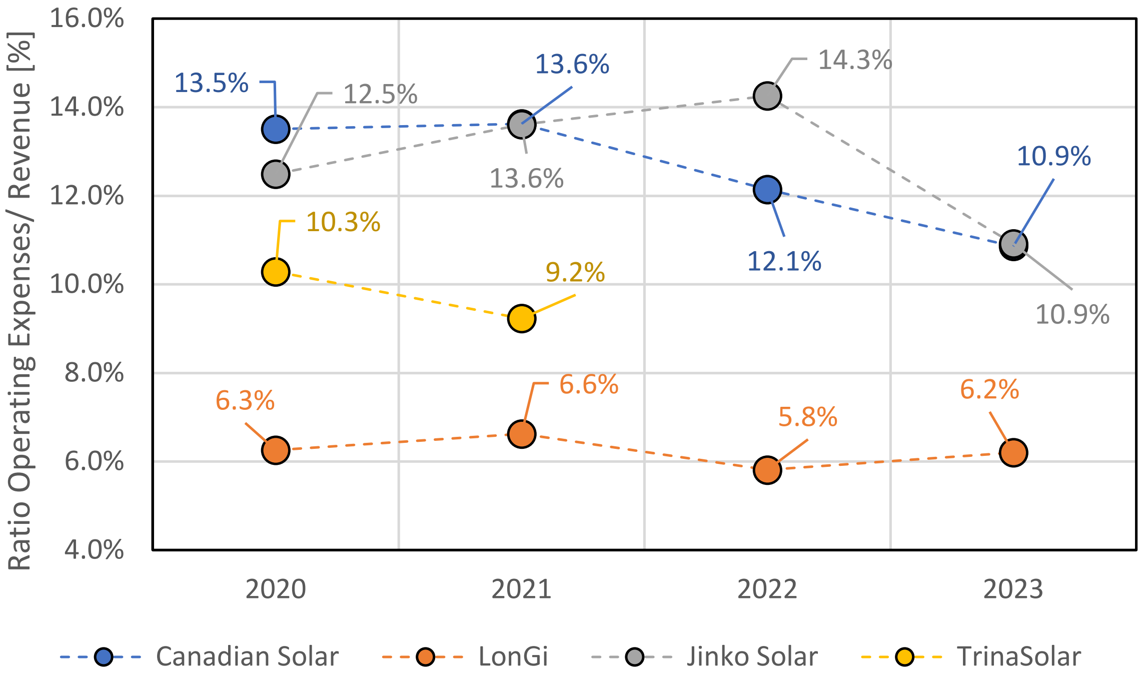

Figure S2. Summary of the ratios operating expenses (S&A + R&D) and revenue for selected PV manufacturers. Source: Own figure with data extracted from Forms 20-F of the different companies or financial statements.

S1.4. Minimum Sustainable Price Calculations

The calculations of the Minimum Sustainable Price of cells were made according to the calculation method explained by Powell et al 2015 [16]. The method was based on Equation S2 to Equation S13. The first step was the calculation of

Equation S2:

$$B_{Gross\ income\ ,t} = B_t - C_{var,t} - D_{facility,t} + D_{tools,t}$$

Where $I_{Gross\ income\ ,t}$ is the gross margin in year t, B_t is the revenue in the year t, $C_{var,t}$ are the variable costs in year t, $D_{facility,t}$ is the depreciation of the facilities in year t and $D_{tools,t}$ is the depreciation of the tools in year t. $C_{var,t}$ was calculated

Equation S3:

$$C_{var,t} = C_{mat,t} + C_{utilities,t} + C_{waste,t} + C_{labour,t} + C_{yield\ loss,t}$$

Where $C_{var,t}$ are the variable costs in year t, $C_{mat,t}$ are the material costs in year t, $C_{utilities,t}$ are the utility costs in year t, $C_{labour,t}$ are the labour costs in year t and $C_{yield\ loss,t}$ are the cost of yield loss in year t. $C_{var,t}$, $C_{utilities,t}$, $C_{labour,t}$ and $C_{yield\ loss,t}$ were obtained from the cost calculations made previously for the estimations of the CoO. After deducting the costs from the revenues, to obtain the gross income, the operating expenses were also subtracted to obtain the operating income, as shown in Equation S4.

Equation S4:

$$B_{Operating\ income,t} = B_{Gross\ income,t} - C_{OPEX,t}$$

Where $B_{Operating\ income,t}$ is the operating income in year t and C_{OPEX} is the operating expenditures (S&A + R&D) in year t. The operating expenditures were calculated as a percentage of the revenue following Equation S5.

Equation S5:

$$C_{OPEX} = f_{OPEX} * B_t$$

Where f_{OPEX} is the ratio between operating expenditures and revenue (See Figure S2) and B_t are the revenues in year t. Furthermore, the taxes were calculated according to the tax rate (See Table S5).

Equation S6:

$$C_{tax,t} = B_{Operating\ income,t} * f_{income\ tax,t}$$

Where $C_{tax,t}$ are the income tax and $f_{income\ tax}$ is the income tax rate in year t

After this, the cash flows for each of the years were calculated as follows.

For $t = 0$:

Equation S7:

$$R_{cash\,flow,0} = C_{Investment,t} + \Delta NWC$$

Whereas for $t > 0$:

Equation S8:

$$R_{cash\,flow,t} = B_{Operating\,income,t} - C_{tax,t} + D_{facility,t} + D_{tools,t} + \Delta NWC + C_{Investment,t} + B_{salvage,t}$$

Where $R_{cash\,flow,t}$ is the incremental cash flow in year t, $B_{Operating\,income,t}$ is the operating income in year t, $C_{tax,t}$ are the income tax in year t, $D_{facility,t}$ is the depreciation of facilities in in year t, $D_{tools,t}$ is the depreciation of tools in in year t, ΔNWC is the change in Net Working Capital in year t, $C_{Investment,t}$ are the investment costs in in year t and $B_{salvage,t}$ are salvage values in in year t. ΔNWC was assumed as 3 months of the sum of variable costs and operating expenses and recovered after the depreciation of the tools.

The net present value was then calculated following Equation S9:

Equation S9:

$$R_{NPV} = R_{cash\,flow,0} + \sum_{t=1}^{T} \frac{IR_{cash\,flow,t}}{(1+i)^t}$$

Where R_{NPV} is the Net present value, $R_{cash\,flow,t}$ is the cash flow in year t, i is the WACC and t is the year. The calculation of the net present value was carried out iteratively by changing the revenue B_t, so that:

Equation S10:

$$R_{NPV} = 0$$

Additional conditions used for the simplification of the calculations were:

$B_t = B_1 \; \forall \; t > 0$

$C_{var,t} = C_{var,1} \; \forall \; t > 0$

$C_{OPEX,t} = C_{OPEX,1} \; \forall \; t > 0$

$C_{tax,t} = C_{tax,1} \; \forall \; t > 0$

The iterations were carried out using the MS and the plug-in “solver” using as objective the function shown in Equation S10. Initial values for B_t were assumed considering B_t equal to the variable costs. Furthermore, the minimum sustainable price for each cell was calculated based on the revenues necessary by the sales of cells necessary to obtain a NPV of 0, based on a 8% WACC, and calculated in terms of peak capacity produced per year (Equation S11), cell area produced per year (Equation S12) and cells produced per year (Equation S13).

Equation S11:

$$MSP = \frac{B_t}{VR_{i,t,power}}$$

Equation S12:

$$MSP = \frac{B_t}{VR_{i,t,area}}$$

Equation S13:

$$MSP = \frac{B_t}{VR_{i,t,cells}}$$

Where B_t is the revenue in year t and $VR_{i,t,power}$ is the manufacturing plant volume output in peak power per year ($Wp*a^{-1}$), $VR_{i,t,area}$ is the manufacturing plant volume output in area per year (m^2*a^{-1}) and $VR_{i,t,cells}$ is the manufacturing plant volume output in cells per year ($cells*a^{-1}$).

S1.5. Module Calculations

Table S7. Module material price assumptions. Source: Own table

Item	Assumed price	Unit	Source
PV Glass, 2.0 mm Double-layer Coating	1.45	USD/m^2	[5]
PV Glass, 2.0 mm Single-layer Coating	1.32	USD/m^2	[5]
PV Glass, 2.0 mm Rear side	1.32	USD/m^2	[5]
PV Glass, 3.2 mm Double-layer Coating	2.40	USD/m^2	[5]
White CPC Backsheet – double fluorine coating	0.62	USD/m^2	[5]
Photovoltaic frame	2,871.23	USD/mt	[5]
Transparency EVA film (PV), 460g/m2	0.70	USD/m^2	[5]
Junction box	2.83	USD/unit	

The Minimum Sustainable Prices obtained for POLO BJ-W, POLO BJ-L and PERC cells were assumed as input for the production costs of modules. In total 66 cells were assumed as necessary for the manufacturing of a module, and the MSP value obtained by piece of cell (See Table S12) used as input to calculate the cost of the cells in the production of the modules. Thus, considering that the MSP per cell piece of POLO BJ-W, POLO BJ-L and PERC cells were 0.79, 0.76 and 0.73 USD*cell^{-1}, the total cell costs in the module production were estimated as 66 times the MSP of cells, or 52.14, 50.16 or 48.18 USD in total. For the other material inputs for module production, the area of the module was assumed as 3.11 m^2 (see Table S9).

A material to module price mark-up factor of 1.92 was assumed in line with the results obtained for cell production. This means that the costs of the materials necessary for the production of a module were multiplied by a factor of 1.92 to obtain the estimated price of the modules, which was further used in the LCOE calculations. This method was used to calculate the results summarized in Table S13.

Furthermore, a summary of the assumptions cost of different items in the installation of utility scale PV (5 MWp) is presented in Table S8. The items "racking and mounting", "mechanical installation" and "inspection" were assumed as scaling with system area, a parameter depending on the efficiency of the modules, which was also assumed to depend on the cell concept and the particular cell efficiency assumed in each of the cases. Considering the module efficiencies reported in Table S9 led to system areas for system fitted with modules based on POLO BJ-W, POLO BJ-W and PERC cells of 22,251, 22,251 and 23,311 m^2, respectively. The higher footprint for systems using PERC cells stems from the lower cell efficiency assumed for this concept (η_{cell}= 23.1%), which results in lower module efficiency (η_{cell}= 21.4%) and thus in a bigger area necessary to install a capacity of 5 MWp (See Table S9).

Table S8. System Calculations and Levelized Cost of Electricity. Source: [18]

Category	Cost component	Unit	Germany	Spain
Module and inverter	Inverters [a)]	¢*Wp^{-1}	3.7	3.8
Balance of System	Racking and mounting [b)]	USD*m^{-2}	15.5	16.1
(BoS) Hardware	Grid connection [a)]	¢*Wp^{-1}	6.5	6.0
	Cabling/wiring [a)]	¢*Wp^{-1}	4.2	4.2
	Safety and security [a)]	¢*Wp^{-1}	1.0	0.2
	Monitoring and control [a)]	¢*Wp^{-1}	0.5	0.4
Installation	Mechanical installation [b)]	USD*m^{-2}	11.7	12.4
	Electrical installation [a)]	¢*Wp^{-1}	4.4	5.3
	Inspection [b)]	USD*m^{-2}	2.0	1.5
Soft costs	Margin [a)]	¢*Wp^{-1}	7.9	7.4
	Financing costs [a)]	¢*Wp^{-1}	0.9	1.2
	System design [a)]	¢*Wp^{-1}	0.8	0.4
	Permitting [a)]	¢*Wp^{-1}	1.7	2.8
	Customer acquisition [a)]	¢*Wp^{-1}	1.0	0.4

[a)] Assumed scaling with system power, originally source reported in USD*kWp^{-1}, converted to ¢*Wp^{-1} by multiplying by 100 and dividing by 1000.

[b)] Assumed scaling with system area. Originally reported in USD*kWp^{-1}, converted to ¢*Wp^{-1} by multiplying by 100 and dividing by 1000. Then converted to area units dividing by the estimated power per unit area for POLO BJ modules will cell efficiency of 24.2%, module efficiency of 22.5%, therefore with an output of 225 Wp*m^{-2}

Table S9. Module assumptions for utility scale 5 MWp system electricity yield

Feature	POLO BJ-L		POLO BJ-W		PERC	
Module type	Monofacial Glass-Backsheet	Bifacial Glass-Glass	Monofacial Glass-Backsheet	Bifacial Glass-Glass	Monofacial Glass-Backsheet	Bifacial Glass-Glass

Cell efficiency [%]	24.2%	24.2%	24.2%	24.2%	23.1%	23.1%
Cell to Module factor [-]	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
Cells per module [-]	66	66	66	66	66	66
Cells area per module [m^2]	2.91	2.91	2.91	2.91	2.91	2.91
Module area [m^2] [a)]	3.11	3.11	3.11	3.11	3.11	3.11
Area derating factor [-]	0.94	0.94	0.94	0.94	0.94	0.94
Module efficiency [%]	22.5%	22.5%	22.5%	22.5%	21.4%	21.4%
Calculated module power [Wp]	698	698	698	698	666	666

[a)] Area considered according to the module HiKu7 Mono PERC of the company Canadian Solar [19]

Table S10. System and location assumptions for utility scale 5 MWp system electricity yield and LCOE calculations. Source: Own table

Feature	POLO BJ-L		POLO BJ-W		PERC	
Module type	Monofacial Glass-Backsheet	Bifacial Glass-Glass	Monofacial Glass-Backsheet	Bifacial Glass-Glass	Monofacial Glass-Backsheet	Bifacial Glass-Glass
Global Horizontal Irradiance (Germany/Spain) [kWh*m^{-2}*a^{-1}]	1050 / 1700	1050 / 1700	1050 / 1700	1050 / 1700	1050 / 1700	1050 / 1700
Irradiation on module plane [kWh*m^{-2}*a^{-1}]	1250 / 1870	1250 / 1870	1250 / 1870	1250 / 1870	1250 / 1870	1250 / 1870
System size [kWp]	5000	5000	5000	5000	5000	5000
System lifetime [a]	25	25	25	25	25	25
Degradation 1st year [%]	1.5	1.5	1.5	1.5	1.5	1.5
Degradation following years [%]	0.5	0.5	0.5	0.5	0.5	0.5
Temperature coefficient	-0.2953	-0.2953	-0.2953	-0.2953	-0.34	-0.34
Bifaciality [-]	0	0.8	0	0.8	0	0.8
Albedo	0.2	0.2	0.2	0.2	0.2	0.2
Back irradiance [kWh*m^{-2}*a^{-1}]	210	210	210	210	210	210

A Nominal Operating Temperature of 58°C at 800 W/m^2 was assumed, resulting in a relative efficiency loss compared to the original efficiency of -9.74%rel for POLO BJ cells and -11.22% rel for PERC cells.

S1.6. Levelized Cost of Electricity

LCOE Calculation was carried out using the Net Present Value (NPV) method as described by Kost et al. 2024 [20] in Equation S14:

Equation S14:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}}$$

Where I_0 are the investment costs in USD, A_t are the yearly operational costs in USD in year t, $M_{t,el}$ is the electricity yield in year t in kWh, i is the real discount rate, n is the lifetime of the system and t is the year in the use term.

Yearly OPEX costs for PV Systems (A_t in Equation S14) were assumed as 1% CAPEX*a^{-1}

I_0 was obtained as the product between the system size of (5000 kWp or alternatively 5.0 MWp) and the values later summarized in Table S8, with the addition of the estimated module prices as summarized in Table S13. The lifetime electricity yield for the utility scale systems as summarized in Table S15 is the denominator in Equation S14 used to calculate the LCOE for the different systems.

S2. Selected Additional Results

In the following section, a collection of additional results for the CoO, MSP, module costs and LCOE are presented.

S2.1. Cell production

Table S11. Alternative reporting units of CoO of POLO BJ-W, POLO BJ-L and PERC cells. Source: Own table

CoO per…	Unit	POLO BJ-W (η=24.2%)	POLO BJ-L (η=24.2%)	PERC (η=23.1%)
Power peak	¢*Wp^{-1}	5.98	5.79	6.31
Piece	$*$cell^{-1}$	0.64	0.62	0.64
Unitary area	$*$m^{-2}$	14.46	14.00	14.57

Table S12. Alternative reporting units of MSP of POLO BJ-W, POLO BJ-L and PERC cells. Source: Own table

MSP per..	Unit	POLO BJ-W (η=24.2%)	POLO BJ-L (η=24.2%)	PERC (η=23.1%)
Power peak	¢*Wp^{-1}	7.38	7.16	7.75
Piece	$*$cell^{-1}$	0.79	0.76	0.79
Unitary area	$*$m^{-2}$	17.87	17.32	17.89

S2.2. PV Systems

Table S13. Module Estimated Prices. Source: Own table

Cell Type	POLO BJ-L		POLO BJ-W		PERC	
Module type	Monofacial	Bifacial	Monofacial	Bifacial	Monofacial	Bifacial

	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass
Module Unitary Price [USD]	84.20	101.72	82.62	100.14	84.38	101.90

Table S14. Specific CAPEX for 5 MWp utility scale systems. Source: Own table

Cell Technology	POLO BJ-L		POLO BJ-W		PERC	
Module type	Monofacial	Bifacial	Monofacial	Bifacial	Monofacial	Bifacial
CAPEX per kWp	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass
Spain [USD*kWp^{-1}]	571	596	573	598	586	612
Germany [USD*kWp^{-1}]	573	598	575	600	587	613

Table S15. Lifetime electricity yield for 5MWp utility scale systems. Source: Own table

Cell Technology	POLO BJ-L		POLO BJ-W		PERC	
Module type	Monofacial	Bifacial	Monofacial	Bifacial	Monofacial	Bifacial
Lifetime yield[a]	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass	Glass-Backsheet	Glass-Glass
Spain [kWh]	19,666.6	22,550.9	19,666.6	22,550.9	19,345.1	22,182.3
Germany [kWh]	13,146.1	14,928.7	13,146.1	14,928.7	12,931.2	14.684,7

[a] Total lifetime yield after discount rate: $\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}$

[b] Deagradation rate of 1.5% in the first year and 0.5% in the subsequent years

[c] Temperature correction included

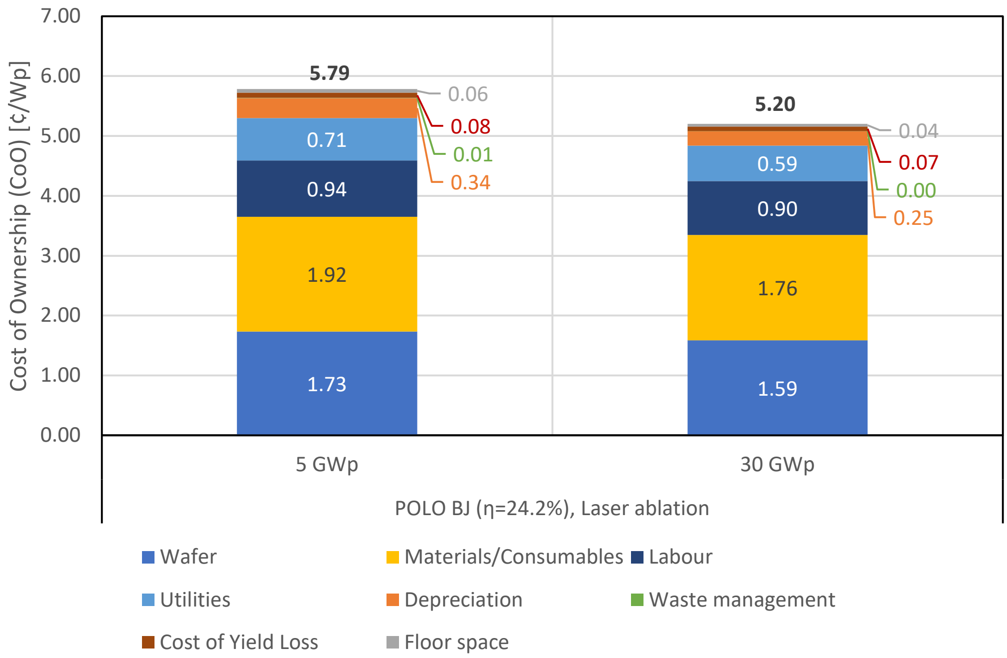

Figure S3. Comparison of the effect of the scale of the production plant on the Cost of Ownership (CoO) of POLO BJ-L cells (ηcell=24.2%). Source: Own figure.

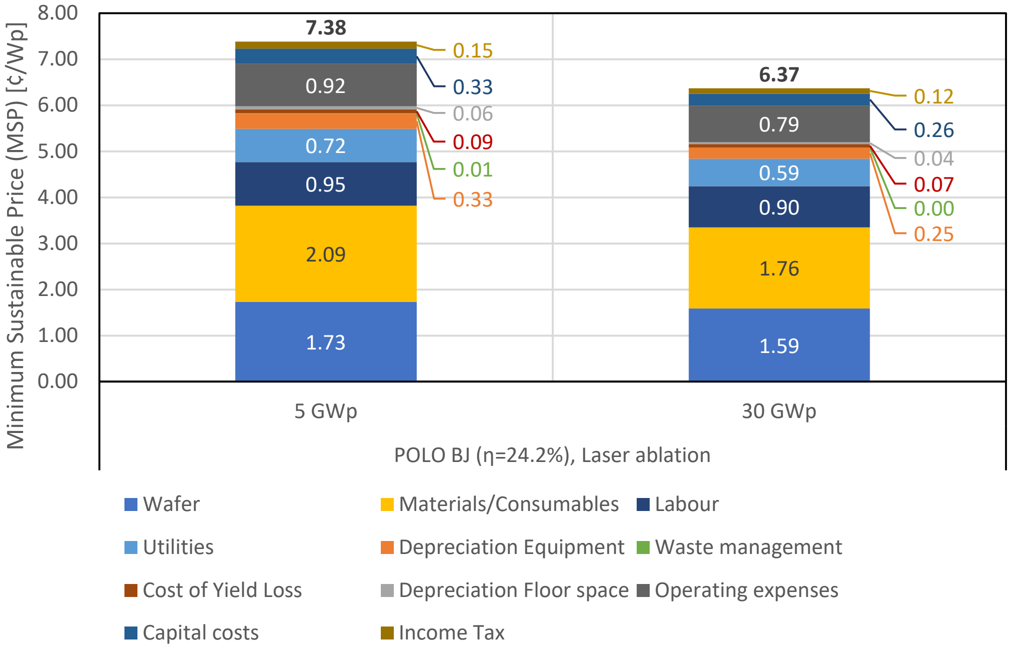

Figure S4. Comparison of the effect of the scale of the production plant on the Minimum Sustainable Price (MSP) of POLO BJ-L cells (ηcell=24.2%). Source: Own figure.

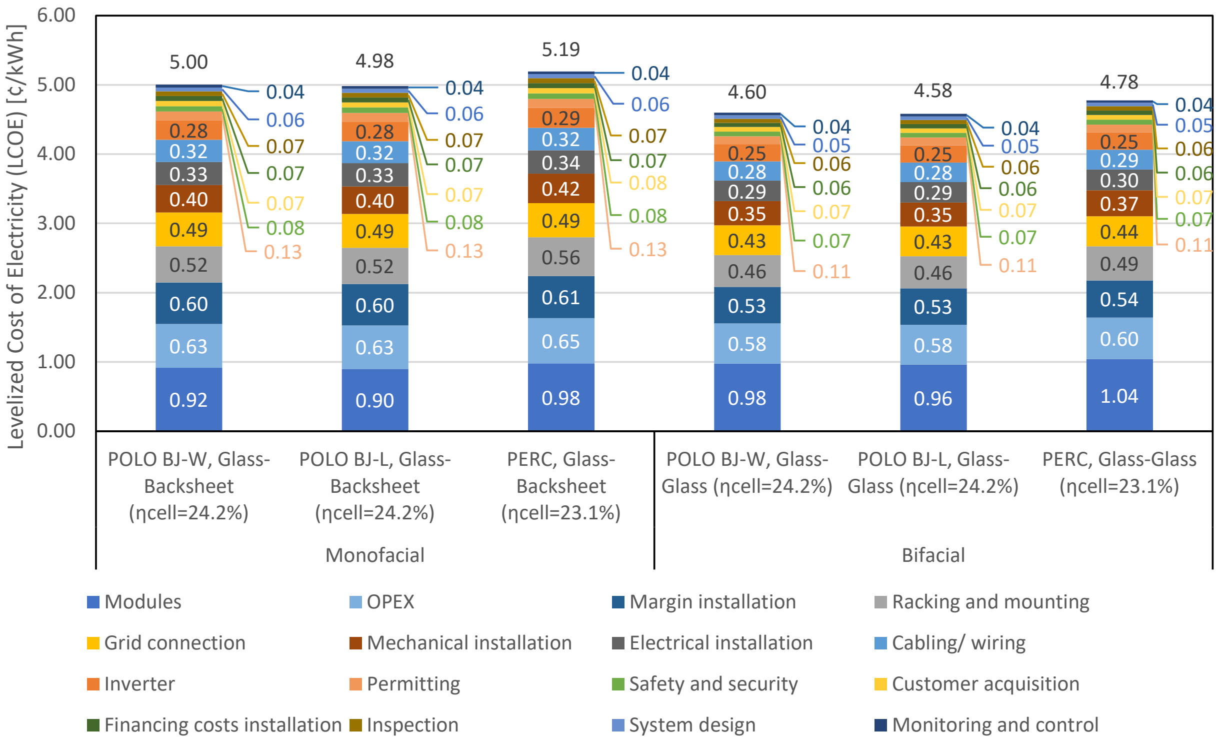

*Figure S5. Contributional analysis of the levelized cost of electricity (LCOE) for systems using monofacial glass-backsheet modules and bifacial glass-glass modules built with POLO BJ-W (ηcell=24.2%), POLO BJ-L (ηcell=24.2%) and PERC cells (ηcell=23.1%). A Global Horizontal Irradiance (GHI) of 1050 kWh/m2*year and an irradiance in plane of array of 1250 kWh/m2*year found typically in Germany are assumed in the analysis. Source: Own figure.*

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