

Adding Climate Effects to NREL's Online LCOE Calculator for the DuraMAT Data Hub

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DuraMAT Webinar September 14, 2020



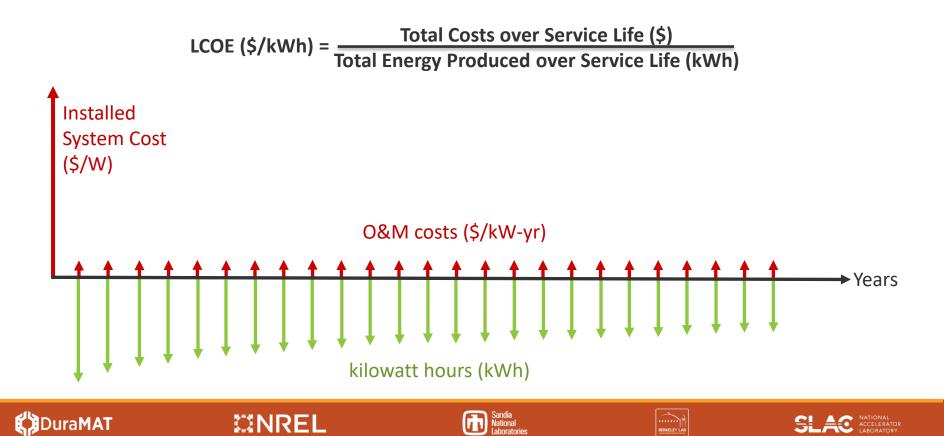








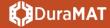
Levelized Cost of Energy



LCOE Calculation Option: SAM

System Advisor Model (SAM): <u>https://sam.nrel.gov/</u>

- + Different financial models
- + Detailed options for module and system designs
- + Can model solar + storage
- Learning curve
- Difficult to quickly evaluate research directions without potentially introducing confounding factors









Simplified PV-Specific Calculator

http://pvlcoe.nrel.gov/

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- Available online since 2018

https://github.com/NREL/PVLCOE

- Source code on GitHub since July 2020

https://www.nrel.gov/analysis/solar-levelized-cost.html

lational

- Tutorial on calculator use, online 9/15/20

type, or location. Use the copy from baseline button (below) to make the proposed inputs match the baseline inputs Baseline Proposed COPY FROM BASELIN Cost Cost Front layer cost (USD/m²) Front layer cost (USD/m²) 4.06 4.06 Cell cost (USD/m²) Cell cost (USD/m²) 34.4 34.4 Back layer cost (USD/m²) Back layer cost (USD/m²) 2.32 2.32 Non-cell module cost (USD/m²) Non-cell module cost (USD/m²) 18.0 18.0 Extra component cost (USD/m²) Extra component cost (USD/m²) 0.00 0.00 O&M cost (USD/kWpc/year) O&M cost (USD/kWpc/year) 15.41 15.41 BOS cost, power-scaling (USD/W) BOS cost, power-scaling (USD/W) 0.31 0.31 BOS cost, area-scaling (USD/m²) BOS cost, area-scaling (USD/m²) 63.0 63.0 Performance Performance Efficiency (%) Efficiency (%) 19.0 19.0 Energy yield (kWh/kWDC) Energy yield (kWh/kWDC) 1475 1475 Reliability Reliability Degradation rate (%/year) Degradation rate (%/year) 0.36 0.36 Service life (years) Service life (years) 25 25 Common settings Financial Discount rate 6.3 LCOE result Proposed LCOE (USD/kWh) 0.0670 Baseline LCOE (USD/kWh) 0.0670 Additional results Baseline Proposed Module price (USD/W) Module price (USD/W) 0.36 0.36 Total installed system cost (USD/W) btal in tal __ system cost (USD/W) 1.00 1.00

Use the presets button (below) to choose a different cell technology, system

Simplified PV-Specific Calculator

If you make a module bifacial....

COPY FROM BASELINE	Baselin	e	PRESETS	pposed	COPY FROM BASELINE
er cost (USD/m²)	Cost Front lay	er cost (USD/m²)	Cos Fror	nt layer cost (USD/m²)	
(USD/m ²)		: (USD/m ²)	Cell	I cost (USD/m ²)	
er cost (USD/m²)	2.32	er cost (USD/m²)		ck layer cost (USD/m ²)	
module cost (USD/m ²)	18.00	module cost (USD/m ²)	18.	n-cell module cost (USD/m ²)	
nponent cost (USD/m ²)	0.00		0.0		
t, power-scaling (USD/W)	15.40	t, power-scaling (USD/W)	15.	M cost (USD/kW _{DC} /year) 40 S cost, power-scaling (USD/W)	
t, area-scaling (USD/m ²)	0.31	t, area-scaling (USD/m ²)	0.3		
	63.04		63.	.04	
ance y (%)	Perform Efficienc 19.0			formance ciency (%) .0	
LCOE (USD/kWh)	Baseline	LCOE (USD/kWh)	0.0670 Prop	posed LCOE (USD/kWh)	0.0676

Cost Cost Front layer cost (USD/m²) Front lay 4.06 4.06 Cell cost (USD/m²) Cell cost 34.40 34.40 Back laver cost (USD/m²) Back laye 2.32 2.32 Non-cell module cost (USD/m²) Non-cell 18.00 18.00 Extra component cost (USD/m²) Extra con 0.00 0.00 O&M cost (USD/kWpc/year) O&M cos 15.40 15.40 BOS cost, power-scaling (USD/W) BOS cos 0.31 0.31 BOS cost, area-scaling (USD/m²) BOS cos 63.04 63.04 Performance Performa Efficiency (%) Efficienc 19.0 19.0 Baseline LCOE (USD/kWh) 0.0670

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Baseline

Propose

PRESETS







Simplified PV-Specific Calculator

How efficient should it be to break even?

Baseline	Proposed COPY FROM BASELINE
Cost Front layer cost (USD/m²)	Cost Front layer cost (USD/m ²)
4.06	4.06
Cell cost (USD/m ²)	Cell cost (USD/m ²)
34.40	34.40
Back layer cost (USD/m²)	Back layer cost (USD/m ²)
2.32	4.06
Non-cell module cost (USD/m ²)	Non-cell module cost (USD/m ²)
18.00	18.00
Extra component cost (USD/m ²)	Extra component cost (USD/m ²)
0.00	0.00
D&M cost (USD/kW _{DC} /year)	<u>Q&M</u> cost (USD/kW _{DC} /year)
15.40	15.40
BOS cost, power-scaling (USD/W)	BOS cost, power-scaling (USD/W)
0.31	0.31
BOS cost, area-scaling (USD/m ²)	BOS cost, area-scaling (USD/m ²)
63.04	63.04
Performance	Performance
Efficiency (%)	Efficiency (%)
19.0	19.0
Baseline LCOE (USD/kWh) 0.0670	Proposed LCOE (USD/kWh) 0.0676

Baseline	PRESETS	roposed	l I	COPY FROM BASELINE
Cost Front layer cost (USD/m ²)		ost ront layer	cost (USD/m ²)	
4.06		4.06		
Cell cost (USD/m ²)	C	ell cost (L	JSD/m ²)	
34.40		34.40		
Back layer cost (USD/m ²)	Ba	ack layer	cost (USD/m ²)	
2.32		4.06		
Non-cell module cost (USD/m ²)	N	on-cell m	odule cost (USD/m ²)	
18.00		18.00		
Extra component cost (USD/m ²)	E	xtra comp	oonent cost (USD/m ²)	
0.00		0.00		
<u>O&M</u> cost (USD/kW _{DC} /year)	0	&M cost	(USD/kW _{DC} /year)	
15.40		15.40		
BOS cost, power-scaling (USD/W)	B	OS cost, j	oower-scaling (USD/W)	
0.31		0.31		
BOS cost, area-scaling (USD/m ²)	B	OS cost, a	area-scaling (USD/m ²)	
63.04		63.04		
Performance		erforman		
Efficiency (%)		fficiency (%)	
19.0		19.3		
Baseline LCOE (USD/kWh)	0.0670 Pr	roposed L	COE (USD/kWh)	0.0670

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System Options

		1	4		
Baseline presets	×	Baseline presets ×	La	Baseline presets	<
Use these menus to choose a set of cost and performance values for the Baseline module.		Use these menus to choose a set of cost and performance values for the Baseline module.		Use these menus to choose a set of cost and performance values for the Baseline module.	
Cell technology		Cell technology		Cell technology	
✓ mono-Si multi-Si CdTe	d at e	mono-Si Cell technology affects cell cost, efficiency,	ar evi Di sy	mono-Si Cell technology affects cell cost, efficiency,	at Se
available values for package type and system ty	pe. v	energy yield, degradation rate, BOS cost, and the available values for package type and system type.	y e c gy	energy yield, degradation rate, BOS cost, and the available values for package type and system type	M .
Package type	tej	Package type	ti st	Package type	te
glass-polymer backsheet	~	🗸 glass-polymer backsheet 🦻	fo	glass-polymer backsheet	
Package type affects back layer cost		glass-glass		Package type affects back layer cost	
System type		System type		System type	
fixed tilt, utility scale	~ a/	fixed tilt, utility scale	a)	✓ fixed tilt, utility scale	a
System type affects energy yield and BOS cost		System type affects energy yield and BOS cost	lt	single-axis tracked, utility scale roof-mounted, residential scale	1
Location		Location	1	Location	
USA MO Kansas City	~	USA MO Kansas City 🗸 🗸		USA MO Kansas City 🗸 🗸	
Location affects energy yield and BOS cost		Location affects energy yield and BOS cost		Location affects energy yield and BOS cost	
CLOSE USE THIS PRESE	.	CLOSE USE THIS PRESET	1	CLOSE USE THIS PRESET	ľ

Baseline presets	×
Use these menus to choose a set of cost and performance values for the Baseline module.	
Cell technology	
mono-Si	~
Cell technology affects cell cost, efficiency, energy yield, degradation rate, BOS cost, a available values for package type and syster	
Package type	
glass-polymer backsheet	~
Package type affects back layer cost	
System type	
fixed tilt, utility scale	~
System type affects energy yield and BOS or USA AK Anchorage Intl Ap USA AL Montgomery	tac
USA AR Little Rock	1
USA AZ Phoenix USA CA Daggett	
USA CO Denver Intl Ap USA CT Hartford	
USA DE Dover Afb	г
USA FL Fort Lauderdale	
USA GA Albany Dougherty County Ap	0



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System Options

té Baseline presets ×	ta Baseline presets ×	Baseline presets ×	Baseline presets ×
Use these menus to choose a set of cost and performance values for the Baseline module. Cell technology	Use these menus to choose a set of cost and performance values for the Baseline module. Cell technology	Use these menus to choose a set of cost and performance values for the Baseline module. Cell technology	Use these menus to choose a set of cost and performance values for the Baseline module. Cell technology
v mono-Si multi-Si CdTe available values for package type and system type.	v mono-Si v Sy Cell technology affects cell cost, efficiency, energy yield, degradation rate, BOS cost, and the available values for package type and system type.	CdTe Cd	wono-Si Cell technology affects cell cost, efficiency, energy yield, degradation rate, BOS cost, and the available values for package type and system type.
si Package type	as) Package type	Package type	Package type
fo glass-polymer backsheet Package type affects back layer cost	glass-polymer backsheet	glass-glass Package type affects back layer cost	fo glass-polymer backsheet Package type affects back layer cost
System type	System type	System type	System type
) fixed tilt, utility scale V k System type affects energy yield and BOS cost	if fixed tilt, utility scale Image: scale ix System type affects energy yield and BOS cost	✓ fixed tilt, utility scale single-axis tracked, utility scale	fixed tilt, utility scale
Location	Location	Location	USA AK Anchorage Intl Ap USA AL Montgomery
USA MO Kansas City Location affects energy yield and BOS cost	USA MO Kansas City V Location affects energy yield and BOS cost	USA MO Kansas City V Location affects energy yield and BOS cost	✓ USA AR Little Rock USA AZ Phoenix USA CA Daggett USA CO Denver Intl Ap
CLOSE USE THIS PRESET	CLOSE USE THIS PRESET		USA CT Hartford USA DE Dover Afb USA FL Fort Lauderdale
		1	USA GA Albany Dougherty County Ap

Certain selections limit which other options are available

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Preset Default Values

Default values pre-populate based on your drop-down selections, but values can be adjusted.

Currently,

- Cell technology affects:
 - cell cost
 - efficiency
 - energy yield
 - degradation rate
 - BOS cost
 - available options for package type and system type
- Package type affects: **back layer cost**
- System type affects: energy yield and BOS cost
- Location affects: energy yield and BOS cost

Baseline PRESETS Cost Front layer cost (USD/m²) 4.06 Cell cost (USD/m²) 34.40 Back layer cost (USD/m²) 2.32 Non-cell module cost (USD/m²) 18.00 Extra component cost (USD/m²) 0.00 O&M cost (USD/kWpc/year) 15.40 BOS cost, power-scaling (USD/W) 0.31 BOS cost, area-scaling (USD/m²) 63.04 Performance Efficiency (%) 19.0 Energy yield (kWh/kWpc) 1475 Reliability Degradation rate (%/year) 0.36 Service life (years) 25

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 - BOS cost

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- available options for package type and system type
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Location affects: energy yield and BOS cost 4

Baseline Cost Front layer cost (USD/m²) 4.06 Cell cost (USD/m²) 34.40 Back laver cost (USD/m²) 2.32 Non-cell module cost (USD/m²) 18.00 Extra component cost (USD/m²) 0.00 O&M cost (USD/kWpc/year) 15.40 BOS cost, power-scaling (USD/W) 0.31 BOS cost area-scaling (USD/m²) Add effects on degradation rate Energy yield (kWh/kWpc) 1475 Reliability Degradation rate (%/year) 0.36 Service life (years) 25





Where to Update Default Values

Here's how the	build-presets					
	CSS		ß	bootstrap.min.js		
GitHub repository	🖿 js	$ \prec $	ß	bos_cost_tree.js		
is organized:	nouislider		ß	jquery-3.2.1.slim.min.js		
			ß	lcoe_calculator.js		ono-Si": { "glass-polymer backsheet": {
	README.md		ß	nouislider.min.js		"fixed tilt, utility scale": { "USA AK Anchorage Intl Ap": ·
	Coe_calculator.html		ß	popper.min.js		"cost_front_layer": 4.06, "cost_cell": 34.4, "cost_back_layer": 2.32,
	Coe_calculator_documentation.html		ß	preset_tree.js		"cost_noncell": 18.0, "cost_om": 15.4, "efficiency": 19.0,
		l	C	preset_tree.min.js	K	"eTTIClency": 19.0, "energy_yield": 928.0, "degradation_rate": 0.36, "state": "AK" },
						<pre>"USA AL Montgomery": { "cost_front_layer": 4.06, "cost_cell": 34.4,</pre>
Most default values are ca	alled from the preset	tree	,			"cost_back_layer": 2.32, "cost_noncell": 18.0, "cost_om": 15.4,
which looks basically like t	this ———				•	"efficiency": 19.0, "energy_yield": 1486.0, "degradation_rate": 0.36,
lovcont POS costs which	are called from the be		oct	trool		"state": "AL" },
(except BOS costs, which a		<u></u>	721	_uee		

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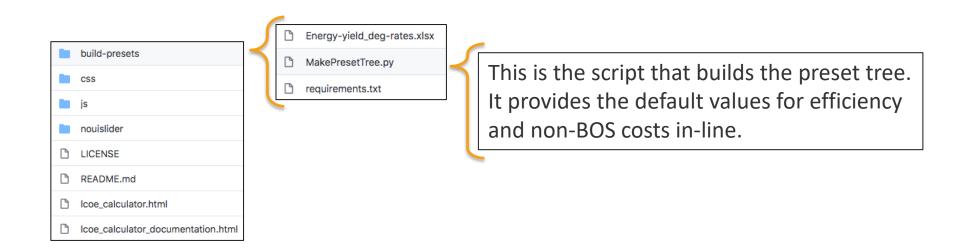
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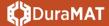






How to Update Default Values





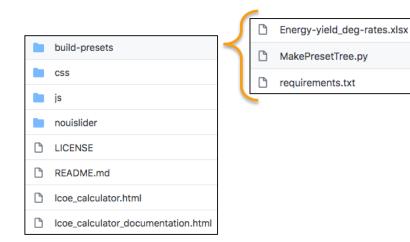
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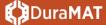




How to Update Default Values



This provides the default values for energy yield and degradation rates (previously, only energy yield)



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How to Update Default Values

•	Aut	toSave 🔵 OFF) ሰ 🖬 🖬	🖻 🕤 🗸 😈 🖛 🐴 Energy-y	vield_deg-rates ~		۹.
н	ome Insert	t Draw	Page Layou	ut Formulas Data Re	view View 🔉 T	ell me	Share 🖓 Comments
G:	L _ ‡ >	< 🗸 fx	Degradation	n Rate (%/year)			
	A	В	С	D	E	F	G
	Cell Technology	Package Type	System Type	Location	First year energy (kWh)	First Year Energy Yield (kWh/kWp)	Degradation Rate (%/year)
	multi-Si	glass-polymer	fixed tilt, utilit	USA NM Albuquerque (TMY2)	1.83E+08	1832	0.65
	multi-Si	glass-polymer	l fixed tilt, utilit	USA NV Las Vegas (TMY2)	1.85E+08	1846	0.65
	multi-Si	glass-polymer	l fixed tilt, utilit	USA TX San Antonio (TMY2)	1.57E+08	1569	0.65
	multi-Si	glass-polymer	l fixed tilt, utilit	USA AL Montgomery (TMY2)	1.48E+08	1484	0.65
	multi-Si	glass-polymer	l fixed tilt, utilit	USA AR Little Rock (TMY2)	1.48E+08	1480	0.65
_	multi-Si	glass-polymer	l fixed tilt, utilit	USA AZ Phoenix (TMY2)	1.82E+08	1822	0.65
	multi-Si	glass-polymer	l fixed tilt, utilit	USA CA Daggett (TMY2)	1.89E+08	1895	0.65
8	multi-Si	glass-glass	single-axis tra	USA WI Madison (TMY2)	1.75E+08	1750	0.65
9	multi-Si	glass-glass	single-axis tra	USA WV Charleston (TMY2)	1.62E+08	1622	0.65
)	multi-Si	glass-glass	single-axis tra	USA WY Cheyenne (TMY2)	2.15E+08	2153	0.65
1	multi-Si	glass-glass	single-axis tra	USA AK Anchorage Intl Ap (TMY3)	1.19E+08	1195	0.65
2	mono-Si	glass-polymer	fixed tilt, utilit	t USA NM Albuquerque (TMY2)	1.83E+08	1828	0.36
3	mono-Si	glass-polymer	fixed tilt, utilit	t USA NV Las Vegas (TMY2)	1.85E+08	1848	0.36
4	mono-Si	glass-polymer	fixed tilt, utilit	t USA TX San Antonio (TMY2)	1.57E+08	1572	0.36
5	mono-Si	glass-polymer	fixed tilt, utilit	t USA AL Montgomery (TMY2)	1.49E+08	1486	0.36
6	mono-Si	glass-polymer	fixed tilt, utilit	t USA AR Little Rock (TMY2)	1.48E+08	1480	0.36

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If updating values for an entire package type or system type, paste & drag might be easiest.

If updating values by location, creating a dictionary and then combining the INDEX and MATCH functions might be best.

...then, run MakePresetTree.py







Climate Effects on Degradation Rate

Jordan, Dirk C., et al. "Compendium of photovoltaic degradation rates." *Progress in Photovoltaics: Research and Applications* 24.7 (2016): 978-989

- 4 climate categories, but differences between degradation rates are not statistically significant
- Module and system degradation rates are each present in the data and are not analyzed separately when comparing climate categories

Deceglie, Michael G., et al. "Fleet-scale energy-yield degradation analysis applied to hundreds of residential and nonresidential photovoltaic systems." *IEEE Journal of Photovoltaics* 9.2 (2019): 476-482

- Shows statistically significant dependence of degradation rate on average temperature











Adding New System Options

edit MakePresetTree.py

9		9	
10	# %% Define feasible system configurations		# % Define feasible system configurations
11	cell_technologies = ['mono-Si', 'multi-Si', 'CdTe']		<pre>cell_technologies = ['mono-Si', 'multi-Si', 'CdTe', 'perovskite']</pre>
12		 12	
13	<pre>package_types = {</pre>		package_types = {
14	'mono-Si': ('glass-polymer backsheet', 'glass-glass'),	14 15	'mono-Si': ('glass-polymer backsheet', 'glass-glass'), 'multi-Si': ('glass-polymer backsheet', 'glass-glass'),
15	'multi—Si': ('glass—polymer backsheet', 'glass—glass'),	 16	mutti-si (glass-putymer udtismeet, glass-glass), ('dTe': ('glass-glass',),
16	'CdTe': ('glass-glass',)	 17	<pre>'perovskite': ('alass-diass','polymer-polymer')</pre>
17	}	18	}
18		19	
19	<pre>system_types = {</pre>		system types = {
20	'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'),	21	'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'),
21	'multi-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale'),	 22	'multi-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale'),
22	'CdTe': ('fixed tilt, utility scale', 'single-axis tracked, utility scale')	23	'CdTe': ('fixed tilt, utility scale', 'single-axis tracked, utility scale'),
23	}	24	' <mark>perovskite</mark> ': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale')
24		 25	}
25		26	
	# %% Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage	27	
27	module details = {	28	# ‰ Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage
28	'cost front layer': 4.06,		<pre>module_details = {</pre>
29	'cost cell': {'mono-Si': 34.4, 'multi-Si': 31.45, 'CdTe': 30},	 30	'cost_front_layer': {'glass-polymer backsheet': 4.06, 'glass-glass': 4.06, 'polymer-polymer': 20},
30	'cost_back_layer': {'glass-polymer backsheet': 2.32, 'glass-glass': 3},	 31 32	'cost_cell': {'mono-Si': 34.4, 'multi-Si': 31.45, 'CdTe': 30, 'perovskite': 20},
31	'cost_buct_clyft': 18.,	 32 33	'cost_back_layer': {'glass-polymer backsheet': 2.32, 'glass-glass': 3, 'polymer-polymer': 2.32}, 'cost noncell': 18
32	'efficiency: {'mono-Si': 19.0, 'multi-Si': 17.0, 'CdTe': 16.0},	 33 34	cost_noncett : 18., 'efficiency': { 'mono-Si': 19.0, 'multi-Si': 17.0, 'CdTe': 16.0, 'perovskite': 16.0},
33		35	
55	1	33	3







Adding New System Options

edit MakePresetTree.py

<pre># % Define feasible system configurations cell_technologies = ['mono-Si', 'multi-Si', 'CdTe'] package_types = { 'mono-Si': ('glass-polymer backheet', 'glass-glass'), 'mono-Si': ('glass-glass', 'polymer-polymer') } system_types = { 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'multi-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'multi-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale'), 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'mono-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'cost_fort_layer': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 'cost_fort_laye</pre>		
<pre>i</pre>	9	9
<pre>12 13 14 15 15 15 15 15 15 15 15 15 15 15 15 15</pre>	10 # % Define feasible system configurations	
<pre>13 package_types = { 13 package_types = { 14 'con-5i: ('iglass-polymer backsheet', 'glass-glass'), 15 'multi-5i': ('glass-polymer backsheet', 'glass-glass'), 15 'multi-5i': ('glass-polymer backsheet', 'glass-glass'), 16 'coff': ('glass-polymer backsheet', 'glass-glass',), 17 'pervoskite': ('glass-polymer packsheet', 'glass-glass',), 18 } 19 system_types = { 19 osystem_types = { 10 'con-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 15 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 16 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 17 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 18 ' 19 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 16 'multi-5i': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 17 'multi-5i': (f</pre>	<pre>11 cell technologies = ['mono-Si', 'multi-Si', 'CdTe']</pre>	
<pre>13 package_types = { 13 mono-Si1: ('glass-polymer backsheet', 'glass-glass'), 14 'mono-Si1: ('glass-polymer backsheet', 'glass-glass'), 15 'multi-Si1: ('glass-polymer backsheet', 'glass-glass'), 16 '(dfe': ('glass-polymer backsheet', 'glass-glass'), 17 'perovskite': ('glass-glass',), 18 } 19 system_types = { 19 system_types = { 10 'mono-Si1: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 11 'multi-Si1: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 12 'fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 12 'fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 13 'fort: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale'), 14 'perovskite': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 14 'fort: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 15 } 16 'fort: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 17 'fort: ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 18 '% Preset values for module parameters: costs are in USD per square meter</pre>	12	
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<pre>24 'perovskite': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 24 25 26 27 26 27 27 27 27 27 28 #% Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage 29 module_details = { 20 'cost_front_layer': 4.06, 21 'cost_cell': ('mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30), 21 'cost_cell': ('mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30), 22 'cost_back_layer': {'glass-polymer backsheet': 2.32, 'glass-glass': 3}, 23 'cost_back_layer': {'glass-polymer backsheet': 2.32, 'glass-glass': 3, 'polymer-polymer': 2.32, 24 'perovskite': ('fixed tilt, utility scale', 'single-axis tracked, utility scale', 'roof-mounted, residential scale') 25 } 26 27 28 #% Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage 29 module_details = { 20 'cost_cell': {'mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30}, 21 'cost_cell': {'mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30}, 22 'efficiency': {'mono-5i': 19.0, 'multi-5i': 17.0, 'CdTe': 16.0}, 23 'efficiency': {'mono-5i': 19.0, 'multi-5i': 17.0, 'CdTe': 16.0}, 24 'perovskite': 16.0} 25 } 26 27 27 28 #% Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage 29 module_details = { 20 'cost_cell': {'mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30, 'perovskite': 20}, 31 'cost_cell': {'mono-5i': 34.4, 'multi-5i': 31.45, 'CdTe': 30, 'perovskite': 20}, 32 'cost_back_layer': {'glass-polymer backsheet': 2.32, 'glass-glass': 3, 'polymer-polymer': 2.32, 'glass-glass': 3, 'polymer-polymer': 2.32, 'glass-glass': 3, 'polymer-polymer': 2.32, 'glass-glass': 16.0}, 'perovskite': 16.0}, 32 'efficiency': {'mono-5i': 19.0, 'multi-5i': 17.0, 'CdTe': 16.0}, 34 'efficiency': {'mono-5i': 19.0, 'multi-5i</pre>	21 'multi-Si': ('fixed tilt, utility scale', 'single-axis tracked, utility scale'),	
<pre>25 } 25 26 # % Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage 27 28 # % Preset values for module parameters: costs are in USD per square meter, efficiency reported as a percentage 28 29 20 20 20 20 20 20 20 20 21 22 25 26 26 27 28 28 29 26 27 28 29 26 27 28 29 26 29 20 20 20 20 20 20 20 20 20 20 20 20 20</pre>	22 'CdTe': ('fixed tilt, utility scale', 'single-axis tracked, utility scale')	
<pre>26 27 28 29 29 29 29 29 29 29 20 20 20 20 20 20 20 20 20 20 20 20 20</pre>	23 }	
<pre>25 26 27 27 28 26 27 28 29 26 27 28 29 20 20 20 20 20 20 20 20 20 20 20 20 20</pre>	24	
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	33 }	35 }

And append Energy-yield_deg-rates.xlsx

601 CdTe	glass-glass	single-axis tra	USA AK Anchorage Intl Ap (TMY3)	1.22E+08	1220	0.4
602 perovskite	glass-glass	single-axis tra	ked, utility scale			
603 perovskite	glass-glass	fixed tilt, utilit	USA CO Denver Intl Ap (TMY3)			
604 perovskite	glass-glass	roof-mounted,	USA CO Denver Intl Ap (TMY3)			
605 perovskite	polymer-polym	n single-axis tra	USA CO Denver Intl Ap (TMY3)			
606 perovskite	polymer-polym	fixed tilt, utilit	USA CO Denver Intl Ap (TMY3)			
607 perovskite	polymer-polym	n roof-mounted,	USA CO Denver Intl Ap (TMY3)			
608			_			









Future Updates to the Calculator

- Complete update of cost and efficiency data (still 2018 data) once NREL's 2020 PV System Benchmark is out
- Improve "value of efficiency" handling
- Potentially, statistically significant degradation rate updates from PV Fleets data, based on:
 - Climate zones
 - Racking types

INREL







Thank You

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