PV-WIND MONTHLY MARKET UPDATE

U.S. PV Capacity Additions Total 1,357 MW in October

January 2022 Issue

(Data Updates for October 2021)

U.S. PV-WIND CAPACITY **October 2021 PV and Wind Capacity Additions**

- In October, PV capacity additions total 1,357 MW.
- In October, wind capacity additions total 1,416 MW.

U.S. ELECTRICITY GENERATION **October 2021 PV and Wind Electricity Generation**

- PV and wind electricity production is 14.1% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 4.0% and wind is 10.1%

TRADE – U.S. PV IMPORTS/EXPORTS **U.S. PV Panel Imports Increase in October**

- In October, the value of U.S. PV panel imports increases 1.4% to $444 million
- Malaysia, Vietnam, and Thailand are the top suppliers of U.S. PV panel imports

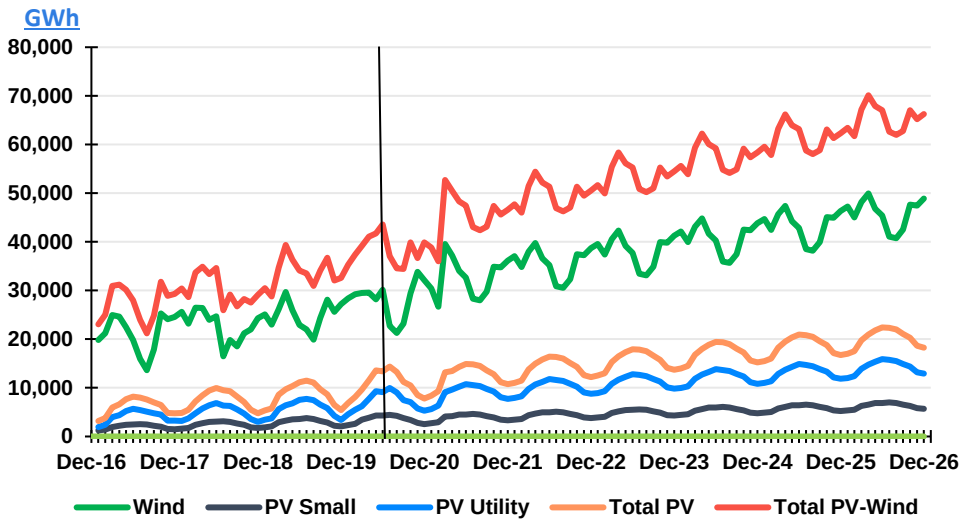
WORLD PV-WIND CAPACITY **2021 World PV and Wind Forecast**

- The world PV forecast is 143 GW of capacity additions
- The world wind forecast is 70 GW of capacity additions

PV-WIND COMPANY FINANCIAL PERFORMANCE **December 2021 ETF Performance**

- For December, TAN (solar) share price performance is negative
- For December, FAN (wind) share price performance is positive

PV-Wind Electricity Generation: Actual to Oct-21; Forecast to Dec-26



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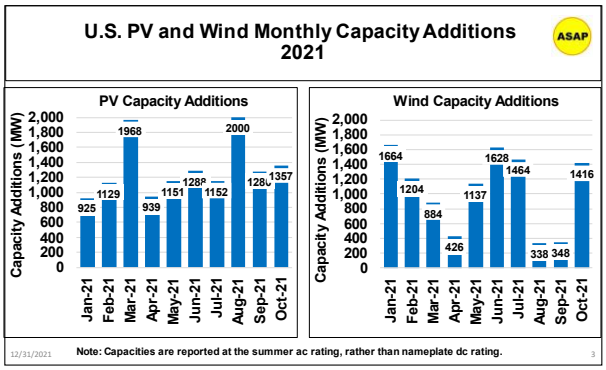
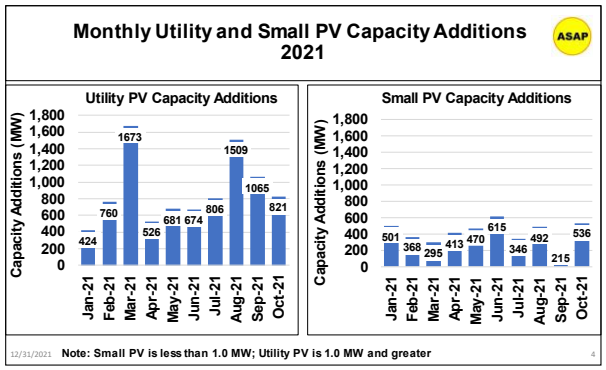
U.S. PV and Wind Capacity

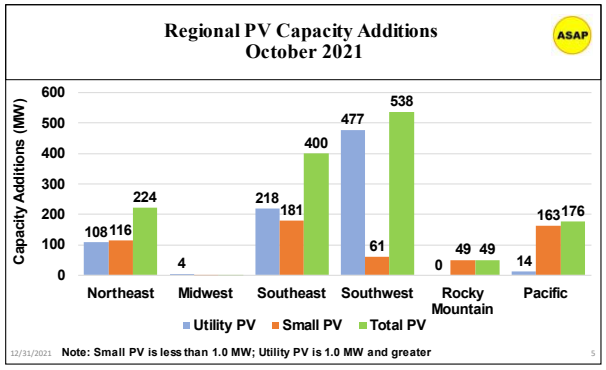
October U.S. PV capacity additions total 1,357 MW

In October, U.S. PV capacity increased 1,357 MW with a cumulative capacity of 87.0 GW. October utility scale PV capacity additions totaled 821 MW, which is 60% of total new PV. In contrast, small PV capacity additions totaled 536 MW. Through October, the annualized pace for PV capacity additions is 15.8 GW. Year-to-date PV installations remain off the pace required to meet the 2021 forecast of 17.0 GW of PV growth.



In October, the Southwest and Southeast regions led in PV capacity additions





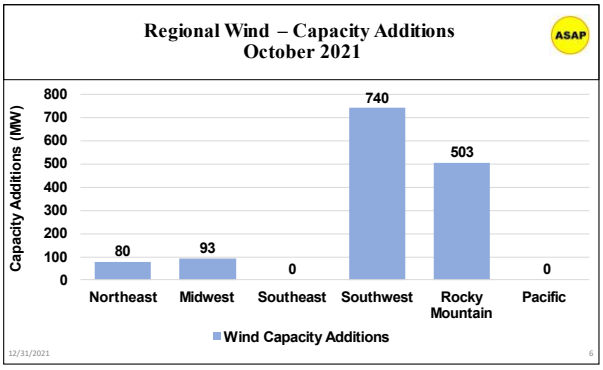
On a regional basis, the Southwest and Southeast regions led the way with 538 MW and 400 MW of capacity additions respectively. In the Southwest utility PV capacity additions accounted for 89% of total PV installations. In contrast, utility PV capacity additions accounted for 54% of total PV installations in the Southeast. The top three states for PV capacity additions were Texas, California and Florida with 510 MW, 163 MW, and 107 MW respectively.

The 2021 PV forecast is 17.0 GW of capacity additions

The 2021 PV forecast of 17.0 GW is supported by the extension of the federal PV investment tax credit. The solar investment tax credit (ITC), which was scheduled to drop from 26% to 22% in 2021, will stay at 26% for two more years. This means that solar projects in all market segments — residential, commercial, industrial, utility-scale — that begin construction in 2021 and 2022 will still be able to receive a tax credit at 26%. In 2023, all PV markets will drop to a 22% tax credit. Beginning in 2024, the solar tax credit is ended for the residential market, while the commercial and utility markets have a permanent 10% solar tax credit. The wind industry also received a limited extension of its production tax credit.

October wind capacity additions total 1,416 MW

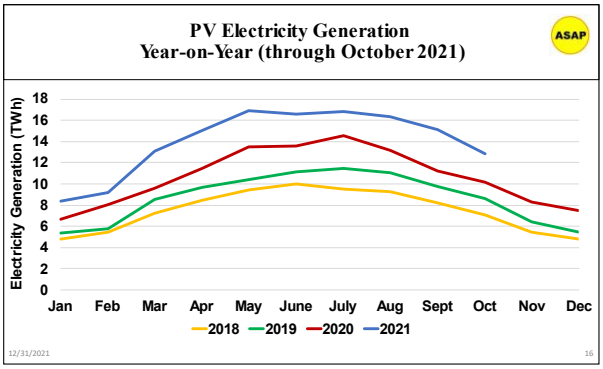
Wind installations in October rebound to 1,416 MW after two disappointing months. The annual pace for wind installations to 12.6 GW, which is shy the pace to meet ASAP's 2021 wind growth forecast of 15.0 GW. The Southwest and Rocky Mountain regions set the pace for October wind capacity additions with 740 MW and 608 MW respectively.



U.S. PV-Wind Electricity Generation Update

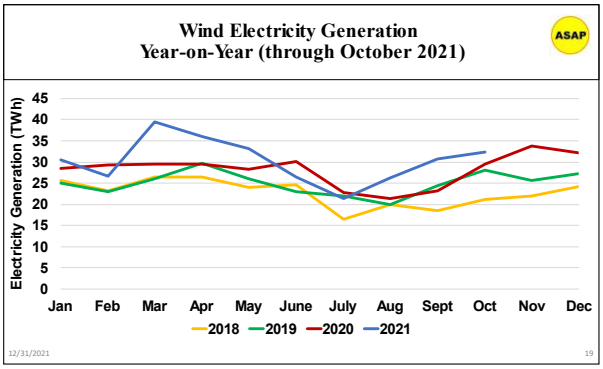
October combined PV and wind electricity generation is 14.1% of total U.S. electricity generation

In October, PV electricity generation was 9.2 TWh (-2.9% MoM), and wind electricity generation was 31.0 TWh (+1.7% MoM). For October, combined PV and wind electricity generation is 14.1% of total U.S. electricity generation. PV contributed 4.0%, and wind provided 10.1%. Combined PV and wind electricity generation is expected to surpass 12% of total electricity generation in 2021.



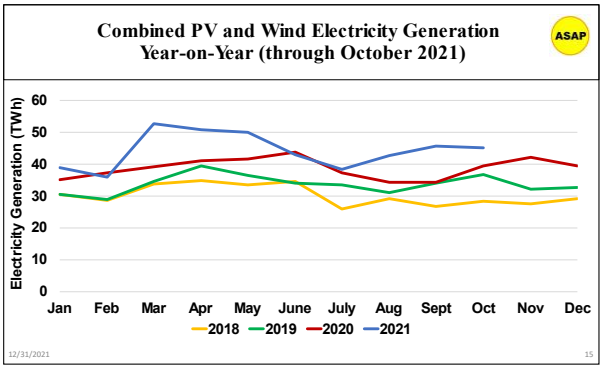
Year-on-year, PV electricity generation increased 14.4%

Year-on-year, October-20 to October-21, PV generation increased 26.6%, and wind generation increased 10.2%. YoY, combined PV and wind electricity generation increased 14.4%.



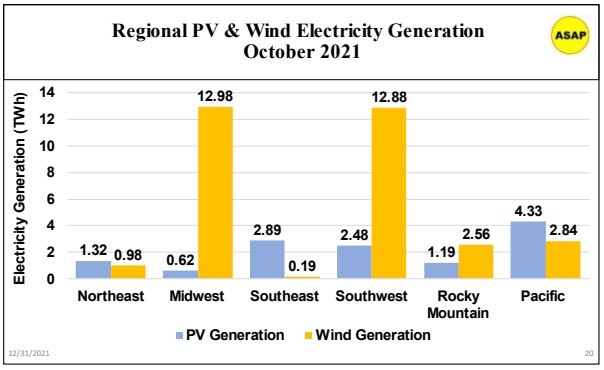
The Pacific region leads the nation in PV electricity generation

In October, the Pacific region led the nation in PV electricity generation with 4.3 TWh and is followed by the Southeast region with 2.9 TWh and the Southwest region with 2.5 TWh. California is the leading state with 4.0 TWh of PV electricity generation, which is 31% of total PV electricity generation in October. Texas is second with 1.5 TWh. Filling out the top five states are Florida with 0.9 TWh, North Carolina with 0.9 TWh, and Arizona with 0.9 TWh.



Year-on-year, U.S. wind electricity generation increased 23% in the Southwest and increased 6% in the Midwest

Wind electricity generation in October totaled 32.4 TWh, which is a MoM increase of 1.7%. The leading regions for wind electricity generation are the Midwest with 13.0 TWh and the Southwest with 12.9 TWh. These two regions combined produced 80% of total U.S. wind electricity in October. The Pacific region is a distant third with 2.8 TWh of electricity generation. Texas is the nation's leader with 8.9 TWh of wind electricity generation and is followed by Iowa with 3.1 TWh, Oklahoma with 2.9 TWh, and Kansas with 2.1 TWh.



Year-on-year, October-20 to October-21, U.S. wind electricity generation increased 3.0 TWh (+10.2%). YoY, Southwest wind electricity generation increased 2.3 TWh (+23.1%), and Midwest wind electricity generation increased 0.5 TWh (+6.3%).

To state the obvious, seasonality combined with variations in weather patterns have significant impacts on month-on-month and year-on-year changes in PV and wind electricity generation.

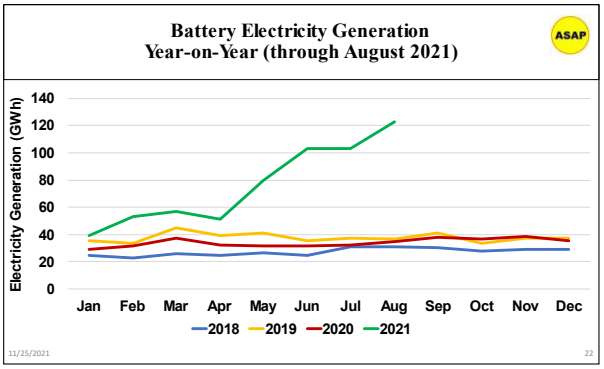
U.S. Utility Battery Storage

U.S. cumulative battery storage capacity increases to 3.3 GW in October

U.S. battery storage capacity additions totaled 186 MW in October, which increases cumulative battery storage capacity to 3.3 GW. Year-to-date, battery capacity additions total 1.8 GW, which brings the annualized pace to 2.2 GW. The annual forecast of 1.0 GW has been realized. Looking ahead, ASAP expects annual battery capacity additions to exceed 5.0 GW by 2025. From company battery installation announcements, four hours of battery storage is becoming the norm.

The October average battery utilization factor is 4.1%

The reported October average monthly battery utilization factor is 4.1% (1.0 hour/day), which implies battery electricity generation of 100.0 GWh. Year-on-year, October-20 to October-21, battery electricity generation has more than doubled. Battery electricity capacity and supply will continue to increase at an exponential rate with a significant scale-up in annual battery capacity additions going forward.



Obviously, variability in PV and wind electricity production requires electricity storage to convert PV and wind into a dependable supply of on-demand electricity. At present, the U.S. has approximately 800 GW of fossil fuel power plants, which implies the need for hundreds of GW of storage if PV and wind electricity is to replace fossil fuel power plants. At present, the large-scale storage options are pumped hydro, batteries, hydrogen, molten salt for thermal solar, underground compressed air energy storage. Currently, pumped hydro is the largest storage technology with over 22 GW of installed capacity.

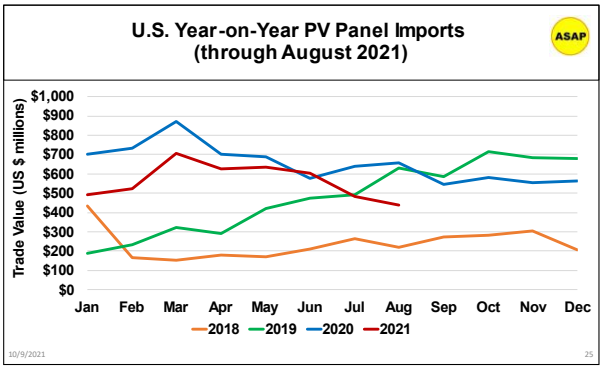
Due to siting constraints, it is expected that pumped hydro storage capacity will remain in the 22 GW neighborhood going forward. On the other hand, battery storage is gaining traction for PV storage.

There are several green hydrogen projects on the drawing board with hydrogen produced from water using PV, wind, and hydro electricity. Green hydrogen is being discussed as a fuel for fuel-cell heavy transport trucks. Molten salt storage for solar concentrating plants and compressed air energy storage are basically being ignored. There is a permitted compressed air energy storage project in Texas using salt storage that is slated to begin construction in 2022.

U.S. PV Trade

In October, the value of U.S. PV panel imports is $589 million

In October, the value of U.S. PV panel imports increased 32.7% month-on-month to $589 million. With the year-to-date value of U.S. PV panel imports standing at $5.54 billion, the annual trajectory for U.S. PV panel imports is $6.65 billion, which is short the forecast of $8.2 billion. PV trade is facing headwinds caused by increasing PV prices due to increases in material and shipping costs.



Vietnam, Malaysia, and Thailand are the top three sources of U.S. PV panel imports in October

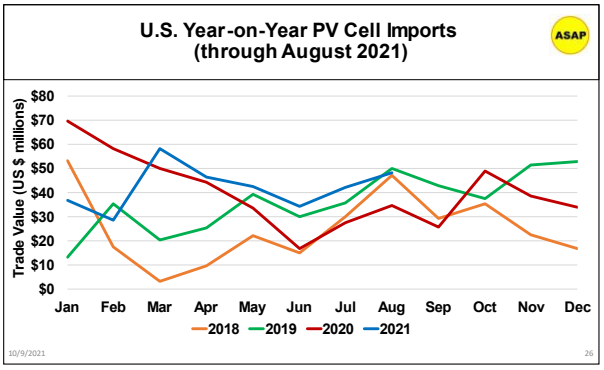
Monocrystalline polysilicon prices in October were above $40/kg, which signifies continuing tightness in supply. The prices quoted are China average PV-grade polysilicon spot prices. The polysilicon market will remain tight until new production plants come online with sufficient capacity to balance supply and demand, which is not expected to occur until the second half of 2022. While the underlying demand for PV remains strong driven by ambitious public and private sector carbon emissions reduction targets, there is an observed increasing price elasticity of demand, which holds the prospect for some utility PV projects to be delayed until 2022.

The polysilicon market will be short into 2022 even with expansion projects coming online in the fourth quarter of 2021. With scheduled expansions continuing to come online, polysilicon supply constraints are expected to ease in the first half of 2022 and to attain a healthy surplus in the second half of 2022 with prices falling under $10/kg. By the end of 2022, low polysilicon prices will support strong market demand for mono-silicon PV driven by ambitious carbon neutrality commitments by all major economies.

Vietnam, Malaysia, and Thailand are the top three countries for U.S. PV module imports in October. These three countries account for 84% of U.S. PV imports. Vietnam leads the market for U.S. PV panel imports with an 33% market share in October, while Malaysia's share of the U.S. PV panel import market fell to a 32% share. Thailand rounds out the top three with an 18% share. Year-to-date, Malaysia leads with a 33% market share, Vietnam has a 31% market share, while Thailand follows with a 18% market share.

South Korea dominates the U.S. PV cell import market in October

Turning attention to U.S. imports of PV cells, the total value of October U.S. PV cell imports increased 35.9% month-on-month to $44 million. South Korea dominates U.S. supply of imported PV cells in October with a 55% share and a YTD 53% share. Malaysia and Vietnam round out the top three sources for U.S. PV cell imports.



The value of 2021 U.S. PV panel and cell exports are minimal

In terms of U.S. exports, the value of U.S. PV panels exports in October declined 59.1% to $1.7 million. Year-to-date, the value of U.S. PV panel exports is $26.2 million, and the annual pace is $33.4 million. For full year 2021, the value of U.S. PV panel exports is above the pace to reach the forecast of $25.0 million. Due to a lack of U.S. PV manufacturing capacity, the U.S. PV panel export market is minimal.

The value of U.S. PV cell exports in October increased 129% to $3.0 million. YTD the value of U.S. PV cell exports is $20.9 million and is on an annual pace of $25.0 million. The 2021 forecast for U.S. PV cell exports is $23 million.

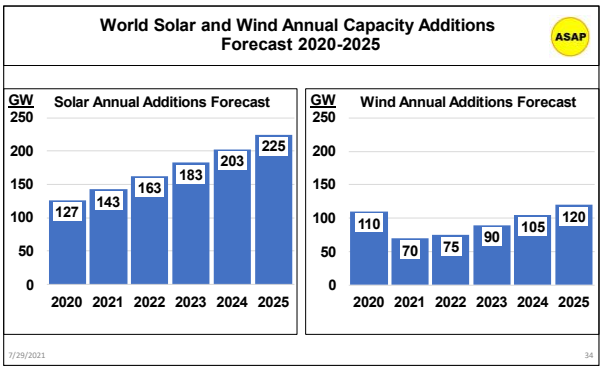
China is dominant in the PV industry space. China's upstream polysilicon manufacturing base supplies about 80% world PV-grade polysilicon. With current and announced expansion plans by Chinese firms, China is likely to supply 90% of the PV-grade polysilicon by 2025. Both Europe and the U.S. are exploring ways to compete with China in the PV market. A bill introduced in the U.S. Congress is the Solar Energy Manufacturing for America Act, which aims to accelerate domestic manufactur2ing by offering tax credits at all stages of the solar supply chain. The fully refundable tax credit would allow companies to front-load capital expenditure and rapidly scale production domestically for components and materials, including photovoltaic cells and modules.

World PV and Wind

The world PV forecast for 2021 is 143 GW

The world wind forecast for 2021 is 70 GW

ASAP's 2021 forecast for global PV capacity additions is 143 GW, which is 12.6% annual growth. The 2021 forecast for wind capacity additions is 70 GW, which is 9.6% annual growth. Wind installations are generally much larger in terms of capacity and require more regulatory hurdles than PV installations. Therefore, the record 2020 wind installation rate is not expected to be replicated in 2021. However, wind installations are expected to return to the 100 GW mark in 2024 and rise to 120 GW in 2025.



At the end of 2020, world cumulative solar capacity was 707 GW and world cumulative wind capacity was 732 GW. Based on the annual solar and wind forecast, the cumulative capacity of solar is expected to surpass that of wind in 2021. The cumulative capacity of

PV is set to cross the terawatt threshold in 2022, and the cumulative capacity of wind will reach the terawatt mark in 2024.

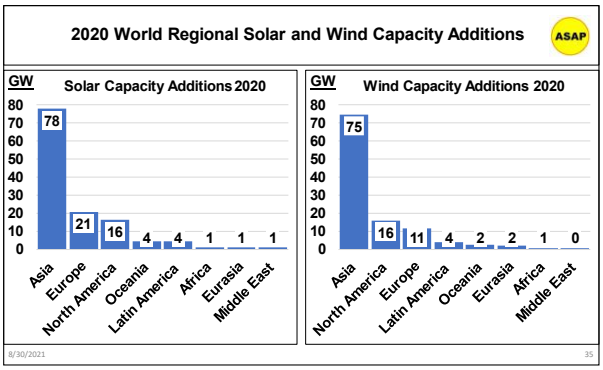
World cumulative PV capacity is expected to surpass world wind capacity in 2021

The 2025 forecast for cumulative PV capacity is 1.62 TW (terawatts). The 2025 forecast for cumulative wind capacity is 1.19 TW. The annualized growth rate, 2020-2025, for PV capacity additions is 18.1% and for wind capacity additions is 10.2%.

PV has capital cost, O&M expense, and electricity price advantages compared with other electricity generation options. At present, utility PV is the lowest cost electricity generation technology with a levelized electricity price under $0.05/kWh USD. These factors support PV's high growth rate.

It should be noted that PV is over 99% of total solar capacity since concentrating thermal solar technologies have not proven cost competitive. Therefore, PV is synonymous with solar for the five-year forecast. For wind, onshore wind systems are 95.5% of the world total. Europe's 25 GWs of offshore wind capacity leads the world. In contrast, Asia has 10 GW of offshore wind capacity.

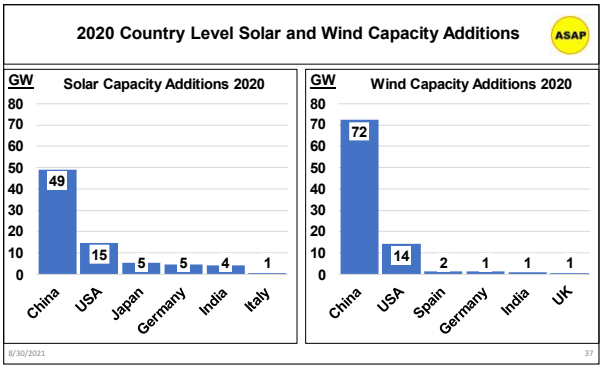
Asia leads the world in both PV and wind capacity



On a world regional basis, Asia, Europe and North America dominate the solar and wind markets. Asia has a substantial lead over Europe and North America as shown in the graphs. In 2020, Asia PV capacity additions were 61.4% of world PV capacity additions. Wind capacity additions in Asia were 67.5% of world wind capacity additions. In terms of world cumulative capacities, Asia accounts for 57% of PV capacity and 45% of wind capacity.

The 2025 forecast for global PV capacity additions is 225 GW and for global wind capacity additions is 120 GW

Europe is second in terms of cumulative PV and wind capacities with 161 GW of PV and 208 GW of wind. Europe's offshore wind capacity is 13% of total European wind capacity. Europe's PV capacity additions are expected to rebound in 2021. Europe's 2021 forecast for PV capacity additions is 12.0 GW. Germany is the top European PV installer and is expected to install 6.4 GW of PV in 2021. Other European countries are also expected to increase PV capacity additions.



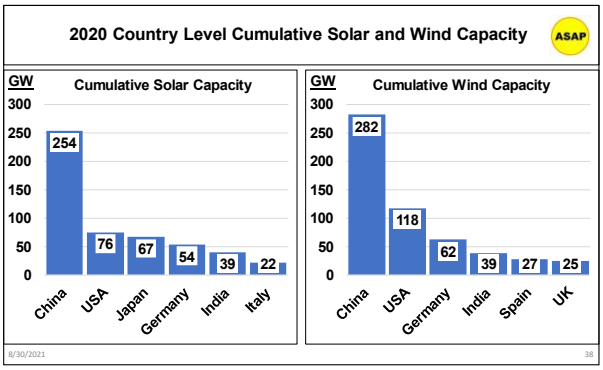
On the country level, China is the world leader in both solar and wind. China installed 49 GW of solar and 72 GW of wind in 2020, which is 38.6% of world PV capacity additions and 64.9% of world wind capacity additions. China's 254 GW of cumulative solar capacity and 282 GW of cumulative wind capacity is 35.6% and 38.5% of world solar and wind cumulative capacity respectively.

The China 2021 forecast for PV capacity additions is 55 GW. China is increasingly adopting distributed rooftop PV installations with 20 GW of distributed systems planned for 2021. China is positioned to dominate the global PV market at least through 2030. China's PV manufacturing base is expected to grow from 80% of world total in 2020 to 90% in 2024.

By 2025, China's annual PV installation rate is expected to exceed 60 GW. With China's current scale-up in PV module, cell, wafer, and polysilicon production, it is conceivable that China will cross the 100 GW annual PV capacity additions threshold before 2030. In addition, China has a massive wind resource base and is expected to ramp-up annual wind capacity additions to the 100 MW level over the next five years.

Polysilicon shortages are causing silicon PV module price increases

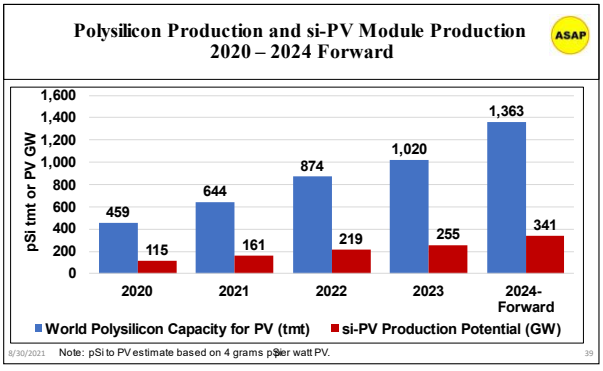
The U.S. has the second largest solar and wind cumulative capacity. The U.S. 2020 cumulative capacity of solar is 76 GW and cumulative wind capacity is 118 GW, which accounts for 10.6% of world solar capacity and 16.1% of world wind capacity. The U.S. is expected to increase annual PV installations from 17 GW in 2021 to 25 GW in 2025, which is a 10% annualized growth rate. Based on China's performance, a U.S. commitment to increase annual PV installations to 60 GW by 2030 appears to be a reasonable goal. The U.S. wind annual capacity additions forecast is 15 GW in 2025 and 20 GW in 2030.



Currently, there is concern about rising silicon PV module prices due to polysilicon shortages. The polysilicon market is tight, and high prices have caused PV module prices to increase about 15%, which has dampened PV demand. At the end of October, polysilicon prices have increased On October 30th, the average polysilicon price is $34.20/kg, which is a whooping 30% increase since the close of October. With strong demand and the announced capacity additions in PV wafer, cell, and module production lines that will be ready for commissioning in 2021, polysilicon supply will likely remain tight into 2022.

Significant polysilicon production increases will come online 2021-2023

Polysilicon price relief is in sight by the middle of 2022. There is 192 tmt (thousand metric tons) of new PV-grade polysilicon production capacity slated to come online by the end of 2021, and an additional 230 tmt is scheduled to come online in 2022. Even with project slippage, the polysilicon production additions should be sufficient to balance polysilicon supply with PV module demand by the middle of 2022 and to drive polysilicon prices back towards $10/kg.



By the end of 2023, China's PV-grade polysilicon production capacity is expected to be about 468 mt greater than the 420 tmt production capacity in 2020. The Chinese expansions bring total world PV-grade polysilicon production capacity to 1,020 tmt in 2023. This PV-grade polysilicon production capacity supports about 255 GW of PV module production, which supports the world forecast for PV annual capacity additions through 2024. Polysilicon producers are planning additional expansions 2024 Forward.

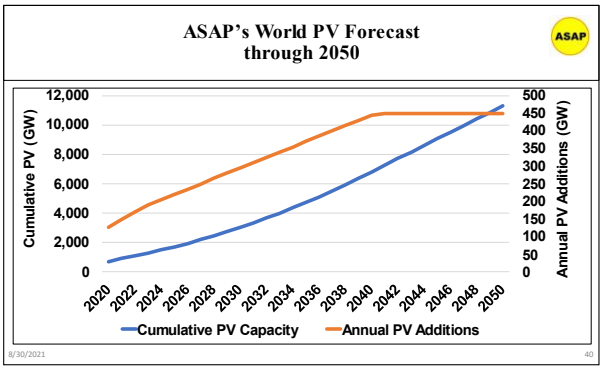
Polysilicon expansions will enable over 250 GW/year of silicon PV module production

The polysilicon to PV module conversion estimate assumes that PV modules consume 4.0 grams of polysilicon per watt of PV module capacity. Bernreuter Research states that PV modules consume 3.6 grams of polysilicon per watt of PV module capacity. To be conservative, ASAP is using 4.0 g/W (+11%) to account for kerf and defect losses, which may or may not be included in the Bernreuter estimate.

Some may doubt the ability of China to increase polysilicon production at the announced rate. However, China has a prior history of building out capital intensive technologies. For example, China successfully commissioned about 4.0 million tonnes of propylene PDH production capacity from 2012 to 2015. China recognizes that initial low plant utilization rates is concomitant with low prices, which breeds demand growth in the years following capacity expansions. With projected world PV demand, China's polysilicon, wafer, cell, and PV module plant utilization rates should reach capacity by 2024.

When world non-silicon, thin film PV module production estimates are added to world silicon PV module production estimates, there is a clear path to 350 GW of total world PV module production 2024 Forward. The PV module production estimates lend support to ASAP's PV 2030 forecast of 310 GW of PV capacity additions.

ASAP forecasts 1,200 GW/year of combined PV and wind capacity additions 2041-2050



By 2031, the polysilicon and PV supply/demand balance is forecast to tighten once again and to justify another round of polysilicon production expansion. To support ASAP's global forecast of 450 GW of annual PV installations in the 2041-2050 timeframe, the PV material resource cycle needs scaled-up by 400-600 tmt in the early 2030s.

The U.S. has plans to manufacture 50 GW of PV by 2030. If these plans materialize, then U.S. polysilicon production will need to be about 200 tmt by 2030 to support the manufacture of U.S. sourced silicon PV models. However, ASAP has not been able to confirm these plans, which are contingent on passage of the Solar Energy Manufacturing for America Act in the U.S. Without sufficient incentives, the U.S. silicon PV market is unlikely to emerge.

IEA Pathway to Net Zero CO_2 Emissions ASAP

Gigawatts of Capacity	2020	2050	% of Total 2050
PV	603	14,458	45%
Wind	623	8,265	26%
Hydro	1,306	2,599	8%
Bio-Energy	153	640	2%
Concentrating Solar Power	6	426	1%
Geothermal	15	126	0%
Nuclear	415	812	3%
Hydrogen	0	1,867	6%
Marine	1	55	0%
Battery Storage	11	3,097	10%

Source: International Energy Agency (IEA), Net Zero by 2050, July 2021 (3rd revision)

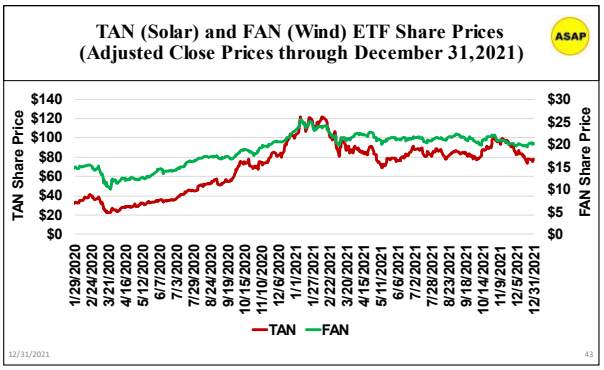
To meet the international goal of limiting the increase in average global temperature to below 2.0 degrees Celsius, ongoing research by the International Energy Agency (IEA) concludes that the world needs to install about 23 TW of PV and wind capacity by 2050 to reach net zero carbon emissions. In addition, the IEA plan calls for 3.0 TW of battery storage and 435 billion kilograms of hydrogen for transportation. ASAP's PV and wind annual installation forecast achieves this target by scaling annual PV installations to 700 GW over the 2041-2050 timeframe. Annual wind installations are scaled to 500 GW from 2041-2050. In addition, ASAP estimates the need for 3.3 TW of wind baseload storage capacity and 5.4 TW of PV storage peak storage capacity. ASAP also models PV for electrolytic hydrogen production of 415 billion kilograms per annum in 2050 for transportation use.

Storage is the primary obstacle to achieving complete zero carbon emissions electricity generation with intermittent PV and wind electricity generation. However, battery, hydrogen, and underground compressed air energy storage systems offer opportunities for PV and wind storage. ASAP estimates the total cost of a PV and wind with storage energy sytem to be in the neighborhood of $3.0 trillion per annum over a thirty-year transition period, 2021-2050. This is a tall order, but it can be done with a firm commitment by the international finance industry.

PV and Wind Industry Financial Performance

In December, TAN share price declined, and FAN share price increased

Each month ASAP reports the share price performance of the TAN (solar) and FAN (wind) ETF index funds as proxy financial indicators of the PV and wind industries.



As shown in the graph, the share prices of the TAN and FAN ETFs have had disappointing performance in 2021. From January 1, 2021 through December 31, 2021, TAN is down $25.79/share (-25.1%), and FAN is down $2.73/share (-11.9%). For the month of December, the TAN share price fell $12.52/share (-14.0%), while the FAN share price increased $0.21/share (+1.0%). The share price declines are attributable to margin squeeze caused by supply chain price increases. However, global demand for PV and wind installations is growing at a healthy rate, which should translate into share price increases for solar and wind companies going forward.

ASAP Methodology

ASAP benchmarks U.S. historical electricity generation and capacity to the Energy Information Administration (EIA) of the U.S. Department of Energy. ASAP benchmarks historical U.S. trade to U.S. Census Bureau trade data. Global data sources include the International Energy Agency (IEA), International Renewable Energy Association (IRENA), European Wind and Solar Industry Associations, China's NEA, and company reports. All forecasts are ASAP generated.