A Forecasting Model for Rooftop Solar Adoption at the State Level

By Maria McCoy and John Farrell

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ILSR INSTITUTE FOR Local Self-Reliance

About the Institute for Local Self-Reliance

The Institute for Local Self-Reliance (ILSR) is a national nonprofit research and educational organization founded in 1974. ILSR has a vision of thriving, diverse, equitable communities. To reach this vision, we build local power to fight corporate control. We believe that democracy can only thrive when economic and political power is widely dispersed. Whether it's fighting back against the outsize power of monopolies like Amazon or advocating to keep local renewable energy in the community that produced it, ILSR advocates for solutions that harness the power of citizens and communities. More at **www.ILSR.org**.

About the Authors

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The authors would like to thank Eric Williams and Eric Hittinger for their generous consultation as we adopted their model. Thanks to Clovis Curl for her diligent work reproducing the Williams et al. model for all 50 states. We also thank our partners at the Sierra Club and Vote Solar for their collaboration in putting ILSR's rooftop solar adoption model to use in Minnesota. Thanks to Katie Kienbaum for her thorough review. All mistakes are our own.

Related Work from ILSR's Energy Democracy Initiative:

- **Why Utilities in Minnesota and Other States Need to Plan for More Competition** (2020)
- The Institute for Local Self-Reliance and Vote Solar's **comments to the Minnesota Public Utilities Commission** on modeling software costs and utility integrated resource plans (2021)

Take a deeper dive into the benefits of distributd solar energy:

- **The National Impact of 30 Million Solar Homes** (2021)
- **The State(s) of Distributed Solar** (updated annually)
- **Visualizing California's Booming Solar Market** (2018)
- **Is Bigger Best in Renewable Energy?** (2016)

Cover illustration by Maria McCoy

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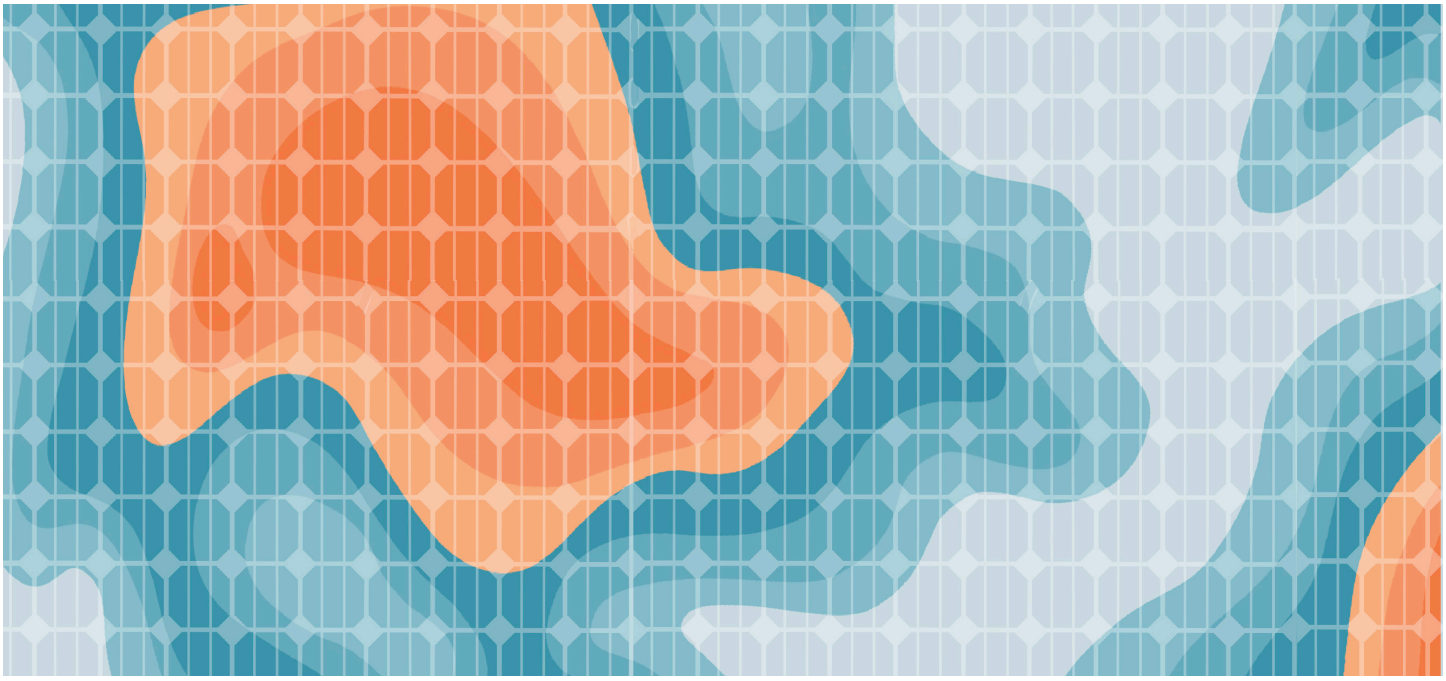

Introduction

Many U.S. states require that electric utilities file integrated resource plans: forecasts of customer demand and how the utility plans to meet it. Even if the state has no formal process, utilities need to plan for the future. Rooftop solar systems can serve as a cost-effective and reliable resource for the electricity grid, but too often, utilities overlook the potential value of distributed solar in favor of centralized, utility-owned power plants.

As a counter to utilities' dismissal of rooftop solar, ILSR is releasing this white paper and an accompanying model that predicts customer rooftop solar adoption. Specifically, ILSR's rooftop solar adoption model forecasts how many residential customers are likely to install solar in all 50 states over the next 30 years. ILSR's model also evaluates how utility incentives could impact each state's rooftop solar adoption rate. ILSR hopes that clean energy advocates will use this model as a tool to influence the utility resource planning process and to pressure utilities to consider rooftop solar as an energy resource.

To create this forecasting tool, ILSR adapted **a solar adoption model** created by Eric Williams, Rexon Carvalho, Eric Hittinger, and Matthew Ronnenberg. Their model approximates the portion of homeowners who will install rooftop solar based on its net present value, which is the value of a solar system to an individual. The Williams et al. model can predict distributed solar adoption in a specific market using localized inputs, including solar system output, eligible occupied housing units, and the solar electricity compensation rate.

ILSR's rooftop solar adoption model forecasts state-level rooftop solar adoption, but advocates can also apply it to individual utility service territories by approximating the number of detached homes within that service territory.

Why Model Rooftop Solar Adoption in Utility Planning?

In doing resource planning, utilities have ignored the ever-growing fleet of customer-owned rooftop solar within their service territories. Utility ignorance of customer-owned generation is rarely accidental or innocent. Investor-owned utilities, in particular, resist deploying distributed generation as a resource because they do not own it. Investor-owned utilities have a fiduciary duty to their shareholders to secure the most financial return — which they typically earn from investing in new grid infrastructure or power plants. The more money these utilities spend, the more return for their shareholders. Customer-owned solar does not fit the utility's financial formula.

However, because state governments have granted utilities their monopolies, these utilities must justify to state regulators how their spending best serves the customers — or how utility spending helps the utility provide affordable, reliable electricity. Though utilities would not propose it as a solution, at times, coordinating or incentivizing customer-owned solar adoption may be more cost effective than upgrading grid infrastructure or constructing new power plants. In fact, **modeling by Vibrant Clean Energy** found that increased distributed energy resource buildout reduced costs across the electricity system in both business-as-usual and clean electricity scenarios.

What will force utilities to consider distributed generation as a resource? Utilities hold the power in their resource planning processes through access to experts, paid professionals, and expensive modeling software. Here, ILSR offers a tool for clean energy advocates who want to challenge that power: a simple but effective model for state-level rooftop solar adoption.

Though the model is simple, ILSR has used it to help change the course of integrated resource planning for two Minnesota utilities.

A Forecasting Model for Rooftop Solar Adoption at the State Level

What is assumed?

The model assumes that homeowners decide to install solar based on its financial value to them (the payback period and eventual return on their investment). The model also assumes that the cost of installing solar will continue to decrease over time and that electricity rates will increase over time.

What can I change?

The constants and state-specific inputs are automatically placed in each state model worksheet. The user can add a utility incentive – see the section on "Applying the Rooftop Solar Adoption Model Results to Utility Resource Planning."

What will the model tell me?

The model forecasts how many residential customers are likely to install solar in a state over the next 30 years. ILSR's model also evaluates how utility incentives could impact the residential rooftop solar adoption rate.

Reading ILSR's Rooftop Solar Adoption Model

ILSR has adapted the model developed by Willams, et al., into an Excel workbook, with worksheets for each of the 50 states.

The Excel workbook includes the following worksheets:

"Data"	This worksheet contains the state-specific inputs, including residential electricity price, annual production of the solar system, and total eligible housing units. The inputs are automatically populated in the individual state spreadsheets. Users do not need to edit or view this worksheet unless adjusting the model.
"Summary"	This worksheet shows the final state-by-state model results, listing the forecasted total rooftop solar adoption figures for each state and year.
State Models	These worksheets apply the rooftop solar adoption model to each of the 50 states, using state-specific inputs. There is one worksheet per state.
"Adoption by Price TEMPLATE"	This worksheet calculates the effect of different incentive levels on rooftop solar adoption. For more information on using this worksheet, go to "Applying the Rooftop Solar Adoption Model Results to Utility Resource Planning."
"Solar Cost Decline"	This worksheet projects the declining cost of solar, which is a model input. Users do not need to edit or view this worksheet unless adjusting the model.

Screen captures of the state model sections and a description of their contents are below. For a more detailed explanation of how to read the model, attend or watch a recording of ILSR's forthcoming webinar.

State Worksheets

Basic NPV Calculation, Williams et al. Model (and State Variables)

On each state worksheet, the first 28 rows contain state-specific inputs from the "Data" worksheet, constants, and the base net present value (NPV) equation from the paper by Williams et al.

	A	B	C	D	E	F	G	H
1	**Basic NPV Calculation, Williams et. al. Model**					https://doi.org/10.1016/j.renene.2019.12.101		
2	System size (kW)	6.5						
3	Cost per Watt	$2.50						
4	Capital cost	$16,281						
5	Subsidy (ITC)	$4,884.19	26%	ITC= 30% for 2022, drops to 26% in 2033, drops to 22% in 203				
6	Annual production	6101.55						
7	Self consumption	77%						
8	Retail price	0.226						
9	Inflation	2%						
10	Interest rate	5%						
11	FIT price	0.05847849						
12	Solar life	25.00						
13	FIT term	25.00						
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

$$NPV\ (\$) = (\ -C_{total} + S) + \sum_{i=1}^{N} \frac{TE \times SC \times RP \times\ (1+\text{inf})^{i}}{(1+int)^{i}} + \sum_{i=1}^{M} \frac{TE \times (1-SC) \times FIT\ Price}{(1+int)^{i}} \quad (1)$$

Where:

C_{total} : capital cost of the PV system ($)
S: capital cost subsidy ($)
TE: total electricity produced by the PV produced in one year (kWh)
SC: self-consumption share (%)
RP: retail price of electricity ($/kWh)
inf: inflation rate (%)
int: lending rate (%)
$FIT\ Price$: fixed feed-in-tariff price ($/kWh)
i: year
N: lifetime of solar system (years)
M: term length of FIT Price (years)

The "eligible occupied detached housing units" variable is in cell F62.

	A	B	C	D	E	F	G	H
60				Total Occupied Detached H		159,112.1	(U.S. Census Data)	
61				Est. solar homes		1,427.0		
62	**Adoption Model by Year**			Eligible Occupied Detache		157,685.1		

Adoption Model by NPV

Rows 29-59 contain the solar adoption model as designed by Williams et al. The values in C37-C59 represent the annual adoption rate (in megawatts per million households) at the net present values listed in cells B37-B59. The annual adoption rate values fall on the "diffusion of technology" curve (see Methods Behind the Model section). This portion of the worksheet is the same for each state.

	A	B	C	D
29	**Adoption Model by NPV (Williams et. al.)**			
30				
31	K	3250	1/2 maximum annual adoption. The formula is (1 million homes * .5 * array size in kW / 1000)	
32	m	9952.25		
33	o	5361.59		
34				
35				
36		NPV per kW	Annual adoption (MW/million)	
37		-$1,000.00	13	
38		-$500.00	19	
39		$0.00	28	
40		$500.00	41	
41		$1,000.00	59	
42		$1,500.00	84	
43		$2,000.00	117	
44		$2,500.00	160	
45		$3,000.00	217	
46		$3,500.00	289	
47		$4,000.00	378	
48		$4,500.00	489	
49		$5,000.00	622	
50		$5,500.00	781	
51		$6,000.00	966	
52		$6,500.00	1178	
53		$7,000.00	1417	
54		$7,500.00	1683	
55		$8,000.00	1971	
56		$8,500.00	2280	
57		$9,000.00	2605	
58		$9,500.00	2941	
59		$10,000.00	3283	

$$\text{Annual adoption}\left(\frac{MW}{\text{million houses}}\right)(NPV) = \alpha \int_{-\infty}^{NPV} dx\, e^{-\left(\frac{x-\mu}{\sigma}\right)^2}$$

$$= K\left(1 + \operatorname{erf}\left(\frac{NPV - \mu}{\sigma}\right)\right) \qquad (4)$$

$$\operatorname{erf} x = \frac{1}{\sqrt{\pi}} \int_{-x}^{x} e^{-t^2}\, dt$$

$$= \frac{2}{\sqrt{\pi}} \int_{0}^{x} e^{-t^2}\, dt.$$

Adoption Model by Year

Rows 62-154 contain the solar adoption model by year, based on state-specific inputs.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1																					
63	Annual solar cost	5%																									
64	ITC decrease	actual (see table)																									
65	Inflation	2%						**NPV Table**																			
66	Solar output degr	0.50%																									
67								Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68								ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69								Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70								FiT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71								FiT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72								Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73								Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74								**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	**Year**	**NPV per kW**	**Annual adoption (MW/mil.)**	**Adoption (MW-DC)**	**Adoption (MW-AC)**	**Solar homes**	**Total Adoption (MW-AC)**	**year**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
76	2022	$1,260.97	71	11	9	1725	9	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2023	$1,408.92	79	12	10	1889	20	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	2024	$1,553.69	87	13	11	2060	31	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	2025	$1,695.53	96	15	12	2236	43	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	2026	$1,834.67	105	16	13	2416	56	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	2027	$1,971.32	115	17	14	2600	70	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	2028	$2,105.72	125	18	15	2785	85	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	2029	$2,238.05	136	19	16	2973	101	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	2030	$2,368.52	148	21	17	3160	118	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	2031	$2,497.31	160	22	18	3345	136	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	2032	$2,624.61	173	23	19	3528	156	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	2033	$2,693.60	181	23	19	3582	175	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	2034	$2,767.13	189	24	20	3640	195	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	2035	$2,613.50	172	21	17	3220	212	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	2036	$2,755.77	187	22	19	3418	**231**	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	2037	$2,896.39	204	23	20	3610	250	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	2038	$3,035.55	221	25	21	3796	271	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	2039	$3,173.43	240	26	22	3973	292	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	2040	$3,310.21	259	27	22	4138	315	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	2041	$3,446.05	280	28	23	4289	**338**	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	2042	$3,581.14	302	29	24	4425	362	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	2043	$3,715.61	325	30	25	4542	386	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	2044	$3,849.64	349	30	25	4639	412	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	2045	$3,983.35	375	31	26	4714	437	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	2046	$4,116.91	402	31	26	4764	463	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101	2047	$4,250.44	431	31	26	4788	489																				
102	2048	$4,384.08	461	31	26	4785	515	**FiT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	2049	$4,517.97	493	31	26	4753	541	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2050	$4,652.22	527	31	25	4693	566	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	2051	$4,786.96	562	30	25	4603	591	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	2052	$4,922.32	600	29	24	4485	615	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107		**Total Adopti**	**8055**	**738**	**615**			5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

Cells I76:AM127 calculate the compensation that solar adopters receive for the energy they produce.

The first place to look here is I76:AM100, shown below. Each of the cells estimate one year of the rooftop solar installation's value through "self-consumption," or the amount of generated electricity the customer would use or value at the retail electricity rate. For states with full retail net metering, self-consumption is 100 percent, even if the customer does not use all of the electricity they generate. This is because all of the generated electricity has a value of the retail electricity rate, whether the customer uses it themselves or sells it to the grid.

The columns indicate which year the customer initially installed the solar panels (year in row 75). The rows are the nth year of operating the solar system, with the system having a maximum life of 25 years.

The rooftop solar installation's value decreases year over year because of present discounted value and solar output degradation.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1																					
63	Annual solar cost	5%																									
64	ITC decrease	actual (see table)																									
65	Inflation	2%						**NPV Table**																			
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67								Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68								ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69								Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70								FiT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71								FiT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72								Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73								Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74								**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	Year	NPV per kW	Annual adoption (MW/mil.)	Adoption (MW-DC)	Adoption (MW-AC)	Solar homes	Total Adoption (MW-AC)	year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
76	2022	$1,260.97	71	11	9	1725	9	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2023	$1,408.92	79	12	10	1889	20	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	2024	$1,553.69	87	13	11	2060	31	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	2025	$1,695.53	96	15	12	2236	43	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	2026	$1,834.67	105	16	13	2416	56	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	2027	$1,971.32	115	17	14	2600	70	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	2028	$2,105.72	125	18	15	2785	85	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	2029	$2,238.05	136	19	16	2973	101	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	2030	$2,368.52	148	21	17	3160	118	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	2031	$2,497.31	160	22	18	3345	136	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	2032	$2,624.61	173	23	19	3528	156	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	2033	$2,693.60	181	23	19	3582	175	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	2034	$2,767.13	189	24	20	3640	195	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	2035	$2,613.50	172	21	17	3220	212	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	2036	$2,755.77	187	22	19	3418	**231**	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	2037	$2,896.39	204	23	20	3610	250	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	2038	$3,035.55	221	25	21	3796	271	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	2039	$3,173.43	240	26	22	3973	292	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	2040	$3,310.21	259	27	22	4138	315	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	2041	$3,446.05	280	28	23	4289	**338**	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	2042	$3,581.14	302	29	24	4425	362	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	2043	$3,715.61	325	30	25	4542	386	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	2044	$3,849.64	349	30	25	4639	412	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	2045	$3,983.35	375	31	26	4714	437	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	2046	$4,116.91	402	31	26	4764	463	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101	2047	$4,250.44	431	31	26	4788	489																				
102	2048	$4,384.08	461	31	26	4785	515	**FiT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	2049	$4,517.97	493	31	26	4753	541	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2050	$4,652.22	527	31	25	4693	566	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	2051	$4,786.96	562	30	25	4603	591	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	2052	$4,922.32	600	29	24	4485	615	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107		**Total Adopti**	**8055**	**738**	**615**			5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

The values in cells I103:AM127, below, estimate additional compensation for the electricity not consumed by the individual (in states where compensation mechanisms other than full retail rate net metering are in effect). If a state does have full retail rate net metering compensation, the values are all zero. The cells show the separate value in a given year for any non-retail rate solar compensation, sometimes called a solar export rate or avoided cost rate.

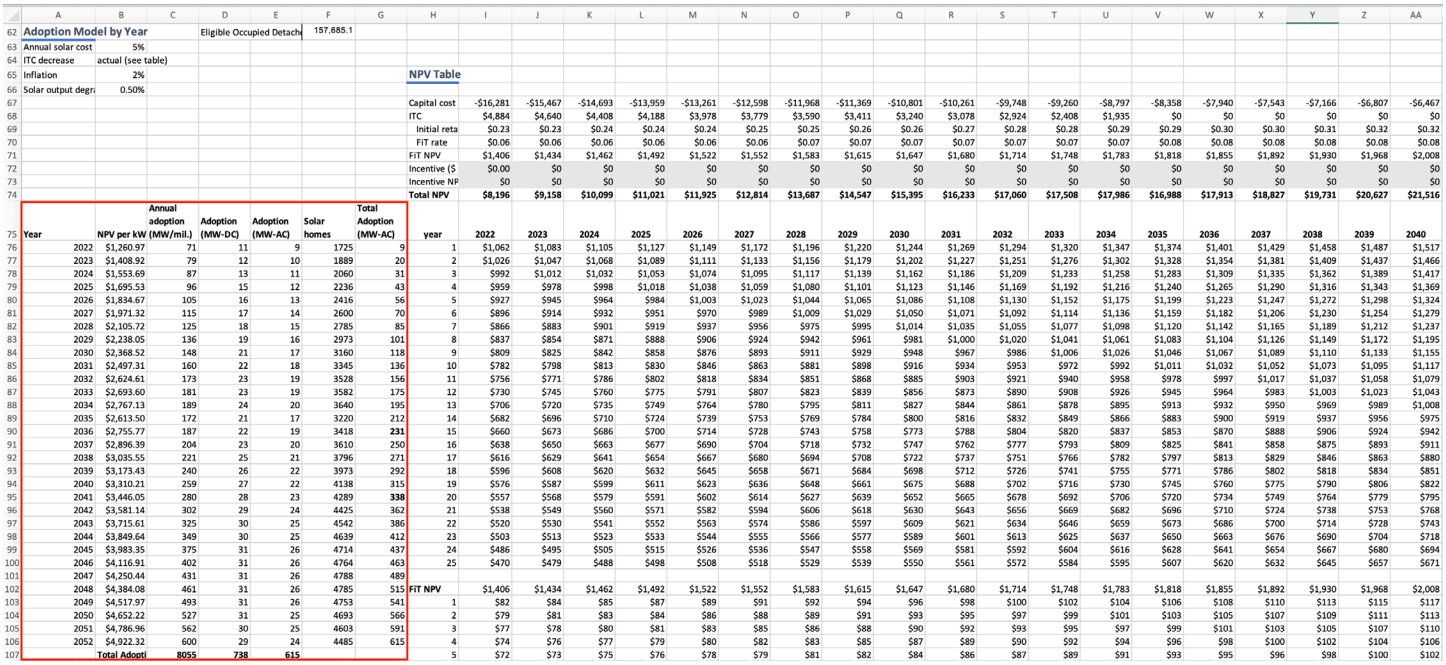
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
82	2028	$2,105.72	125	18	15	2785	85	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	2029	$2,238.05	136	19	16	2973	101	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	2030	$2,368.52	148	21	17	3160	118	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	2031	$2,497.31	160	22	18	3345	136	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	2032	$2,624.61	173	23	19	3528	156	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	2033	$2,693.60	181	23	19	3582	175	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	2034	$2,767.13	189	24	20	3640	195	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	2035	$2,613.50	172	21	17	3220	212	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	2036	$2,755.77	187	22	19	3418	**231**	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	2037	$2,896.39	204	23	20	3610	250	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	2038	$3,035.55	221	25	21	3796	271	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	2039	$3,173.43	240	26	22	3973	292	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	2040	$3,310.21	259	27	22	4138	315	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	2041	$3,446.05	280	28	23	4289	**338**	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	2042	$3,581.14	302	29	24	4425	362	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	2043	$3,715.61	325	30	25	4542	386	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	2044	$3,849.64	349	30	25	4639	412	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	2045	$3,983.35	375	31	26	4714	437	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	2046	$4,116.91	402	31	26	4764	463	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101	2047	$4,250.44	431	31	26	4788	489																				
102	2048	$4,384.08	461	31	26	4785	515	**FIT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	2049	$4,517.97	493	31	26	4753	541	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2050	$4,652.22	527	31	25	4693	566	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	2051	$4,786.96	562	30	25	4603	591	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	2052	$4,922.32	600	29	24	4485	615	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107		**Total Adopti**	**8055**	**738**	**615**			5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102
108								6	$69	$71	$72	$73	$75	$76	$78	$80	$81	$83	$84	$86	$88	$90	$91	$93	$95	$97	$99
109								7	$67	$68	$70	$71	$72	$74	$75	$77	$78	$80	$82	$83	$85	$87	$88	$90	$92	$94	$96
110								8	$65	$66	$67	$69	$70	$71	$73	$74	$76	$77	$79	$80	$82	$84	$85	$87	$89	$91	$92
111								9	$63	$64	$65	$66	$68	$69	$70	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$88	$89
112								10	$60	$62	$63	$64	$65	$67	$68	$69	$71	$72	$74	$75	$77	$78	$80	$81	$83	$85	$86
113								11	$58	$60	$61	$62	$63	$64	$66	$67	$68	$70	$71	$73	$74	$76	$77	$79	$80	$82	$83
114								12	$56	$58	$59	$60	$61	$62	$64	$65	$66	$67	$69	$70	$72	$73	$74	$76	$78	$79	$81
115								13	$55	$56	$57	$58	$59	$60	$61	$63	$64	$65	$67	$68	$69	$71	$72	$73	$75	$76	$78
116								14	$53	$54	$55	$56	$57	$58	$59	$61	$62	$63	$64	$66	$67	$68	$70	$71	$72	$74	$75
117								15	$51	$52	$53	$54	$55	$56	$57	$59	$60	$61	$62	$63	$65	$66	$67	$69	$70	$71	$73
118								16	$49	$50	$51	$52	$53	$54	$55	$57	$58	$59	$60	$61	$62	$64	$65	$66	$68	$69	$70
119								17	$48	$49	$50	$51	$52	$53	$54	$55	$56	$57	$58	$59	$60	$62	$63	$64	$65	$67	$68
120								18	$46	$47	$48	$49	$50	$51	$52	$53	$54	$55	$56	$57	$58	$60	$61	$62	$63	$64	$66
121								19	$45	$45	$46	$47	$48	$49	$50	$51	$52	$53	$54	$55	$56	$58	$59	$60	$61	$62	$64
122								20	$43	$44	$45	$46	$47	$47	$48	$49	$50	$51	$52	$53	$55	$56	$57	$58	$59	$60	$61
123								21	$42	$42	$43	$44	$45	$46	$47	$48	$49	$50	$51	$52	$53	$54	$55	$56	$57	$58	$59
124								22	$40	$41	$42	$43	$43	$44	$45	$46	$47	$48	$49	$50	$51	$52	$53	$54	$55	$56	$57
125								23	$39	$40	$40	$41	$42	$43	$44	$45	$46	$46	$47	$48	$49	$50	$51	$52	$53	$54	$55
126								24	$38	$38	$39	$40	$41	$41	$42	$43	$44	$45	$46	$47	$48	$49	$50	$51	$52	$53	$54
127								25	$36	$37	$38	$39	$39	$40	$41	$42	$43	$43	$44	$45	$46	$47	$48	$49	$50	$51	$52
128																											
129								**Incentive NF**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
130								1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
131								2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
132								3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

The data below row 128 (filled in gray) is the value in a given year for an additional incentive, such as a rebate or per kilowatt-hour payment. By default, this is set to zero. More on this portion in the "Applying the Model Results to Utility Resource Planning" section.

Next, the NPV table in rows 65-74 uses the yearly solar electricity compensation values, described above, to calculate the net present value of a solar system installed in a given year. To find the net present value, the compensation values from individual years in the rows below are summed, the initial capital cost is subtracted (row 67), and the investment tax credit is added (row 68). The values in row 74 are the net present value to a customer for installing solar in that respective year (row 75), shown below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1																					
63	Annual solar cost	5%																									
64	ITC decrease	actual (see table)																									
65	Inflation	2%							**NPV Table**																		
66	Solar output degr	0.50%																									
67									Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68									ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69									Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70									FIT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71									FIT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72									Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73									Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74									**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	**Year**	**NPV per kW**	**Annual adoption (MW/mil.)**	**Adoption (MW-DC)**	**Adoption (MW-AC)**	**Solar homes**	**Total Adoption (MW-AC)**	**year**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
76	2022	$1,260.97	71	11	9	1725	9	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2023	$1,408.92	79	12	10	1889	20	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	2024	$1,553.69	87	13	11	2060	31	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	2025	$1,695.53	96	15	12	2236	43	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	2026	$1,834.67	105	16	13	2416	56	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	2027	$1,971.32	115	17	14	2600	70	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	2028	$2,105.72	125	18	15	2785	85	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	2029	$2,238.05	136	19	16	2973	101	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	2030	$2,368.52	148	21	17	3160	118	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	2031	$2,497.31	160	22	18	3345	136	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	2032	$2,624.61	173	23	19	3528	156	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	2033	$2,693.60	181	23	19	3582	175	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	2034	$2,767.13	189	24	20	3640	195	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	2035	$2,613.50	172	21	17	3220	212	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	2036	$2,755.77	187	22	19	3418	**231**	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	2037	$2,896.39	204	23	20	3610	250	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	2038	$3,035.55	221	25	21	3796	271	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	2039	$3,173.43	240	26	22	3973	292	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	2040	$3,310.21	259	27	22	4138	315	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	2041	$3,446.05	280	28	23	4289	**338**	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	2042	$3,581.14	302	29	24	4425	362	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	2043	$3,715.61	325	30	25	4542	386	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	2044	$3,849.64	349	30	25	4639	412	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	2045	$3,983.35	375	31	26	4714	437	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	2046	$4,116.91	402	31	26	4764	463	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101	2047	$4,250.44	431	31	26	4788	489																				
102	2048	$4,384.08	461	31	26	4785	515	**FIT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	2049	$4,517.97	493	31	26	4753	541	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2050	$4,652.22	527	31	25	4693	566	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	2051	$4,786.96	562	30	25	4603	591	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	2052	$4,922.32	600	29	24	4485	615	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107		**Total Adopti**	**8055**	**738**	**615**			5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

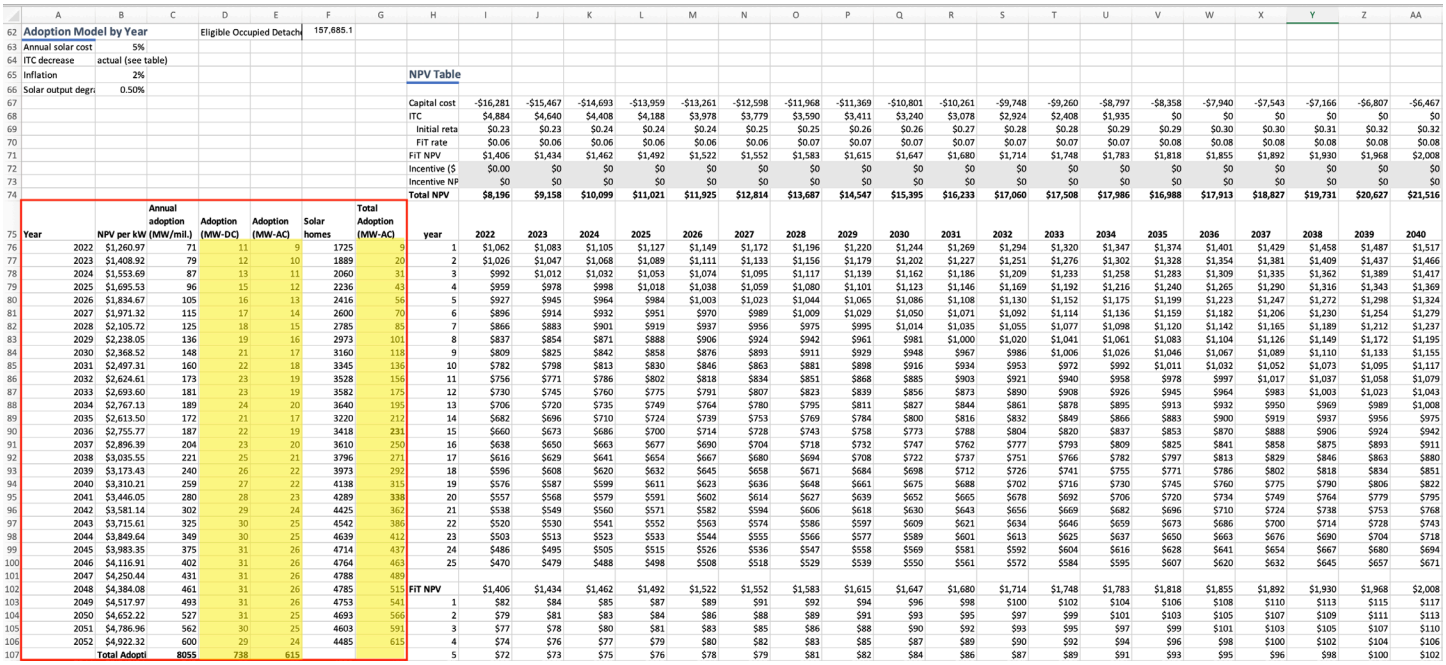
Finally, cells A75:G107 calculate the forecasted state rooftop solar adoption over the next 30 years. The net present values from the NPV table are fed through the adoption curve into annual adoption (megawatts per million households) in cells C76:C106. This value, a proportion, is then used to calculate the total adoption in that state (megawatts AC) in cells E76:E106.



	A	B	C	D	E	F	G
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1	
63	Annual solar cost	5%					
64	ITC decrease	actual (see table)					
65	Inflation	2%					
66	Solar output degr	0.50%					
67							
68							
69							
70							
71							
72							
73							
74							
75	Year	NPV per kW	Annual adoption (MW/mil.)	Adoption (MW-DC)	Adoption (MW-AC)	Solar homes	Total Adoption (MW-AC)
76	2022	$1,260.97	71	11	9	1725	9
77	2023	$1,408.92	79	12	10	1889	20
78	2024	$1,553.69	87	13	11	2060	31
79	2025	$1,695.53	96	15	12	2236	43
80	2026	$1,834.67	105	16	13	2416	56
81	2027	$1,971.32	115	17	14	2600	70
82	2028	$2,105.72	125	18	15	2785	85
83	2029	$2,238.05	136	19	16	2973	101
84	2030	$2,368.52	148	21	17	3160	118
85	2031	$2,497.31	160	22	18	3345	136
86	2032	$2,624.61	173	23	19	3528	156
87	2033	$2,693.60	181	23	19	3582	175
88	2034	$2,767.13	189	24	20	3640	195
89	2035	$2,613.50	172	21	17	3220	212
90	2036	$2,755.77	187	22	19	3418	**231**
91	2037	$2,896.39	204	23	20	3610	250
92	2038	$3,035.55	221	25	21	3796	271
93	2039	$3,173.43	240	26	22	3973	292
94	2040	$3,310.21	259	27	22	4138	315
95	2041	$3,446.05	280	28	23	4289	**338**
96	2042	$3,581.14	302	29	24	4425	362
97	2043	$3,715.61	325	30	25	4542	386
98	2044	$3,849.64	349	30	25	4639	412
99	2045	$3,983.35	375	31	26	4714	437
100	2046	$4,116.91	402	31	26	4764	463
101	2047	$4,250.44	431	31	26	4788	489
102	2048	$4,384.08	461	31	26	4785	515
103	2049	$4,517.97	493	31	26	4753	541
104	2050	$4,652.22	527	31	25	4693	566
105	2051	$4,786.96	562	30	25	4603	591
106	2052	$4,922.32	600	29	24	4485	615
107		Total Adopti	8055	738	615		

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
	NPV Table																			
67	Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68	ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69	Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70	FiT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71	FiT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72	Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73	Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74	**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
76	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101																				
102	**FiT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107	5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

Cells G76:G106 contain the cumulative residential solar adoption (megawatts AC) forecasted in the corresponding year (column A). **THESE ARE THE STATE MODEL RESULTS!** The "Summary" worksheet lists these values for each state.



	A	B	C	D	E	F	G
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1	
63	Annual solar cost	5%					
64	ITC decrease	actual (see table)					
65	Inflation	2%					
66	Solar output degr	0.50%					
67							
68							
69							
70							
71							
72							
73							
74							
75	Year	NPV per kW	Annual adoption (MW/mil.)	Adoption (MW-DC)	Adoption (MW-AC)	Solar homes	Total Adoption (MW-AC)
76	2022	$1,260.97	71	11	9	1725	9
77	2023	$1,408.92	79	12	10	1889	20
78	2024	$1,553.69	87	13	11	2060	31
79	2025	$1,695.53	96	15	12	2236	43
80	2026	$1,834.67	105	16	13	2416	56
81	2027	$1,971.32	115	17	14	2600	70
82	2028	$2,105.72	125	18	15	2785	85
83	2029	$2,238.05	136	19	16	2973	101
84	2030	$2,368.52	148	21	17	3160	118
85	2031	$2,497.31	160	22	18	3345	136
86	2032	$2,624.61	173	23	19	3528	156
87	2033	$2,693.60	181	23	19	3582	175
88	2034	$2,767.13	189	24	20	3640	195
89	2035	$2,613.50	172	21	17	3220	212
90	2036	$2,755.77	187	22	19	3418	231
91	2037	$2,896.39	204	23	20	3610	250
92	2038	$3,035.55	221	25	21	3796	271
93	2039	$3,173.43	240	26	22	3973	292
94	2040	$3,310.21	259	27	22	4138	315
95	2041	$3,446.05	280	28	23	4289	338
96	2042	$3,581.14	302	29	24	4425	362
97	2043	$3,715.61	325	30	25	4542	386
98	2044	$3,849.64	349	30	25	4639	412
99	2045	$3,983.35	375	31	26	4714	437
100	2046	$4,116.91	402	31	26	4764	463
101	2047	$4,250.44	431	31	26	4788	489
102	2048	$4,384.08	461	31	26	4785	515
103	2049	$4,517.97	493	31	26	4753	541
104	2050	$4,652.22	527	31	25	4693	566
105	2051	$4,786.96	562	30	25	4603	591
106	2052	$4,922.32	600	29	24	4485	615
107		Total Adopti	8055	738	615		

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
	NPV Table																			
67	Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68	ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69	Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70	FiT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71	FiT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72	Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73	Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74	**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
76	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101																				
102	**FiT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107	5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

With this spreadsheet alone, users have a model-tested forecast for residential distributed solar adoption based on a continuation of existing compensation policies (e.g. net metering) and the assumptions chosen.

Estimating Non-Residential Solar Adoption

In two applications of the rooftop solar adoption model, ILSR also used national data on the ratio of residential distributed solar adoption to non-residential distributed solar adoption to infer total distributed solar adoption over time (using a ratio of 1.00:0.71 for residential to non-residential solar, based on national adoption rates in 2019, as reported by the Solar Energy Industries Association). This is useful for a ballpark estimate, but the estimate for non-residential solar does not have a basis in the model design itself. This ratio is also very fluid, and **was as low as 1.00:0.34 in 2021**.

Applying the Rooftop Solar Adoption Model Results to Utility Resource Planning

ILSR's state models forecast how many customers will adopt rooftop solar – without action or expense on a utility's part. However, clean energy advocates can adapt the model, as explained below, to calculate how incentives increase rooftop solar adoption, making it possible to compare a utility's cost of incentivizing additional rooftop solar capacity versus the cost of purchasing other energy resources, such as a power plant. In Minnesota, ILSR and our partners Vote Solar and the Sierra Club used this approach to promote rooftop solar as a cost-effective option in the resource planning process for Xcel Energy and Minnesota Power.

In their resource planning, utilities often use "capacity expansion" software such as Encompass to model what new electric generation resources to purchase in the coming years. Technicians feed the software a range of assumptions — particularly the cost of new energy resources — with the intent of providing the most cost-effective and reliable menu of electricity generation. It is important to note that utilities can and do select inputs and assumptions that align with their financial interests. Utilities typically ignore distributed solar, despite several elements in its favor:

- It requires zero capital investment
- It has zero marginal cost because it's treated as demand reduction, like energy efficiency
- It tends to be located near demand, reducing the likelihood of system upgrades in order to deliver its electricity production to consumers

The basic premise of these resource planning models is to identify how much of a resource can be purchased at a given price point — $10 per megawatt-hour (MWh), $20 per MWh, etc. — over the resource plan time horizon (e.g. 15 years). The ILSR rooftop solar adoption model, based on the Williams et al. model, can be used to predict the amount of distributed solar adopted at various price points. This allows utilities and advocates to include distributed solar as a resource option in capacity expansion modeling.

The default rooftop solar adoption model results, explained in "Reading the Model," already provide a key baseline: the amount of residential rooftop solar likely to be developed at $0 marginal cost to the utility (assuming no existing incentive). To determine how much distributed solar the utility could incentivize or "buy" at higher price points, we ran ILSR's model with different incentive inputs. Each incentive corresponds with a price point for the capacity expansion model. For example, a 1 cent per kilowatt-hour production incentive for rooftop solar generators corresponds to a price point of $10 per MWh for the capacity expansion model.

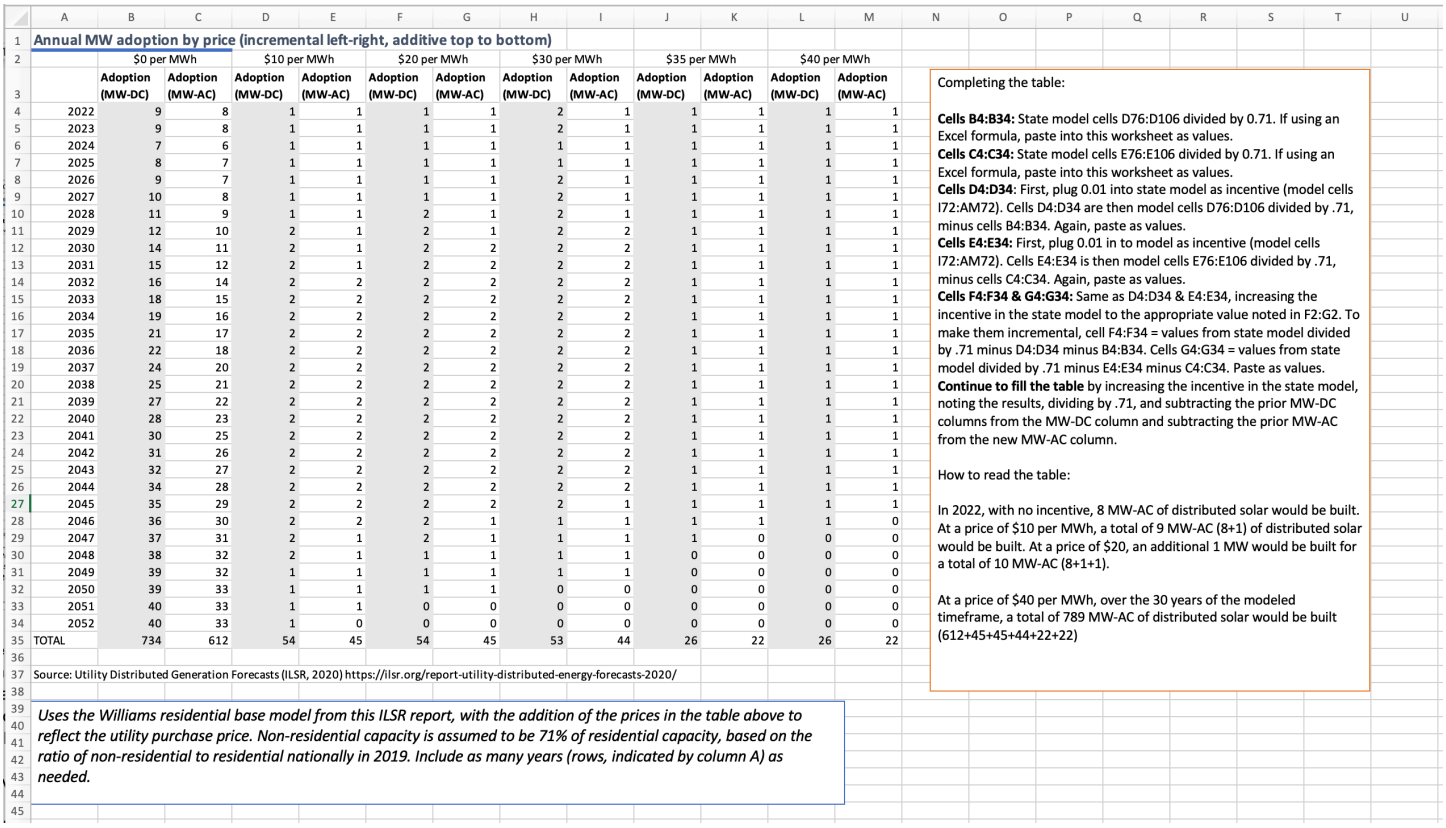
Below, we show how to add the incentive into the state model worksheets and how to then tabulate the results in the "Adoption by Price TEMPLATE" worksheet.

To predict the results of various per-kilowatt incentives, plug the incentive into row 72 in the NPV table in the relevant state model worksheet. ILSR used incentives of $0.01, $0.02, $0.03, $0.035, and $0.04 per kilowatt-hour, corresponding with purchase prices for the utility resource expansion model of $10, $20, $30, $35, and $40 per megawatt-hour.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
62	**Adoption Model by Year**			Eligible Occupied Detach		157,685.1																					
63	Annual solar cost	5%																									
64	ITC decrease	actual (see table)																									
65	Inflation	2%						**NPV Table**																			
66	Solar output degr	0.50%																									
67								Capital cost	-$16,281	-$15,467	-$14,693	-$13,959	-$13,261	-$12,598	-$11,968	-$11,369	-$10,801	-$10,261	-$9,748	-$9,260	-$8,797	-$8,358	-$7,940	-$7,543	-$7,166	-$6,807	-$6,467
68								ITC	$4,884	$4,640	$4,408	$4,188	$3,978	$3,779	$3,590	$3,411	$3,240	$3,078	$2,924	$2,408	$1,935	$0	$0	$0	$0	$0	$0
69								Initial reta	$0.23	$0.23	$0.24	$0.24	$0.24	$0.25	$0.25	$0.26	$0.26	$0.27	$0.28	$0.28	$0.29	$0.29	$0.30	$0.30	$0.31	$0.32	$0.32
70								FiT rate	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
71								FiT NPV	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
72								Incentive ($	$0.00	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
73								Incentive NP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
74								**Total NPV**	**$8,196**	**$9,158**	**$10,099**	**$11,021**	**$11,925**	**$12,814**	**$13,687**	**$14,547**	**$15,395**	**$16,233**	**$17,060**	**$17,508**	**$17,986**	**$16,988**	**$17,913**	**$18,827**	**$19,731**	**$20,627**	**$21,516**
75	Year	NPV per kW	Annual adoption (MW/mil.)	Adoption (MW-DC)	Adoption (MW-AC)	Solar homes	Total Adoption (MW-AC)	year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
76	2022	$1,260.97	71	11	9	1725	9	1	$1,062	$1,083	$1,105	$1,127	$1,149	$1,172	$1,196	$1,220	$1,244	$1,269	$1,294	$1,320	$1,347	$1,374	$1,401	$1,429	$1,458	$1,487	$1,517
77	2023	$1,408.92	79	12	10	1889	20	2	$1,026	$1,047	$1,068	$1,089	$1,111	$1,133	$1,156	$1,179	$1,202	$1,227	$1,251	$1,276	$1,302	$1,328	$1,354	$1,381	$1,409	$1,437	$1,466
78	2024	$1,553.69	87	13	11	2060	31	3	$992	$1,012	$1,032	$1,053	$1,074	$1,095	$1,117	$1,139	$1,162	$1,186	$1,209	$1,233	$1,258	$1,283	$1,309	$1,335	$1,362	$1,389	$1,417
79	2025	$1,695.53	96	15	12	2236	43	4	$959	$978	$998	$1,018	$1,038	$1,059	$1,080	$1,101	$1,123	$1,146	$1,169	$1,192	$1,216	$1,240	$1,265	$1,290	$1,316	$1,343	$1,369
80	2026	$1,834.67	105	16	13	2416	56	5	$927	$945	$964	$984	$1,003	$1,023	$1,044	$1,065	$1,086	$1,108	$1,130	$1,152	$1,175	$1,199	$1,223	$1,247	$1,272	$1,298	$1,324
81	2027	$1,971.32	115	17	14	2600	70	6	$896	$914	$932	$951	$970	$989	$1,009	$1,029	$1,050	$1,071	$1,092	$1,114	$1,136	$1,159	$1,182	$1,206	$1,230	$1,254	$1,279
82	2028	$2,105.72	125	18	15	2785	85	7	$866	$883	$901	$919	$937	$956	$975	$995	$1,014	$1,035	$1,055	$1,077	$1,098	$1,120	$1,142	$1,165	$1,189	$1,212	$1,237
83	2029	$2,238.05	136	19	16	2973	101	8	$837	$854	$871	$888	$906	$924	$942	$961	$981	$1,000	$1,020	$1,041	$1,061	$1,083	$1,104	$1,126	$1,149	$1,172	$1,195
84	2030	$2,368.52	148	21	17	3160	118	9	$809	$825	$842	$858	$876	$893	$911	$929	$948	$967	$986	$1,006	$1,026	$1,046	$1,067	$1,089	$1,110	$1,133	$1,155
85	2031	$2,497.31	160	22	18	3345	136	10	$782	$798	$813	$830	$846	$863	$881	$898	$916	$934	$953	$972	$992	$1,011	$1,032	$1,052	$1,073	$1,095	$1,117
86	2032	$2,624.61	173	23	19	3528	156	11	$756	$771	$786	$802	$818	$834	$851	$868	$885	$903	$921	$940	$958	$978	$997	$1,017	$1,037	$1,058	$1,079
87	2033	$2,693.60	181	23	19	3582	175	12	$730	$745	$760	$775	$791	$807	$823	$839	$856	$873	$890	$908	$926	$945	$964	$983	$1,003	$1,023	$1,043
88	2034	$2,767.13	189	24	20	3640	195	13	$706	$720	$735	$749	$764	$780	$795	$811	$827	$844	$861	$878	$895	$913	$932	$950	$969	$989	$1,008
89	2035	$2,613.50	172	21	17	3220	212	14	$682	$696	$710	$724	$739	$753	$769	$784	$800	$816	$832	$849	$866	$883	$900	$919	$937	$956	$975
90	2036	$2,755.77	187	22	19	3418	**231**	15	$660	$673	$686	$700	$714	$728	$743	$758	$773	$788	$804	$820	$837	$853	$870	$888	$906	$924	$942
91	2037	$2,896.39	204	23	20	3610	250	16	$638	$650	$663	$677	$690	$704	$718	$732	$747	$762	$777	$793	$809	$825	$841	$858	$875	$893	$911
92	2038	$3,035.55	221	25	21	3796	271	17	$616	$629	$641	$654	$667	$680	$694	$708	$722	$737	$751	$766	$782	$797	$813	$829	$846	$863	$880
93	2039	$3,173.43	240	26	22	3973	292	18	$596	$608	$620	$632	$645	$658	$671	$684	$698	$712	$726	$741	$755	$771	$786	$802	$818	$834	$851
94	2040	$3,310.21	259	27	22	4138	315	19	$576	$587	$599	$611	$623	$636	$648	$661	$675	$688	$702	$716	$730	$745	$760	$775	$790	$806	$822
95	2041	$3,446.05	280	28	23	4289	**338**	20	$557	$568	$579	$591	$602	$614	$627	$639	$652	$665	$678	$692	$706	$720	$734	$749	$764	$779	$795
96	2042	$3,581.14	302	29	24	4425	362	21	$538	$549	$560	$571	$582	$594	$606	$618	$630	$643	$656	$669	$682	$696	$710	$724	$738	$753	$768
97	2043	$3,715.61	325	30	25	4542	386	22	$520	$530	$541	$552	$563	$574	$586	$597	$609	$621	$634	$646	$659	$673	$686	$700	$714	$728	$743
98	2044	$3,849.64	349	30	25	4639	412	23	$503	$513	$523	$533	$544	$555	$566	$577	$589	$601	$613	$625	$637	$650	$663	$676	$690	$704	$718
99	2045	$3,983.35	375	31	26	4714	437	24	$486	$495	$505	$515	$526	$536	$547	$558	$569	$581	$592	$604	$616	$628	$641	$654	$667	$680	$694
100	2046	$4,116.91	402	31	26	4764	463	25	$470	$479	$488	$498	$508	$518	$529	$539	$550	$561	$572	$584	$595	$607	$620	$632	$645	$657	$671
101	2047	$4,250.44	431	31	26	4788	489																				
102	2048	$4,384.08	461	31	26	4785	515	**FIT NPV**	$1,406	$1,434	$1,462	$1,492	$1,522	$1,552	$1,583	$1,615	$1,647	$1,680	$1,714	$1,748	$1,783	$1,818	$1,855	$1,892	$1,930	$1,968	$2,008
103	2049	$4,517.97	493	31	26	4753	541	1	$82	$84	$85	$87	$89	$91	$92	$94	$96	$98	$100	$102	$104	$106	$108	$110	$113	$115	$117
104	2050	$4,652.22	527	31	25	4693	566	2	$79	$81	$83	$84	$86	$88	$89	$91	$93	$95	$97	$99	$101	$103	$105	$107	$109	$111	$113
105	2051	$4,786.96	562	30	25	4603	591	3	$77	$78	$80	$81	$83	$85	$86	$88	$90	$92	$93	$95	$97	$99	$101	$103	$105	$107	$110
106	2052	$4,922.32	600	29	24	4485	615	4	$74	$76	$77	$79	$80	$82	$83	$85	$87	$89	$90	$92	$94	$96	$98	$100	$102	$104	$106
107		Total Adopti	8055	738	615			5	$72	$73	$75	$76	$78	$79	$81	$82	$84	$86	$87	$89	$91	$93	$95	$96	$98	$100	$102

Then, record the state model results (cells C75:G107) under that incentive in the "Adoption by Price TEMPLATE" worksheet. For our purposes in previous applications (needing to forecast all distributed solar, not just residential), we assumed non-residential solar capacity to be 71 percent of residential solar capacity. Therefore, state model results recorded in the "Adoption by Price TEMPLATE" worksheet are all divided by 0.71. More instructions are in the "Adoption by Price TEMPLATE" worksheet and ILSR's webinar.

Note that the "Adoption by Price TEMPLATE" worksheet is pre-populated with column labels matching ILSR's chosen incentive levels, listed above — the user can change these values. The user can also use as many years (rows) as needed, likely the same number of years as are at stake in the utility's resource plan.



Annual MW adoption by price (incremental left-right, additive top to bottom)

	$0 per MWh		$10 per MWh		$20 per MWh		$30 per MWh		$35 per MWh		$40 per MWh	
	Adoption (MW-DC)	Adoption (MW-AC)	Adoption (MW-DC)	Adoption (MW-AC)	Adoption (MW-DC)	Adoption (MW-AC)	Adoption (MW-DC)	Adoption (MW-AC)	Adoption (MW-DC)	Adoption (MW-AC)	Adoption (MW-DC)	Adoption (MW-AC)
2022	9	8	1	1	1	1	2	1	1	1	1	1
2023	9	8	1	1	1	1	2	1	1	1	1	1
2024	7	6	1	1	1	1	1	1	1	1	1	1
2025	8	7	1	1	1	1	1	1	1	1	1	1
2026	9	7	1	1	1	1	2	1	1	1	1	1
2027	10	8	1	1	1	1	2	1	1	1	1	1
2028	11	9	1	1	2	1	2	1	1	1	1	1
2029	12	10	2	1	2	1	2	2	1	1	1	1
2030	14	11	2	1	2	2	2	2	1	1	1	1
2031	15	12	2	1	2	2	2	2	1	1	1	1
2032	16	14	2	2	2	2	2	2	1	1	1	1
2033	18	15	2	2	2	2	2	2	1	1	1	1
2034	19	16	2	2	2	2	2	2	1	1	1	1
2035	21	17	2	2	2	2	2	2	1	1	1	1
2036	22	18	2	2	2	2	2	2	1	1	1	1
2037	24	20	2	2	2	2	2	2	1	1	1	1
2038	25	21	2	2	2	2	2	2	1	1	1	1
2039	27	22	2	2	2	2	2	2	1	1	1	1
2040	28	23	2	2	2	2	2	2	1	1	1	1
2041	30	25	2	2	2	2	2	2	1	1	1	1
2042	31	26	2	2	2	2	2	2	1	1	1	1
2043	32	27	2	2	2	2	2	2	1	1	1	1
2044	34	28	2	2	2	2	2	2	1	1	1	1
2045	35	29	2	2	2	2	2	1	1	1	1	1
2046	36	30	2	2	2	1	1	1	1	1	1	0
2047	37	31	2	1	2	1	1	1	1	0	0	0
2048	38	32	2	1	1	1	1	1	0	0	0	0
2049	39	32	1	1	1	1	1	1	0	0	0	0
2050	39	33	1	1	1	1	0	0	0	0	0	0
2051	40	33	1	1	0	0	0	0	0	0	0	0
2052	40	33	1	0	0	0	0	0	0	0	0	0
TOTAL	734	612	54	45	54	45	53	44	26	22	26	22

Source: Utility Distributed Generation Forecasts (ILSR, 2020) https://ilsr.org/report-utility-distributed-energy-forecasts-2020/

Uses the Williams residential base model from this ILSR report, with the addition of the prices in the table above to reflect the utility purchase price. Non-residential capacity is assumed to be 71% of residential capacity, based on the ratio of non-residential to residential nationally in 2019. Include as many years (rows, indicated by column A) as needed.

Completing the table:

Cells B4:B34: State model cells D76:D106 divided by 0.71. If using an Excel formula, paste into this worksheet as values.
Cells C4:C34: State model cells E76:E106 divided by 0.71. If using an Excel formula, paste into this worksheet as values.
Cells D4:D34: First, plug 0.01 into state model as incentive (model cells I72:AM72). Cells D4:D34 are then model cells D76:D106 divided by .71, minus cells B4:B34. Again, paste as values.
Cells E4:E34: First, plug 0.01 in to model as incentive (model cells I72:AM72). Cells E4:E34 is then model cells E76:E106 divided by .71, minus cells C4:C34. Again, paste as values.
Cells F4:F34 & G4:G34: Same as D4:D34 & E4:E34, increasing the incentive in the state model to the appropriate value noted in F2:G2. To make them incremental, cell F4:F34 = values from state model divided by .71 minus D4:D34 minus B4:B34. Cells G4:G34 = values from state model divided by .71 minus E4:E34 minus C4:C34. Paste as values.
Continue to fill the table by increasing the incentive in the state model, noting the results, dividing by .71, and subtracting the prior MW-DC columns from the MW-DC column and subtracting the prior MW-AC from the new MW-AC column.

How to read the table:

In 2022, with no incentive, 8 MW-AC of distributed solar would be built. At a price of $10 per MWh, a total of 9 MW-AC (8+1) of distributed solar would be built. At a price of $20, an additional 1 MW would be built for a total of 10 MW-AC (8+1+1).

At a price of $40 per MWh, over the 30 years of the modeled timeframe, a total of 789 MW-AC of distributed solar would be built (612+45+45+44+22+22)

Each incentive level on the "Adoption by Price TEMPLATE" worksheet represents the incremental changes to distributed solar adoption at each incentive level. For example, columns D:E show the amount of distributed solar adopted with an incentive of $10 per MWh in addition to the amount of distributed solar already adopted with no incentive in columns B:C. Similarly, columns F:G show the amount of distributed solar adopted with an incentive of $20 per MWh in addition to the amount of distributed solar already adopted at an incentive of $10 per MWh and with no incentive in columns B:E.

To calculate total distributed solar adoption at a certain incentive level, add the distributed solar adoption amount at that incentive level to the distributed solar adoption amounts at lower incentive levels and the base distributed solar adoption amount. For instance, to find total solar adoption over 30 years with a $30 per MWh incentive, you would add up cells C35, E35, G35, and I35.

Here's an example of what the "buckets" of incremental solar adoption at each incentive level might look like over 15 years:

- Default ($0 per MWh incentive) - adoption of 10 MW AC
- $10 per MWh incentive - 2 MW AC additional distributed solar
- $20 per MWh incentive - 3 MW AC additional distributed solar
- $30 per MWh incentive - 5 MW AC additional distributed solar
- $40 per MWh incentive - 5 MW AC additional distributed solar

For the capacity expansion model, ILSR and our partners input the incremental "buckets" of distributed solar for the capacity expansion model to select. Since the default results with no incentive cost nothing, the capacity expansion model automatically selected the initial 10 MW AC of distributed solar. The capacity expansion model then purchased each increment above that if it was the most cost-effective resource compared to the other options presented (e.g. utility-scale solar, wind energy, etc). As you might expect, distributed solar was very cost-effective and our "distributed solar as a resource" model helped to convince the Minnesota Public Utilities Commission to order Xcel Energy to investigate this approach to resource planning in the future.

See also ILSR and the Distributed Solar Parties's **reply comments to Xcel Energy's Integrated Resource Plan**, filed to the Minnesota Public Utilities Commission.

Methods Behind the Model

Adaptation From the Williams et al. Model

ILSR adapted its rooftop solar adoption model from the parsimonious model proposed in "**Empirical development of a parsimonious model for international diffusion of residential solar**" (2019). The authors of the paper are Eric Williams (Golisano Institute for Sustainability, Rochester Institute of Technology, USA), Rexon Carvalho (North American Power, Energy Aspects, USA), Eric Hittinger (Department of Public Policy, Rochester Institute of Technology, USA), and Matthew Ronnenberg (Program of Color Science, Rochester Institute of Technology, USA). Elsevier published the paper in December 2019 in Renewable Energy: an International Journal.

The authors wanted to create a model that is simple, but still "reasonably explains" solar adoption trends from 2005 to 2016. They built their model with data from Germany, Japan, and three U.S. states: Arizona, California, and Massachusetts. The model functions not only to predict solar adoption under the status quo, but also to predict the consumer reaction to proposed policies and incentives.

The Williams et al. model has one explanatory variable: net present value (NPV), which estimates the value of a solar system to an individual. In other words, the Williams et al. model assumes that the more financially rewarding the investment, the more customers will install rooftop solar. It's common sense, and it works well to explain solar adoption in the jurisdictions that the authors reviewed.

Here is the Williams et al. equation for the net present value of a subsidized residential PV system:

$$NPV\ (\$) = (\ -C_{total} + S) + \sum_{i=1}^{N} \frac{TE \times SC \times RP \times\ (1 + \inf)^i}{(1 + int)^i}$$
$$+ \sum_{i=1}^{M} \frac{TE \times (1 - SC) \times FIT\ Price}{(1 + int)^i} \qquad (1)$$

Where:

C_{total} : capital cost of the PV system ($)
S: capital cost subsidy ($)
TE: total electricity produced by the PV produced in one year (kWh)
SC: self-consumption share (%)
RP: retail price of electricity ($/kWh)
inf: inflation rate (%)
int: lending rate (%)
$FIT\ Price$: fixed feed-in-tariff price ($/kWh)
i: year
N: lifetime of solar system (years)
M: term length of FIT Price (years)

The Williams et al. solar adoption model must then estimate what portion of individuals in a region will install solar, given its net present value to residents.

When faced with the same risk and reward, people arrive at different conclusions. There is no magic net present value at which everyone will choose to go solar; some may only install solar panels when the net present value is extremely high, while others will choose to install solar panels when their net value is negative. Most people fall somewhere in the middle. The authors took this into account by assuming that solar adoption follows a normal distribution, or the "diffusion of innovation" logic.

Here is the Williams et al. equation for annual residential solar adoption:

$$Annual\ adoption\left(\frac{MW}{million\ houses}\right)(NPV) = \alpha \int_{-\infty}^{NPV} dx\, e^{-\left(\frac{x-\mu}{\sigma}\right)^2}$$
$$= K\left(1 + \mathrm{erf}\left(\frac{NPV - \mu}{\sigma}\right)\right)$$

The variable α (alpha) is an arbitrary constant that helps fit the model to the data. μ (mu) and σ (sigma) are calculated constants that are used to fit the model to real-world data. K represents one half of the maximum annual adoption. Originally, it was 2,000 megawatts per million households. In ILSR's model, due to increasing the system size, K was recalculated to be 3250 (formula for K = 1 million homes * ½ of system size in kilowatts / 1,000).

Click to read the Williams et al. paper in full.

Eric Hittinger, Eric Williams, and two other authors also used the Williams et al. solar adoption model in **an exploration of the optimal subsidy for residential solar.**

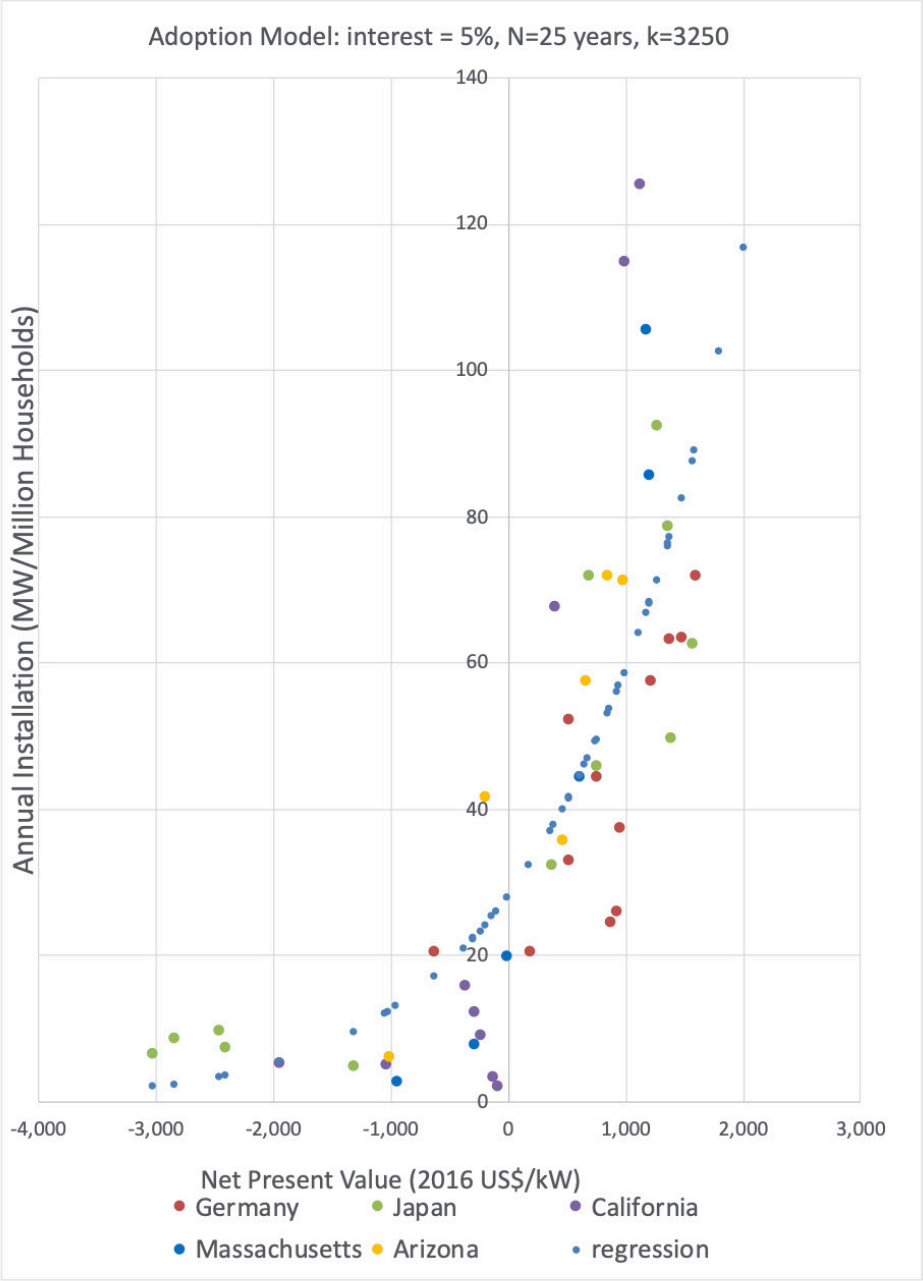
ILSR's Adjustments to the Williams et al. Model

1. **Increased solar system size to 6.5 kilowatts.** ILSR's rooftop solar adoption model uses a system size of 6.5 kilowatts, or the 2019 median residential system size from Lawrence Berkeley National Laboratory's **Tracking the Sun 2021 report**. The Williams et al. model, for reference, used a system size of 4 kilowatts.

2. **Changed k to 3250.** Because k reflects the upper bound on solar adoption in a year, this was necessary after changing the solar system size.

3. **Increased system life to 25 years.** ILSR's rooftop solar adoption model uses a solar system life of 25 years, which is in line with the average lifespan of panels installed now. The Williams at. al. model used a system life of 20 years.

4. **Changed Mu and Sigma constants.** Paper author Eric Williams ran a new regression to find an appropriate mu and sigma after we changed module size and k. Mu = 9952.25 Sigma = 5361.59. The TSE is increased from the Williams et al. model, meaning ILSR's adapted model is not quite as good of a fit to the historical data as the original model. However, it is still a reasonable fit.



Mu	9952.25
Sigma	5361.59
K	3250
TSE	18332

5. ILSR's model, first iterated in 2019, uses a **five percent interest rate and two percent inflation rate.** Five percent was a **common home equity loan interest rate in 2019**. Two percent is the average annual inflation rate **from the years 2000-2020**. ILSR acknowledges that these rates have changed since 2019, which could affect the data.

6. **Added a solar annual cost decline of five percent.** Because we extended our model out over multiple years, some inputs that were static in the Williams et al. single year model needed to change year over year. Between 2008 and 2018, the median cost of residential installed solar **decreased by 60 percent**. We expect the cost of installing solar to decrease five percent per year in the modeled years (2022-2052). Data supporting our five percent estimate is in the "Solar Cost Decline" worksheet of the model Excel workbook.

7. **Added a solar output degradation of 0.5% per year.** The output of a solar panel, given the same conditions, decreases over time. The National Renewable Energy Laboratory has found the solar PV panel output degradation to be **.5% per year**.

8. **Accounted for homes already with solar at the start of the modeled time period.** Homes with solar would not be eligible for a new solar system. We subtracted a figure representing existing solar homes from the eligible occupied, detached housing units.

9. **Accounted for homes that go solar through the modeled time period.** The homes estimated to go solar in the first modeled year are subtracted from the eligible occupied, detached housing units in the subsequent year, and so on.

10. **Added the Solar Investment Tax Credit (ITC) for 2022-2034.** ILSR's rooftop solar adoption model assumes that customers have sufficient tax liability to get the full value of the ITC (30% in 2022 through 2032, 26% in 2023, and 22% in 2024.

State Model Parameters

This section outlines the baseline inputs for each state's rooftop solar adoption model.

Rooftop solar module output:

A one kilowatt system was **run through NREL's PVWatts® calculator** with default settings. The location (city) used for each state is recorded in the "Data" worksheet of the Excel workbook, column C (threaded comment).

Retail electricity prices:

Avg. Residential Electricity Price (cents/kWh) (Energy Information Administration, Nov 2021).

Average residential solar cost (dollars per watt):

2021 average residential solar costs ($/W) (**EnergySage**). There was no EnergySage Marketplace Data for AL, AK, HI, KS, KY, MS, ND, NE, OK, SD, TN, WV, and WY, so their costs were adjusted from **Solarreviews** data using the difference between Solarreviews' average 2021 solar cost ($2.80/W) and Energysage's average 2021 solar cost ($2.91/W).

Estimated solar homes:

Residential net metering customers, December 2020 (**Energy Information Administration**).

Solar eligible occupied, detached housing units:

Total occupied, detached housing units = total detached single units by state (**U.S. Census Bureau, 2019**) * total occupied housing units as a percent (**U.S. Census Bureau, 2019**).

Eligible occupied, detached housing units = total occupied, detached housing units - est. solar homes.

Net metering policy:

A table of states, their net metering policies, self consumption rates for ILSR's rooftop solar adoption model, and feed-in tariff (FiT) rates for ILSR's model is in Appendix 1. The table omits any additional state incentive programs on top of net metering for simplicity. ILSR's rooftop solar adoption model does not account for fixed charges or minimum bills (i.e. New York's Customer Benefit Contribution Charge, Rhode Island Conservation Charge, Michigan System access charge). We also do not account for state net metering capacity limitations, which would change the forecast for many states. We do not account for state policies with reduced compensation for annual excess or the expiration of annual excess. Realistically, net metering policies may change, but ILSR's model takes the policy as static for the duration of its time frame.

Net metering policy determines the use of the self consumption variable. See below.

Self-consumption:

Without battery storage, a residential solar generator is unlikely to use all of the electricity they generate on site. The solar customer is often exporting their excess generation to the grid. For customers in states with full retail net metering, the exported electricity has the same value as if they used it — the retail electricity rate. Accordingly, the solar customer is getting a retail compensation rate for 100% of the electricity they generate. In states without full retail net metering, customers may receive lower compensation for the electricity they export. To calculate the value of their solar installation, we must estimate the portion of their electricity generation that is used on site (self-consumed) and the portion that is exported.

In states that have monthly netting but reduce compensation for monthly net excess generation, ILSR estimated system self-consumption by subtracting average monthly electricity usage from each month's PVWatts® solar output. We summed any monthly excess generation for the year and divided it by the annual solar system output. This is the estimated portion of generation the customer would export to the grid. For example, we estimated that residential solar generators in Alaska (with monthly netting) would export 33% of their solar system generation to the grid. Self-consumption is one (1) minus this value — 77% for Alaska customers.

Some states without full retail net metering still had a calculated self-consumption of 100%. So, though customers in states including Arizona, Georgia, Indiana, Kansas, Mississippi, North Dakota, Nebraska, Ohio, Oklahoma, South Carolina, and Tennessee would receive sub-retail rate compensation for monthly net excess generation, this did not come into play as we estimated that they were consuming all of their generation. This is likely a result of system size — our conservative 6.5-kilowatt system generated less than the average monthly electricity usage in most states.

For states without net metering (no monthly netting), self-consumption is meant to estimate the portion of monthly electricity that is consumed at that instant. **A study in Denmark** found this to be approximately 38%. For a conservative estimate, we set self-consumption in states with no net metering policy at 35%.

Wholesale electricity rates:

ILSR used wholesale electricity rates as a replacement for a utility's avoided-cost rate. Wholesale rates are estimated using **Intercontinental Exchange (ICE) data via the U.S. Energy and Information Administration**. This data takes the average wholesale rate at each price hub for the year 2021. Some regional transmission associations did not have data. For states within these regions, ILSR used an average of the seven price hubs.

Appendix 1

State net metering policies determine whether the self-consumption variable is 100 percent or less than 100 percent in the model. In a state with full retail net metering, self-consumption is 100 percent — even if the customer consumes less electricity than they generate. This is because the customer is compensated for all of their generated power is valued at the retail rate, whether the customer "uses" it or not. States without full retail net metering treat "excess" generation differently, so the energy that they don't consume will receive compensation that is not the retail rate.

Conclusions are drawn from **DSIRE** and **Solarreviews** data.

Assumed State Self-Consumption Ratios

All power credited as self-consumption receives a retail rate credit. Where self-consumption is less than 100%, the remaining electricity is credited at the FiT rate listed.

AK: Net excess generation credited at a non-firm power rate (sub-retail rate). Self-consumption: 77% FiT rate: $0.058 (national average wholesale rate)
AL: No net metering policy. Self-consumption: 35% FiT rate: $0.058
AR: Full retail net metering for residential customers. Self-consumption: 100%
AZ: Net excess generation credited at export rate/avoided-cost rate. Self-consumption: 100% FiT rate: $0.03 (average from Solar Reviews)
CA: Full retail net metering. Self-consumption: 100%
CO: Full retail net metering. Self-consumption: 100%
CT: Net excess generation credited at sub-retail rate plus a quarterly REC payment (Eversource). Self-consumption: 97% FiT rate: [retail rate] + $0.0318
DC: Full retail net metering. Self-consumption: 100%
DE: Full retail net metering. Self-consumption: 100%

FL: Full retail net metering. Self-consumption: 100%
GA: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.0585 (wholesale rate)
HI: Net excess generation credited at export rate. Self-consumption: 68% FiT rate: $0.1507 (Oahu island export rate)
IA: Full retail net metering. Self-consumption: 100%
ID: Full retail net metering. Self-consumption: 100%
IL: Full retail net metering. Self-consumption: 100%
IN: Net excess generation credited at 125% of wholesale rate. Self-consumption: 100% FiT rate: $0.0726 (wholesale rate x 1.25)
KS: Net excess generation credited at average cost rate (sub-retail rate). Self-consumption: 100% FiT rate: $0.0585 (wholesale rate)
KY: Electricity usage not offset by generation, all generation compensated at sub-retail rate. Self-consumption: 0% FiT rate: $0.09746 (PUC rate for Kentucky Power, other rates haven't been set yet)
LA: Electricity usage not offset by generation, all generation compensated at avoided-cost rate. Self-consumption: 0% FiT rate: $0.0585 (wholesale rate)
MA: Full retail net metering. Self-consumption: 100%
MD: Full retail net metering. Self-consumption: 100%
ME: Full retail net metering. Self-consumption: 100%
MI: Electricity usage not offset by generation, all generation compensated at "outflow" rate. Self-consumption: 0% FiT rate: $0.058 (wholesale rate)
MN: Full retail net metering. Self-consumption: 100%
MO: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.0581 (wholesale rate)

MS: Net excess generation credited at avoided-cost plus DG adder. Self-consumption: 100% FiT rate: $0.0587 (wholesale rate + $0.025)
MT: Full retail net metering. Self-consumption: 100%
NC: Full retail net metering. Self-consumption: 100%
ND: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.058 (wholesale rate)
NE: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.058 (wholesale rate)
NH: Full retail net metering. Self-consumption: 100%
NJ: Full retail net metering. Self-consumption: 100%
NM: Full retail net metering. Self-consumption: 100%
NV: Net excess generation credited at 75% of retail rate. Self-consumption: 97.6% FiT rate: 0.75 * retail electricity rate
NY: Full retail net metering. Self-consumption: 100%
OH: Net excess generation credited at unbundled generation rate. Self-consumption: 100% FiT rate: $0.045 (estimate from Solarreviews)
OK: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.058
OR: Full retail net metering. Self-consumption: 100%
PA: Full retail net metering. Self-consumption: 100%
RI: Net excess generation credited at avoided-cost rate. Self-consumption: 85% FiT rate: $0.052 (wholesale rate)
SC: Net excess generation credited at avoided-cost rate or "solar choice" credit rate. Self-consumption: 100% FiT rate: Can't find solar choice credit rate, but it would be n/a since self-consumption is 100%.

SD: No net metering policy. Self-consumption: 35% FiT rate: $0.058
TN: Net excess generation credited at avoided-cost rate. Self-consumption: 100% FiT rate: $0.058
TX: No net metering policy. Self-consumption: 35% FiT rate: $0.058
UT: Net excess generation credited at export rate (Rocky Mountain Power). Self-consumption: 92% FiT rate: $0.06 (Rocky Mountain Power export rate)
VA: Full retail net metering. Self-consumption: 100%
VT: Full retail net metering. Self-consumption: 100%
WA: Full retail net metering. Self-consumption: 100%
WI: Net excess generation credited at rate determined by utility. Self-consumption: 92% FiT rate: $0.04245
WV: Full retail net metering. Self-consumption: 100%
WY: Full retail net metering. Self-consumption: 100%