With utility-scale solar installations accelerating, Wiki-Solar founder Philip Wolfe drills into the data to highlight some interesting variations in relative progress around the world.

The race for 100% solar

The perennial top three countries – China, the USA and India – continue to account for some 2/3 of global utility-scale solar capacity. But look beyond these simple totals and you find some impressive relative results by many of those countries in the remaining one-third.

From Wiki-Solar's comprehensive database of over 22,000 utility-scale solar projects around the world, we can derive a wide range of comparators, including performance ratios, average yield and land utilisation. This article looks at national achievements and rates of progress.

Contribution to national energy consumption

Firstly, we have assessed the nominal annual output of the large solar capacity in each country, and compared it with national electricity consumption. On that basis, five countries now meet over 10% of their electric power from utility-scale solar. Most of these figures would be significantly higher if you add rooftop and other smaller scale solar generation.

Contribution of utility-scale solar to consumption 2022

Rank	Country	Solar MWac	Rank	Yield MWhpa/MW	Consumption TWhpa	Solar nom. TWhpa	Solar proportion
1	Chile	5,983	13	2,976	80.99	17.80	22.0%
2	El Salvador	410	49	2,685	6.44	1.10	17.1%
3	Jordan	1,108	33	2,663	17.37	2.95	17.0%
4	Spain	16,950	4	2,293	229.66	38.86	16.9%
5	Australia	10,899	7	2,470	244.94	26.92	11.0%
6	Honduras	487	46	2,291	11.44	1.12	9.8%
7	United Arab Emirates	5,903	14	2,170	144.29	12.81	8.9%
8	India	55,579	3	2,152	1,392.22	119.63	8.6%
9	Vietnam	9,484	8	1,995	275.00	18.92	6.9%
10	Mexico	8,442	9	2,171	276.68	18.33	6.6%
11	Cambodia	383	44	1,776	10.31	0.68	6.6%
12	Portugal	1,388	30	1,987	49.61	2.76	5.6%
13	Dominican Republic	528	45	2,337	23.36	1.23	5.3%
14	Greece	1,197	32	2,059	47.50	2.46	5.2%
15	Israel	1,345	31	2,066	59.19	2.78	4.7%
16	Denmark	1,086	34	1,313	33.08	1.43	4.3%
17	United States	70,996	2	2,443	4,081.83	173.41	4.2%
18	United Kingdom	8,069	11	1,323	280.47	10.68	3.8%
19	Netherlands	3,584	15	1,130	108.17	4.05	3.7%
20	France	8,323	10	1,765	424.54	14.69	3.5%

Solar figures are utility-scale only; nominal not actual.
Total solar contribution would be typically 1-3 times higher.

The top 20 countries by proportional contribution of utility-scale solar

Chile tops the list thanks in part to its exceptional yield – with so many high altitude desert sites. El Salvador and Jordan feature strongly with solar contributing substantially to their more modest electricity demand. Spain carries the banner for Europe, while Australia has progressed strongly after a slow start.

Large solar plants at 1,000m around Diego de Almagro in Chile's Atacama region

The UAE owes much of its elevated position to a single huge project, the Mohammed Bin Rashid Al Maktoum Solar Park in Dubai. India may be only #3 in terms of total capacity but leads the USA and China in relative terms, with 8.6% of its electricity from utility-scale solar, and 13.2% from solar overall.

An extended list showing most of the countries with significant utility-scale solar capacity is shown on Wiki-Solar's website. There you will find Germany with 3.2% a few places above China at #29 with 2.6%

Leaders and laggards – How long will it take?

The rate of progress is another key indicator, which we have evaluated by looking at the change over the 5-year period from 2017 to 2022.

For comparison, we have extended this rate forward until utility-scale solar meets 100% of electricity demand. This is, of course, a theoretical exercise: No nation would in practice generate all of their power this way; and neither the growth of solar nor the trend in electricity consumption will continue as a straight line. But the results are nonetheless illuminating.

Rate of change of contribution of utility-scale solar

Rank	Country	Solar MWac	Rank	2017 Solar proportion	2022 Solar proportion	Years to 100%	100% in year
1	Chile	5,983	13	6.4%	22.0%	25	2047
2	Spain	16,950	4	3.7%	16.9%	31	2053
3	El Salvador	410	49	3.5%	17.1%	31	2053
4	Jordan	1,108	33	5.2%	17.0%	35	2057
5	Australia	10,899	7	0.4%	11.0%	42	2064
6	United Arab Emirates	5,903	14	0.6%	8.9%	55	2077
7	Vietnam	9,484	8	0.0%	6.9%	68	2090
8	Cambodia	383	44	0.0%	6.6%	71	2093
9	Mexico	8,442	9	0.2%	6.6%	73	2095
10	India	55,579	3	2.6%	8.6%	77	2099

100% solar projections are for comparison only!
Solar figures solely utility-scale; nominal not actual.

Rate of change of solar contribution to national electricity, with projection to '100% solar paradigm'

Chile again tops the list, needing just 25 years to achieve that notional 100% utility-scale solar. Spain has seen outstanding renewed growth in recent years taking it to #2 in this list, with El

Salvador and Jordan not far behind. In theory, these ten countries would all, at this rate, reach 100% solar, from utility-scale alone, before the end of the century.

Again the full list is available online, with a strong European contingent – Portugal, Greece, Netherlands and Denmark – just outside the top ten. Some countries, where recent progress in utility-scale solar has been slow, would need several centuries by this measure.

People and large-scale solar

The large power stations we are considering here are not, of course, for individuals or households. But another measure of comparative achievement is the relative capacity per capita.

Utility-scale solar per head of population 2022 + 2017

Rank	Country	Solar MWac	Rank	Solar nom. TWhpa	Population millions	Output/head 2022 MWh	Output/head 2017 MWh
1	United Arab Emirates	5,903	14	12.81	9.4	1.36	0.08
2	Australia	10,899	7	26.92	26.2	1.03	0.04
3	Chile	5,983	13	17.80	19.6	0.91	0.25
4	Spain	16,950	4	38.86	47.6	0.82	0.20
5	United States	70,996	2	173.41	338.3	0.51	0.17

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Total solar contribution would be typically 1-3 times higher.

Relative table of capacity per head for the top five countries

Inevitably this is quite similar to the first table above, but this time the UAE and Australia leapfrog Chile. The USA has a much higher ranking in this table because its power consumption per capita is much higher than most others. Again the full table is available online.

Have we got enough land?

Wiki-Solar has accurate site footprints for the majority of utility-scale plants, enabling us to assess the land area typically used in different parts of the world. Relating this to the land area of each country, it is no surprise to find that land usage is seldom an issue.

Land usage for utility-scale solar

Rank	Country	Solar MWac	Rank	Land cover Ha/MWp	Coverage 2022 sq.km	Proportion of total	Proportion 100% solar
1	Taiwan	892	35	1.6	16.7	0.052%	8.376%
2	South Korea	1,512	27	1.2	20.8	0.021%	4.749%
3	Netherlands	3,584	15	0.8	35.1	0.104%	2.769%
4	Israel	1,345	31	1.4	22.5	0.111%	2.363%
5	Japan	11,821	6	1.0	140.6	0.039%	2.136%
6	United Kingdom	8,069	11	1.8	184.1	0.076%	2.000%
7	China	161,082	1	2.1	4,010.2	0.043%	1.685%
8	Czechia	453	47	2.3	12.6	0.016%	1.585%
9	Germany	12,396	5	1.1	158.1	0.045%	1.410%
10	Vietnam	9,484	8	2.5	297.2	0.096%	1.393%

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Land devoted to utility-scale solar now - and required for '100% solar paradigm'

The most that any country currently devotes to utility-scale solar is just ove one tenth of 1 percent. Only two relatively small and energy intensive countries – Taiwan and South Korea – would need to allocate more than 3%, even to achieve the theoretical 100% solar paradigm.

The full list shows the USA down amongst the countries that would need to devote about ½% of their land area. Of course, the use of building mounted systems, and the growth of agri-voltaics, means that the land allocated can also be productive for other purposes.

Terminology, disclaimer and acknowledgments

We use the expression 'nominal output' to refer to the design or expected annual output of solar power stations. Actual output in practice will vary with solar radiation and other climatic and site factors, such as grid constraint.

The '100% solar paradigm' is used for illustrative and comparative purposes. The author does not anticipate that any country will in practice aim to produce all their electricity from utility-scale solar to the exclusion of other generation options. A 100% renewable scenario, using wind, hydro and biomass alongside solar, is a more realistic scenario.

MWh: megawatt-hours = 1,000 kWh. TWh: terawatt-hours = 1,000,000 MWh. National power consumption figures are mainly from Enerdata and the International Energy Agency; population data mainly from the UN. Utility-scale solar figures are from the Wiki-Solar database. For consistency, capacities are quoted in MW/GW/TW_{AC} to allow direct comparison between PV and CSP plants and other forms of generation.

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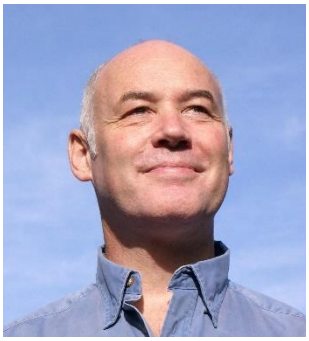

Philip Wolfe has been active in the renewables arena since the 1970s. He is now seeking to identify partners who can take Wiki-Solar forward, when he retires in the next few years.