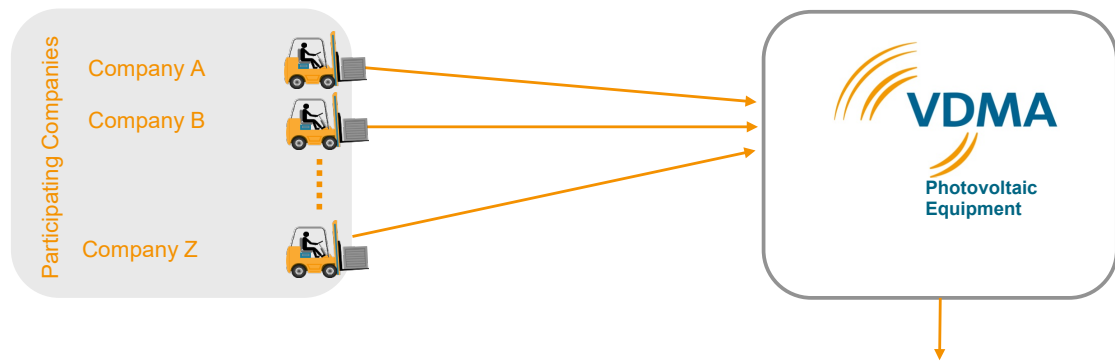


Methodology for Data Collection

1. Proprietary company data input directly to VDMA and only to Jutta Trube or Alexandra Janik-Hannen

2. Data aggregated and company confidentiality ensured



4. Agreed Data, parameters and summary report prepared and released (ITRPV edition)

3. Reports & analysis produced and distributed to participants only (mean, max, median, average)

Summary:

1 - Input to be sent to Jutta Trube or Alexandra Janik-Hannen ONLY
2 - No other person is allowed to see individual data
3 - Data will be summarized and only min, max, average will be discussed if all participants give input (if not all, but more than 3 feedbacks, the median value will be shown; contributors only will get min/max median if there are more than 5 inputs) discussion will be internally, only median values on agreed parameters are published
4 - Individual questionnaires are not stored longer than 3 months and will be deleted afterwards
5 - Jutta Trube is ready to enter individual NDAs with every company

ITRPV 2019 Questionnaire

Wafer

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Question No

2018 2019 2021 2023 2026 2029

Comments

Silicon feedstock technology		2018	2019	2021	2023	2026	2029	Comments
1	Materials	Share of Siemens Process [%]						all shares have to add to 100%
2	Materials	Share of FBR Process [%]						
3	Materials	Share of other (please specify) [%]						
		Control value needs to be 100%						
		0%	0%	0%	0%	0%	0%	
Wafer thickness								
4	Products	Wafer thickness p-type multi for BSF [μm]						
5	Products	Wafer thickness p-type multi for PERx [μm]						
6	Products	Wafer thickness p-type mono BSF [μm]						
7	Products	Wafer thickness p-type mono PERx [μm]						
8	Products	Wafer thickness n-type mono PERx [μm]						
9	Products	Wafer thickness n-type mono IBC [μm]						
10	Products	Wafer thickness n-type mono HJT [μm]						
Average poly-silicon utilization per wafer (156,75x156,75mm), (wafer thickness, kerf loss, crucible size,... from squaring to cropping)								
11	Materials	Grams polysilicon consumed per multicrystalline wafer by diamond wire sawing technology?						
12	Materials	Grams polysilicon consumed per monocrystalline wafer by diamond wire sawing technology?						
Wafering technology for multi Si								
13	Materials	Share of diamond wire technology with resin-bonded diamonds in production for multi Si [%]						all shares have to add to 100%
14	Materials	Share of diamond wire technology with diamonds bonded by electroplating (EP) in production for multi Si [%]						
15	Materials	Share of kerfless wafers for multi Si [%]						
16	Materials	Share of other technologies (pls. specify) in production for multi Si [%]						
		Control value needs to be 100%						
		0%	0%	0%	0%	0%	0%	
Wafering technology for mono Si								
17	Materials	Share of diamond wire technology with resin-bonded diamonds in production for mono Si [%]						all shares have to add to 100%
18	Materials	Share of diamond wire technology with diamonds bonded by electroplating (EP) in production for mono Si [%]						
19	Materials	Share of kerfless wafers for mono Si [%]						
20	Materials	Share of epitaxy wafers for mono Si [%]						
21	Materials	Share of other technologies (pls. specify) in production for mono Si [%]						
		Control value needs to be 100%						
		0%	0%	0%	0%	0%	0%	
Recycling rates in Diamond wire sawing								
22	Materials	Silicon recycling [%]						
23	Materials	Diamond wire recycling [%]						
Material parameters in Diamond wire sawing technology								
24	Materials	Resin-bond diamond wire core diameter size [μm]						
25	Materials	Electroplated (EP) bond diamond wire core diameter size [μm]						
26	Materials	Diamond grain size [μm]						
Throughput in diamond wire sawing								
27	Processes	throughput for diamond wire sawing per tool [%, 2018 = 100%]						
Loading lengths per run for diamond wire sawing technology								
28	Processes	Multi Si brick loading length per run for diamond wire technology [mm]						
29	Processes	Mono Si brick loading length per run for diamond wire technology [mm]						
Effective brick length in multi/HPM crystal growth								
30	Processes	Effective Brick Length [mm]						
Kerf loss and TTV for diamond wire sawing								
31	Processes	Kerf loss for diamond wire sawing [μm]						
32	Processes	TTV for diamond wire sawing [μm]						
Ingot mass in crystal growth								
33	Processes	Ingot Mass HPM (high performance multi) mc-Si [kg]						
34	Processes	Ingot Mass mono-Si [kg]						
Crucible generation (ingot footprint) in crystal growth								
35	Processes	Crucible Generation for HPM (high performance multi) mc-Si (ingot footprint) [Gen]						
36	Processes	Crucible Generation for mono-like (ingot footprint) [Gen]						
Share of ready to use (RTU) crucibles in crystal growth								
37	Materials	Share of ready-to-use (RTU) crucible [%]						all shares have to add to 100%
38	Materials	Share of standard crucible [%]						
		Control value needs to be 100%						
		0%	0%	0%	0%	0%	0%	
Conversion Cost (2018 = 100%)								
39	Processes	Conversion cost of multi-Si ingot growth [%]						
40	Processes	Conversion cost of mono-Si ingot growth [%]						

ITRPV 2019 Questionnaire

Wafer

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Question No		2018	2019	2021	2023	2026	2029	Comments
41	Processes Conversion cost of multi-Si wafer diamond wire slicing [%]							
42	Processes Conversion cost of mono-Si wafer diamond wire slicing [%]							
	Processes Power consumption							
43	Processes Power consumption of multi-Si ingot growth [kWh/kg]							
44	Processes Power consumption of mono-Si ingot growth [kWh/kg]							
	Blending ratios of different feedstocks in multi/HPM crystal growth							
45	Processes Blending ratio of Siemens poly feedstock [%]							all shares have to add to 100%
46	Processes Blending ratio of FBR poly feedstock [%]							
47	Processes Blending ratio of UMG poly feedstock [%]							
48	Processes Blending ratio of other poly (or recycled feedstock) [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Throughput in crystal growth for different technologies (2018 = 100%)							
49	Processes for HPM (high performance multi) mc-Si per tool [%]							
50	Processes for mono-like per tool [%]							
51	Processes for Cz-Si per tool [%]							
	Relative throughput ratio in crystal growth for CCz to Cz							
52	Processes CCz[kg/h]/Cz(kg/h) [%]							
	World market share of full square Cz-mono wafers							
53	Products Share of full square Cz-mono wafer in world market [%]							all shares have to add to 100%
54	Products Share of pseudo square (PSQ) Cz-mono wafer in world market [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World market share of different wafer types							
55	Products p-type HPmc-Si [%]							all shares have to add to 100%
56	Products p-type monolike-Si [%]							
57	Products p-type mono-Si [%]							
58	Products n-type HPmc-Si [%]							
59	Products n-type monolike-Si [%]							
60	Products n-type mono-Si [%]							
61	Products other (e.g. ribbon, kerfless ...) [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World Market share of p-type HPmc-Si doping elements [%]							
62	Products Share of doping with B							all shares have to add to 100%
63	Products Share of co-doping with Ga and compensation with P							
64	Products Share of other doping, please specify							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World market share of different mono crystallisation methods							
65	Products Share of continuous Cz (CCz) mono [%]							all shares have to add to 100%
66	Products Share of Cz mono [%]							
67	Products Share of Fz mono [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World market share of different mc-Si wafer sizes							
68	Products Share of 156.0 +/-0.5 * 156.0 +/- 0.5 mm ² [%]							all shares have to add to 100%
69	Products Share of 156.75 +/-0.25 * 156.75 +/- 0.25mm ² [%]							
70	Products Share of 157.75 +/-0.25 * 157.75 +/- 0.25mm ² [%]							
71	Products Share of 161.75 +/-0.25 * 161.75 +/-0.25 mm ² [%]							
72	Products Share of >161.75 +/-0.25 * 161.75 +/-0.25 mm ² [%]							
73	Products Share of other format , please specify format[%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World market share of different mono-Si wafer sizes							
74	Products Share of 156.0 +/-0.5 * 156.0 +/- 0.5 mm ² [%]							all shares have to add to 100%
75	Products Share of 156.75 +/- 0.25 * 156.75 +/- 0.25mm ² [%]							
76	Products Share of 157.75 +/- 0.25 * 157.75 +/- 0.25mm ² [%]							
77	Products Share of 161.75 +/-0.25 * 161.75 +/-0.25 mm ² [%]							
78	Products Share of >161.75 +/-0.25 * 161.75 +/-0.25 mm ² [%]							
79	Products Share of other format , please specify format [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	World market share of pseudosquare (PSQ) mono wafer diameter							
80	Products Share of 195 mm							all shares have to add to 100%
81	Products Share of 200 mm							

ITRPV 2019 Questionnaire

Wafer

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Question No		2018	2019	2021	2023	2026	2029	Comments
82	Products Share of 210 mm							
83	Products Share of 211 mm							
84	Products Share of >211 mm							
85	Products Share of other diameter, please specify [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
World market share for size of wafer production fabs?								
86	Share of <500 MW							all shares have to add to 100%
87	Share of 500 MW to 2 GW							
88	Share of > 2 GW							

ITRPV 2019 Questionnaire

Cell

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Question No

Comments

2018 2019 2021 2023 2026 2029

Processes		2018	2019	2021	2023	2026	2029	Comments
World market share of different texturing technologies for mc-Si								
1	Processes	Standard acidic etching (incl. use of additives) [%]						all shares have to add to 100%
2	Processes	MCCE (metal-catalyzed chemical etching) or wet chemical nanotexturing technology [%]						
3	Processes	Reactive Ion Etching (RIE) [%]						
4	Materials	Other (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
Future trends in Si solar cell metallization materials (values asked for 156,75x156,75mm² cell size)								
5	Materials	Lead free metallization paste in BSF [1=yes / 0=no]						
6	Materials	Lead free metallization paste in PERC _x [1=yes / 0=no]						
7	Materials	Lead free metallization paste in bifacial [1=yes / 0=no]						
8	Materials	Lead free metallization paste in Si-heterojunction (SHJ) [1=yes / 0=no]						
9	Materials	Total amount of overall remaining silver per monofacial p-type cell [mg/cell] (front + rear side)						
10	Materials	Total amount of overall remaining silver per bifacial p-type cell [mg/cell] (front + rear side)						
11	Materials	Total amount of overall remaining silver per HJT n-type cell [mg/cell] (front + rear side)						
12	Materials	Total amount of overall remaining silver per n-type cell (all cell types, without HTJ) [mg/cell] (front + rear side)						
13	Materials	Amount of overall remaining Al per monofacial cell [mg/cell] (front + rear side)						
14	Materials	Amount of overall remaining Al per bifacial cell [mg/cell] (front + rear side)						
World market share of different front side metallization materials								
15	Materials	Silver-based [%]						all shares have to add to 100%
16	Materials	Copper-based [%]						
17	Materials	Other (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
World market share of different front side metalization technologies								
18	Processes	Share of screen-printing in world market [%]						all shares have to add to 100%
19	Processes	Share of stencil-printing in world market [%]						
20	Processes	Share of inkjet/aerosol/dispensing in world market [%]						
21	Processes	Share of direct plating on Si in world market [%]						
22	Processes	Share of plating on seed layer in world market [%]						
23	Processes	Share of other metallization technology in world market (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
Relative share for front silver grid printing								
24	Processes	Single print (one screen print process for the whole front silver grid)						all shares have to add to 100%
25	Processes	Double print (also known as print on print)						
26	Processes	Dual print (where fingers and busbars are printed separately in two different printing processes).						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
World market share of different back side metalization technology								
27	Processes	Share of screen-printing in world market [%]						all shares have to add to 100%
28	Processes	Share of stencil-printing in world market [%]						
29	Processes	Share of inkjet/aerosol/dispensing in world market [%]						
30	Processes	Share of plating in world market [%]						
31	Processes	Share of PVD (evaporation/sputtering) in world market [%]						
32	Processes	Share of other metallization technology in world market (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
Cell production tool throughput of state of the art new tools								
Indicate average output/h per machine (including downtime). Number to be seen as minimum requirement for tool.								
33	Processes	Throughput / tool chemical processes [w/h]						
34	Processes	Throughput / tool thermal processes [w/h]						
35	Processes	Throughput / tool metallization and classification processes [w/h]						
Overall Equipment Effectiveness (OEE) of cell production tools (of state of the art new tools)								
<p>OEE = Availability (A) * Performance (P) * Quality (Q) A = run time / planned production time P = Utilisation (U) * Rate efficiency P = U * actual machine rate [units / h] / theoretical (or max.) machine rate [units / h] Q = good parts manufactured / total parts manufactured</p>								
36	Processes	Average OEE (Availability x Utilization x rate efficiency x rate of quality) per toolset chemical [%]						
37	Processes	Average OEE (Availability x Utilization x rate efficiency x rate of quality) per toolset thermal [%]						
38	Processes	Average OEE (Availability x Utilization x rate efficiency x rate of quality) per toolset metallization & classification [%]						
Smart fab - status of machine learning								
39	Processes	Machine learning implemented at process machines [yes=1, no=0]						
40	Processes	Machine learning implemented at inspection tools [yes=1, no=0]						
41	Processes	Automated fab logistic system [yes=1, no=0]						
42	Processes	Automated fab logistic system with machine learning [yes=1, no=0]						
43	Processes	Automated recipe download / MES integration to tools [yes=1, no=0]						
44	Processes	Automated lot dispatching and scheduling system [yes=1, no=0]						
45	Processes	Automated Wafer to wafer & lot to lot process control system [yes=1, no=0]						

ITRPV 2019 Questionnaire

Cell

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Question No

2018 2019 2021 2023 2026 2029

Comments

Processes	Smart fab - status of WIP tracking	2018	2019	2021	2023	2026	2029	Comments
46	Processes	Carrier tracking [yes=1, no=0]						
47	Processes	Single wafer tracking w/ virtual tracking [yes=1, no=0]						
48	Processes	Single wafer tracking w/ marking [yes=1, no=0]						
49	Processes	Module assembly to cell Fab traceability [yes=1, no=0]						
50	Processes	Other tracking methode - please specify [yes=1, no=0]						
	Processes	Cell process technology - recombination current densities						This shall include the metallisation region Measured according to: D.E. Kane, R.M. Swanson, 18th IEEE PVSEC, 578 (1985)]. Measured according to: D.E. Kane, R.M. Swanson, 18th IEEE PVSEC, 578 (1985)] or extract from IV curve if J0 front/bulk are known.
51	Processes	J0 bulk p-type multi [fA/cm ²]						
52	Processes	J0 bulk p-type mono [fA/cm ²]						
53	Processes	J0 front p-type material [fA/cm ²]						
54	Processes	J0 rear p-type material [fA/cm ²]						
55	Processes	J0 bulk n-type mono SHJ [fA/cm ²]						
56	Processes	J0 bulk n-type mono back contact (or other) [fA/cm ²]						
57	Processes	J0 front n-type mono SHJ [fA/cm ²]						
58	Processes	J0 front n-type mono back contact (or other) [fA/cm ²]						
59	Processes	J0 rear n-type mono SHJ [fA/cm ²]						
60	Processes	J0 rear n-type mono back contact (or other) [fA/cm ²]						
	Processes	Emitter sheet resistance						if selective emitter this should refer to lower doped emitter region, assume a surface concentration of less than 5x10¹⁹/ cm³ Contact resistance shall be below
61	Processes	Emitter sheet resistance for phosphorous doping (p-type cells) [ohm/square]						
62	Processes	Emitter sheet resistance for boron doping (n-type cells) [ohm/square]						
	Processes	World market share of different phosphorous emitter technologies for p-type cells						
63	Processes	Share of homogenous emitter by gas phase diffusion [%]						all shares have to add to 100%
64	Processes	Share of homogenous emitter by ion implantation [%]						
65	Processes	Share of selective emitter by laser doping [%]						
66	Processes	Share of selective emitter by etch back [%]						
67	Processes	Share of selective emitter by ion implantation [%]						
68	Processes	Share of selective emitter by printed dopant [%]						
69	Processes	Share of selective emitter by other technology (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
	Processes	World market share of different technologies for boron doping (n-type cells)						
70	Processes	Share of BBr3 thermal doping [%]						all shares have to add to 100%
71	Processes	Share of BCl3 thermal doping [%]						
72	Processes	Share of Ion implantation with subsequent thermal activation [%]						
73	Processes	Share of others, please specify [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
	Processes	World market of different rear side passivation technologies						
74	Processes	Share of remote plasma PECVD AlOx + integrated capping layer [%]						all shares have to add to 100%
75	Processes	Share of direct plasma PECVD AlOx + integrated capping layer [%]						
76	Processes	Share of single sided ALD AlOx + separate capping layer [%]						
77	Processes	Share of batch ALD AlOx + separate capping layer [%]						
78	Processes	Share of others, please specify [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
	Processes	Front side metallization paramters						
79	Processes	Finger width [µm]						Conductivity of finger should not be significantly reduced line resistivity: 2 – 2.5 µOhm cm, Line resistance: 0.3 Ohm/cm @ 50 µm width)
80	Processes	Alignment precision [µm]						Max. distance in µm for which one point of a printed pattern varies from the theoretical position, incl. e.g. screen wear (3 sigma value), pattern placement precision at +/- 3 sigma
	Processes	Worldwide marketshare of busbar technology for double side contacted cells						
81	Processes	Share of 3 busbars in world market [%]						all shares have to add to 100%
82	Processes	Share of 4 busbars in world market [%]						
83	Processes	Share of 5 busbars in world market [%]						
84	Processes	Share of 6 and more busbars in world market [%]						
85	Processes	Share of busbarless in world market (incl. multi wire technology) [%]						
86	Processes	Share of other busbar technology in world market (please specify) [%]						
		Control value needs to be 100%	0%	0%	0%	0%	0%	
	Processes	Worldwide marktlet share of inline process control in new and upgrated lines						
87	Processes	Share of inline incoming wafer inspection in world market [%]						
88	Processes	Share of inline sheet resistance measurement after diffusion in world market [%]						

ITRPV 2019 Questionnaire

Cell

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Question No

Comments

		2018	2019	2021	2023	2026	2029		
89	Processes	share of inline optical quality control after antireflective coating (ARC) deposition in world market [%]							
90	Processes	Share of inline automatic optical inspection (AOI) after front silver print in world market [%]							
91	Processes	Share of inline automatic optical inspection (AOI) after back silver print in world market [%]							
92	Processes	Share of inline automatic optical inspection (AOI) after back aluminum print in world market [%]							
93	Processes	Share of inline infrared (IR) imaging for hotspot detection in world market [%]							
94	Processes	Share of inline electroluminescence (EL) imaging in world market [%]							
95	Processes	Share of inline automatic optical inspection (AOI) for front side in cell tester/sorter in world market [%]							
96	Processes	Share of inline automatic optical inspection (AOI) for back side in cell tester/sorter in world market [%]							
97	Processes	Share of inline color inspection for front side in cell sorter in world market [%]							
98	Processes	Share of inline color inspection for back side in cell sorter in world market [%]							
99	Processes	Share of inline photoluminescence (PL) imaging as incoming wafer test in world market [%]							
	Products	Average stabilized efficiency values for Si solar cells in mass production (156,75x156,75mm²) measured with bus bars, no BB-less measurement and Frontside STC						Please put in highest average efficiency you expect in mass production	
100	Products	BSF p-type cells mc-Si [%]							
101	Products	BSF cells p-type mono-Si [%]							
102	Products	leading product (PERC, PERL or PERT cells including w/ passivated contacts at rear side) p-type mc-Si [%]							
103	Products	leading product (PERC, PERL or PERT cells including w/ passivated contacts at rear side) p-type mono-Si [%]							
104	Products	leading product (PERC, PERL or PERT cells including w/ passivated contacts at rear side) n-type mono-Si [%]							
105	Products	Silicon heterojunction (SHJ) cells n-type mono-Si [%]							
106	Products	back contact cells n-type mono-Si [%]							
	Products	Worldwide market share of different cell technology							
107	Products	Share of BSF cells in world market [%]							all shares have to add to 100%
108	Products	Share of PERC/PERL/PERT cells including w/ passivated contacts at rear side in world market [%]							
109	Products	Share of Si-heterojunction (SHJ) cells in world market [%]							
110	Products	Share of back contact cells in world market [%]							
111	Products	Share of Si-based tandem cells in world market [%]							
112	Products	Share of other cell technology in world market [%] (please specify)							
		Control value needs to be 100%						0%	0%
	Products	Worldwide market share of different passivated emitter and rear cell (PERC) technology							
113	Products	Share of PERC/PERL with AlO/SiN passivating stack on mc-Si [%]							
114	Products	Share of PERC on p-type mono-Si [%]							
115	Products	Share of PERC on n-type mono-Si [%]							
116	Products	Share of passivated contacts on p-type mono-Si [%]							
117	Products	Share of passivated contacts on n-type mono-Si [%]							
118	Products	Share of other cell technology in world market [%] (please specify)							
		Control value needs to be 100%						0%	0%
	Products	Worldwide market share of different BSF technology							
119	Products	Share of BSF on mc-Si [%]							
120	Products	Share of BSF on mono-Si [%]							
		Control value needs to be 100%						0%	0%
	Processes	Technologies for PERC with passivated contacts at rear side							
121	Processes	forming of tunnel oxide [in situ = 1, ex situ = 0]							
122	Processes	forming of poly silicon with [LPCVD=1, PECVD=0]							
123	Processes	thickness of poly-silicon [nm]							
124	Processes	doping method of poly silicon [in situ = 1, ex situ = 0]							
	Products	Worldwide market share of bifacial cell technology							
125	Products	share of bifacial c-Si cells in world market [%]							all shares have to add to 100%
126	Products	share of monofacial c-Si cells in world market [%]							
		Control value needs to be 100%						0%	0%
		World market share for size of cell production fabs?							
127		Share of <500 MW							all shares have to add to 100%
128		Share of 500 MW to 2 GW							
129		Share of > 2 GW							
		Control value needs to be 100%						0%	0%

ITRPV 2019 Questionnaire

Module

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Question No

2018 2019 2021 2023 2026 2029

Comments

Materials	Module Technology	2018	2019	2021	2023	2026	2029	Comments
1	Materials	Transmission of glass with antireflective (AR) coating [%]						Measured in the intervall 300 nm -1200 nm
2	Materials	Transmission of glass without antireflective (AR) coating [%]						
Materials Lifetime of AR-Coating on module front glass								
3	Materials	Expected lifetime of AR-coating on module front glass [a]						
Materials Worldwide market share of different front cover materials								
4	Materials	Share of modules with non-structured + non-coated front glass in world market [%]						all shares have to add to 100%
5	Materials	Share of modules with AR-coated front glass in world market [%]						
6	Materials	Share of modules with deeply structured front glass in world market [%]						
7	Materials	Share modules with other front cover material (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Worldwide market share of different technologies for cell interconnection								
8	Materials	Share of lead-containing soldering in world market [%]						all shares have to add to 100%
9	Materials	Share of lead-free soldering in world market [%]						
10	Materials	Share of conductive adhesives in world market [%]						
11	Materials	Share of other cell interconnection technologies (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Worldwide market share of different cell interconnect materials								
12	Materials	Share of Cu-ribbons as interconnectors in world market [%]						all shares have to add to 100%
13	Materials	Share of Cu-wires as interconnectors in world market [%]						
14	Materials	Share of structured foils (mainly for back contact cells) as interconnectors in world market [%]						
15	Material	Share of shingled/overlapping cell interconnection in world market [%]						
16	Materials	Share of other interconnect materials (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Worldwide market share of different encapsulant materials								
17	Materials	Share of EVA (Ethylene Vinyl Acetat) as encapsulant in world market [%]						all shares have to add to 100%
18	Materials	Share of TPU (Thermoplastic Polyurethane) as encapsulant in world market [%]						
19	Materials	Share of PVB (Polyvinyl Butyral) as encapsulant in world market [%]						
20	Materials	Share of polyolefin as encapsulant in world market [%]						
21	Materials	Share of PDMS (Polydimethyl Silicone)/silicone as encapsulant in world market [%]						
22	Materials	Share of other materials in world market (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Material thickness of different encapsulant materials								
23	Materials	EVA (Ethylene Vinyl Acetat) [µm]						
24	Materials	TPU (Thermoplastic Polyurethane) [µm]						
25	Materials	PVB (Polyvinyl Butyral) [µm]						
26	Materials	Polyolefin [µm]						
27	Materials	PDMS (Polydimethyl Silicone)/silicone [µm]						
Materials Worldwide market share of different back cover technologies with glass front cover								
28	Materials	Share of glass front and foil as back cover (glass-foil) in world market [%]						all shares have to add to 100%
29	Materials	Share of glass front and back cover (glass-glass) in world market [%]						
30	Materials	Share of glass front and other materials (glass-other) in world market (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Worldwide market share of different backsheets materials								
31	Materials	Share of TPT (Tedlar-Polyester-Tedlar) as backsheets in world market [%]						all shares have to add to 100%
32	Materials	Share of TPA (tedlar-PET-Polyamid) as backsheets in world market [%]						
33	Materials	Share of APA (Polyamid-PET-Polyamid) as backsheets in world market [%]						
34	Materials	Share of polyolefin (PO) as backsheets [%]						
35	Materials	Share of KPE(Kynar (PVDF)- PET- EVA) products as backsheets [%]						
36	Materials	Share of other materials in world market (please specify) [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Market share of back sheets with different colors								
37	Materials	Share of white backsheets						all shares have to add to 100%
38	Materials	Share of black back sheet						
39	Materials	Share of transparent back sheet						
40	Materials	Share of backsheets with other color (please specify)						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Thickness of front glasses in modules								
41	Materials	Share of front glass with thickness > 3mm in world market [%]						all shares have to add to 100%
42	Materials	Share of front glass with thickness between 2mm - 3mm in world market [%]						
43	Materials	Share of front glass with less than 2mm in world market [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Thickness of back glasses in modules								
44	Materials	Share of back glass with thickness > 3mm in world market [%]						
45	Materials	Share of back glass with thickness between 2mm - 3mm in world market [%]						
46	Materials	Share of back glass with less than 2mm in world market [%]						
		0%	0%	0%	0%	0%	0%	Control value needs to be 100%
Materials Worldwide market share of different frame materials								
47	Materials	Share of aluminum frame in world market [%]						all shares have to add to 100%
48	Materials	Share of plastics frame in world market [%]						

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Module

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Question No

		2018	2019	2021	2023	2026	2029	Comments	
49	Materials	Share of frameless modules in world market (incl. corner protect) [%]							
50	Materials	Share of other materials in world market (if, please specify)							
		Control value needs to be 100%						0%	0%
	Worldwide market share of different glass-galss modules								
51	Products	Share of framed glass-glass modules [%]							all shares have to add to 100%
52	Products	Share of frameless glass-glass modules [%]							
		Control value needs to be 100%						0%	0%
	Materials Worldwide share of adhesive materials between frame and glass								
53	Materials	Share of tape adhesive in world market							all shares have to add to 100%
54	Materials	Share of silicone adhesive in world market							
55	Materials	Share of other materials in world market (please specify) [%]							
		Control value needs to be 100%						0%	0%
	Processes Worldwide market share of different module interconnect technologies								
56	Materials	Share of lead-containing soldering in world market [%]							all shares have to add to 100%
57	Materials	Share of lead-free soldering in world market [%]							
58	Materials	Share of conductive adhesives in world market [%]							
59	Materials	Share of other module interconnection technologies (please specify) [%]							
		Control value needs to be 100%						0%	0%
	Processes Production tool throughput in module production								
60	Processes	Throughput increase for 4 busbar stringing [%] 2018 = 100%							
61	Processes	Throughput increase for 5 busbar stringing [%] 2018 = 100%							
62	Processes	Throughput increase for 6 and more busbar stringing [%] 2018 = 100%							
63	Processes	Throughput increase for multi busbar (MBB) busbar stringing [%] 2018 = 100%							
64	Processes	Throughput increase for glass / back sheet lamination [%] 2018 = 100%							
65	Processes	Throughput increase for glass / glass lamination [%] 2018 = 100%							
	Processes Trend of Cell to Module power ratio (Frontside STC)								
	i.e. Cell has 4W - in module only 3,95W = 98,7% means 3,95/4 (module power / cell power)								
66	Processes	Cell to Module Power Ratio for acidic texturied multi-Si full cells [%]							
67	Processes	Cell to Module Power Ratio for acidic texturied multi-Si half cells [%]							
68	Processes	Cell to Module Power Ratio for alkaline textured mono-Si full cells [%]							
69	Processes	Cell to Module Power Ratio for alkaline textured mono-Si half cells [%]							
	Products Module Power for 60-cell / 120 half cell (156,75x156,75mm²) module (include highest stabilized power - measured frontside STC)								
70	Products	PERC, PERT or PERL cells n-type mono-Si [Wp]							
71	Products	BSF cells p-type mono-Si [Wp]							
72	Products	PERC/PERT cells p-type mono [Wp]							
73	Products	BSF p-type cells mc-Si [Wp]							
74	Products	PERC/PERT cells p-type mc-Si [Wp]							
75	Products	Silicon heterojunction (SHJ) cells n-type mono-Si [Wp]							
76	Products	back contact cells n-type mono-Si [Wp]							
	Products Module Power for 72-cell/ 144 half-cell (156,75x156,75mm²) module (include highest stabilised power - measured frontside STC)								
77	Products	PERC, PERT or PERL cells n-type mono-Si [Wp]							
78	Products	BSF cells p-type mono-Si [Wp]							
79	Products	PERC/PERT cells p-type mono [Wp]							
80	Products	BSF p-type cells mc-Si [Wp]							
81	Products	PERC/PERT cells p-type mc-Si [Wp]							
82	Products	Silicon heterojunction (SHJ) cells n-type mono-Si [Wp]							
83	Products	back contact cells n-type mono-Si [Wp]							
	Products Worldwide market share of "true" bifacial modules								
84	Products	share of "true" bifacial c-Si modules with bifacial cells and transparent backcover in world market [%]							all shares have to add to 100%
85	Products	share of mono-facial c-Si modules with bifacial cells in world market [%]							
		Control value needs to be 100%						0%	0%
	Products Worldwide market share of different cell dimensions								
86	Products	share of full cell c-Si modules in world market [%]							all shares have to add to 100%
87	Products	share of half cell c-Si modules in world market [%]							
88	Products	share of quarter cell c-Si modules in world market [%]							
89	Products	share of other cell size c-Si modules in world market [%] (please specify)							
		Control value needs to be 100%						0%	0%
	Products Worldwide market share of different module sizes								
90	Products	Share of 60-cell / 120-half-cell modules in world market [%]							all shares have to add to 100%
91	Products	Share of 66-cell / 132-half-cell modules in world market [%]							
92	Products	Share of 72-cell / 144-half-cell modules in world market [%]							
93	Products	Share of 78-cell / 156-half-cell modules in world market [%]							
94	Products	Share of < 60-cell / 120-half-cell modules in world market [%]							please specify size
95	Products	Share of > 78-cell / 156-half-cell modules in world market [%]							please specify size
96	Products	Share of other sizes in world market [%]							please indicate number of cells
		Control value needs to be 100%						0%	0%
	Products Cell dimesion requirements in module technology								
97	Products	Limit of cell thickness in future module technology for full cells [µm]							
98	Products	Limit of cell thickness in future module technology for half cells [µm]							
99	Products	Limit of cell thickness in future module technology for shingled cells [µm]							

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Module

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Question No

		2018	2019	2021	2023	2026	2029	Comments	
100	Products	Limit of cell thickness in future module technology for multi bus bar cells [µm]							
101	Products	Limit of cell thickness in future module technology for Silicon heterojunction (SHJ) cells [µm]							
102	Products	Limit of cell thickness in future module technology for back contacted cells [µm]							
	Products	Junction box parameters							
103	Products	Junction Box Reverse Current Capacity [A]							maximum specified panel current when operated in forward bias (for parallel stringing in PV systems)
104	Products	Junction Box Concept							0= single, 1 = multiple
105	Products	Mounting of Junction Box							0=silicone, 1=tape, 2=others (pls specify)
106	Products	Electrical Interconnect technology for bypass diode							0=soldering, 1=clamping, 2=welding
	Products	Worldwide market share of "smart" J-Box technology							
107	Products	Share of standard J-Box without additional function in world market [%]							all shares have to add to 100%
108	Products	Share of smart J-Box with module level power optimiser in world market [%]							
109	Products	Share of other function (please specify) in world market [%]							
		Control value needs to be 100%						0%	0%
	Products	Worldwide market share of Micro-inverter based technologies							
110	Products	Share of frame/rack - mounted microinverter (DC/AC) in world market [%]							all shares have to add to 100%
111	Products	Share of integrated module mounted microinverter (DC/AC) in world market [%]							
112	Products	Share of other any other microinverter technology (please specify) in world market [%]							
		Control value needs to be 100%						0%	0%
	Products	Worldwide market share of J-Box monitoring technology							
113	Products	Share of J-Box without additional safety/monitoring function in world market [%]							all shares have to add to 100%
114	Products	Share of module level shut down (MLS) for power off in world market [%]							
115	Products	Share of module level monitoring (MLM) in world market [%]							
116	Products	Share of other function (please specify) in world market [%]							
		Control value needs to be 100%						0%	0%
	Products	Relative module cost adder for different J-Box technologies [%]							
117	Products	Standard J-Box						0%	0%
118	Products	Relative cost adder for microinverter DC/AC [%]							example:.. cost adder of 0.1ct/Wp equals to 0,25% @ 40ct/Wp
119	Products	Relative cost adder for converter DC/DC [%]							
120	Products	Relative cost adder for module level shut down (MLS) for power off [%]							
121	Products	Relative cost adder for module level monitoring (MLM) [%]							
	Products	Cell interconnection stability testing							
122	Products	minimum busbar pull force [N/mm]							
123	Products	Indicate preferred test method							
	Products	Worldwide market share of Modules for special regional applications							
124	Products	Share of standard modules [%]							all shares have to add to 100%
125	Products	Share of modules for desert environment [%]							
126	Products	Share of modules for tropical climate [%]							
127	Products	Share of modules for other environment (please specify) in world market [%]							
		Control value needs to be 100%						0%	0%
	Products	Waranty requirements for c-Si PV modules							
128	Products	Initial degradation after 1st year of operation [%]							power degradation calculated according to name plate
129	Products	Degradation per year during performance waranty [%]							
130	Products	Performance waranty [years]							
131	Products	Product waranty [years]							
		Inline testing / MES							
132	Processes	Share of inline automatic optical inspection (AOI) for cells (in stringer) in world market [%]							
133	Processes	Share of inline cell colour inspection in stringer in world market [%]							
134	Processes	Share of inline automatic optical inspection (AOI) for modules (after lamination) in world market [%]							
135	Processes	Share of inline infrared (IR) imaging for hotspot detection in world market [%]							
136	Processes	Share of inline electroluminescence (EL) imaging for modules in world market [%]							
137	Processes	Share of MES based module manufacturing in world market [%]							
		World market share for size of module production fabs?							
138		Share of <500 MW							all shares have to add to 100%
139		Share of 500 MW to 2 GW							
140		Share of > 2 GW							
		Control value needs to be 100%						0%	0%

ITRPV 2019 Questionnaire System

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Question No

		2018	2019	2021	2023	2026	2029	Comments
	Products Cost elements of PV System in Europe in [USD 2018]	For Systems > 100 kW						
1	Products Module [USD 2016]							
2	Products Inverter [USD 2016]							
3	Products Wiring [USD 2016]							
4	Products Mounting [USD 2016]							
5	Products Ground [USD 2016]							
	Products Cost elements of PV System in Asia in [USD 2018]	For Systems > 100 kW						
6	Products Module [USD 2016]							
7	Products Inverter [USD 2016]							
8	Products Wiring [USD 2016]							
9	Products Mounting [USD 2016]							
10	Products Ground [USD 2016]							
	Products Cost elements of PV System in the US in [USD 2018]	For Systems > 100 kW						
11	Products Module [USD 2016]							
12	Products Inverter [USD 2016]							
13	Products Wiring [USD 2016]							
14	Products Mounting [USD 2016]							
15	Products Ground [USD 2016]							
	Products Average module power class for systems > 100 kW	For Systems > 100 kW						
16	Products for 60-cell module [Wp]							
17	Products for 72-cell module [Wp]							
	Products Maximum system voltage of new PV systems	For Systems > 100 kW						
18	Products share of new systems with max. system voltage of 1000 V in world market [%]							all shares have to add to 100%
19	Products share of new systems with max. system voltage of 1500 V in world market [%]							
20	Products share of new systems with different max. system voltage in world market (please specify) [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Products World market share of tracking systems for c-Si PV	For c-Si PV only						add floating?
21	Products No tracking (fixed tilt) [%]							all shares have to add to 100%
22	Products 1-axis tracking [%]							
23	Products 2-axis tracking [%]							
24	Products Other (please specify) [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Products World Market share of different enduse							
25	Products share of roof top systems [%]							all shares have to add to 100%
26	Products share of power plant systems [%]							
27	Products share of building integrated (BIPV) systems [%]							
28	Products share of floating systems [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Products World Market share of recyclable modules							
29	Products share of recyclable modules sold [%]							
30	Products share of modules sold requires recyclability [%]							
	Products World Market share of PV systems which are combined with storage							
31	Products Share of systems <= 10kW							
32	Products Share of systems >10kW to <= 100kW							
33	Products Share of systems > 100kW							
	Products World market share of inverter technology							
34	Products Share of string inverter in world market [%]							
35	Products Share of central inverter in world market [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Products World market share of CPV for c-Si PV	For c-Si PV only						
36	Products No concentration [%]							all shares have to add to 100%
37	Products Low concentration < 10 X [%]							

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Question No		2018	2019	2021	2023	2026	2029	Comments
38	Products High concentration $\geq 10 X$ [%]							
	Control value needs to be 100%	0%	0%	0%	0%	0%	0%	
	Products New Solutions for mounting							
39	Products Please list new concepts							