

# PV-Wind Electricity Generation Is 18.4% of Total Generation

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(Data Updates for March 2022)

## U.S. PV-WIND CAPACITY March 2022 PV and Wind Capacity Additions

- In March, PV capacity additions total 1,734 MW.
- In March, wind capacity additions total 1,302 MW.

## U.S. ELECTRICITY GENERATION March 2022 PV and Wind Electricity Generation

- PV and wind electricity production is 18.4% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 5.1% and wind is 13.3%

## TRADE – U.S. PV IMPORTS/EXPORTS U.S. PV Panel Imports Increase in March

- In March, the value of U.S. PV panel imports increased 39% to \$610 million
- Vietnam, Malaysia, Thailand are the top suppliers of U.S. PV panel imports

## WORLD PV-WIND CAPACITY 2022 World PV and Wind Forecast

- The world PV forecast is 165 GW of capacity additions
- The world wind forecast is 90 GW of capacity additions

## PV-WIND COMPANY FINANCIAL PERFORMANCE May 2022 ETF Performance

- For April 2022, TAN (solar) share price performance is negative 14.9%
- For April 2022, FAN (wind) share price performance is negative 8.5%

## SOLAR AND WIND MARKET ANALYTICS

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other

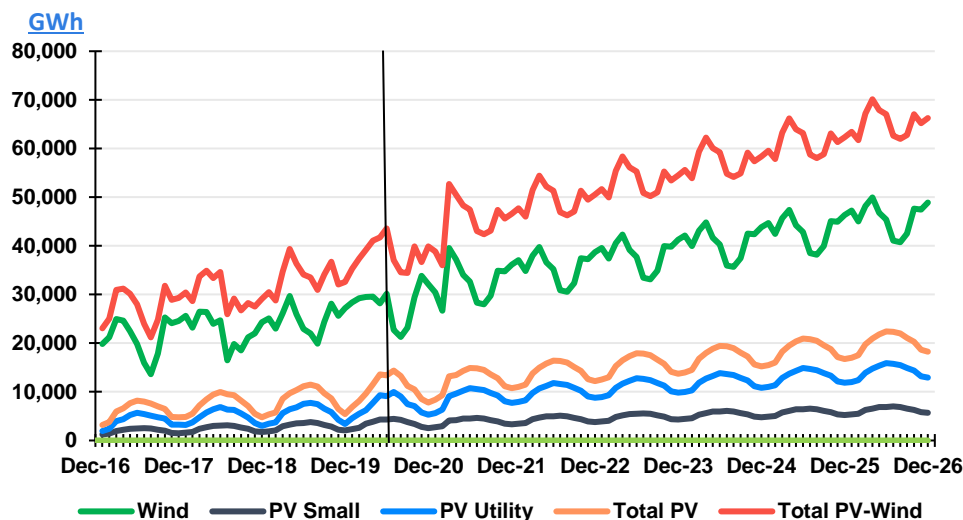
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## PV-Wind Electricity Generation: Actual to Mar-22; Forecast to Dec-26



## U.S. PV and Wind Capacity

In March, U.S. PV capacity increased 1,734 MW, which brings cumulative capacity to 96.8 GW. March utility scale PV capacity additions totaled 1,043 MW, which is 60% of total new PV. In contrast, small PV capacity additions totaled 691 MW. The pace for full year 2022, U.S. PV capacity additions is 17.2 GW, which is shy the 2022 U.S. PV capacity additions forecast of 22.0 GW.

On a regional basis, the Pacific region led in March PV capacity additions with 537 MW. The Southeast and Rocky Mountain regions followed with 373 MW and 341 MW respectively. The top three states for PV capacity additions are California, Nevada, and North Carolina with 468 MW, 312 MW, and 161 MW respectively.

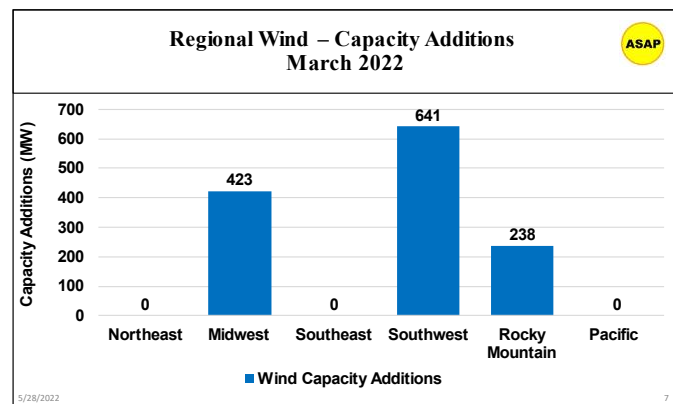
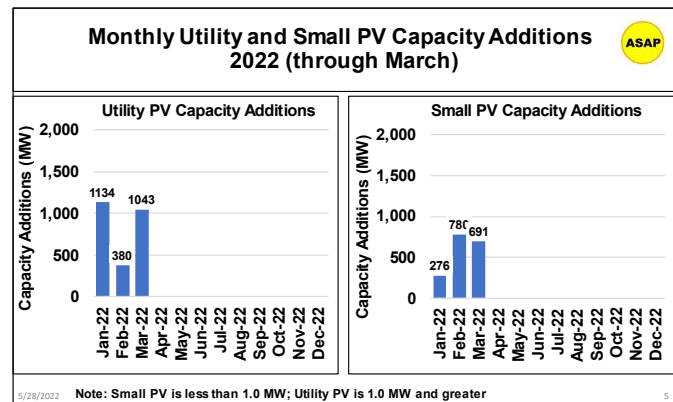
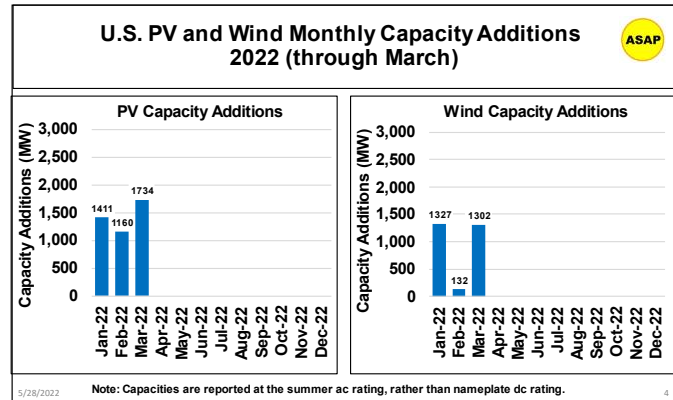
Wind installations in March total a meager 1,302 MW, which brings cumulative wind capacity to 135.2 GW. The pace for full year 2022 U.S. wind capacity additions is 11.0 GW, which below ASAP’s 2022 wind forecast of 15.0 GW. The Southwest and Midwest regions set the pace for March wind capacity additions with 641 MW and 423 MW respectively. The leading states for wind capacity additions are Texas with 495 MW and Nebraska with 298 MW.

The 2022 forecast for PV capacity additions is 22 GW. The 20% increase in U.S. PV capacity additions in 2022 is supported by the solar investment tax credit (ITC). The solar ITC for 2022 is 26% for solar projects in all market segments — residential, commercial, industrial, utility-scale — that begin construction in 2022. In 2023, all PV markets will drop to a 22% ITC. 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.

March U.S. PV capacity additions are 1,734 MW

March wind capacity additions total 1,302 MW

The 2022 PV forecast for capacity additions is 22 GW, and the wind forecast is 15 GW



A downside to the 2022 U.S. PV forecast is the Commerce Department’s pending investigation of source PV materials contained in Southeast Asia PV imports. If any of the materials for PV components is from China sources that are covered by the import tariffs, then the cost of PV from Malaysia, Vietnam, Cambodia, and Thailand could be increased by the assignment of tariffs. ASAP does not believe this will prove to be a serious impediment to PV capacity additions in 2022. This being said, these developments will be monitored closely.

The wind forecast for 2022 is 15 GW. The wind industry has received a limited extension of the wind production tax credit. The wind forecast is constrained by limited areas for development, i.e., the Southwest and Midwest regions. Atlantic offshore wind projects are beginning construction and will enable a modest increase in wind capacity additions going forward.

### U.S. PV-Wind Electricity Generation Update

March combined PV and wind electricity generation is 18.4% of total U.S. electricity generation

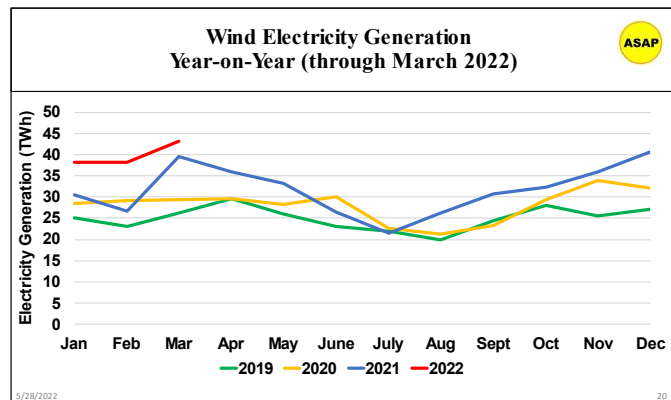
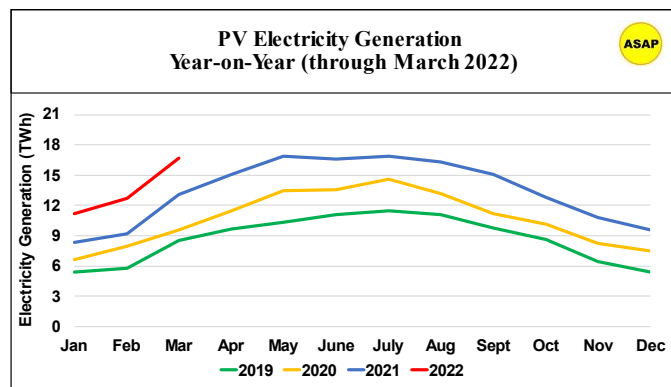
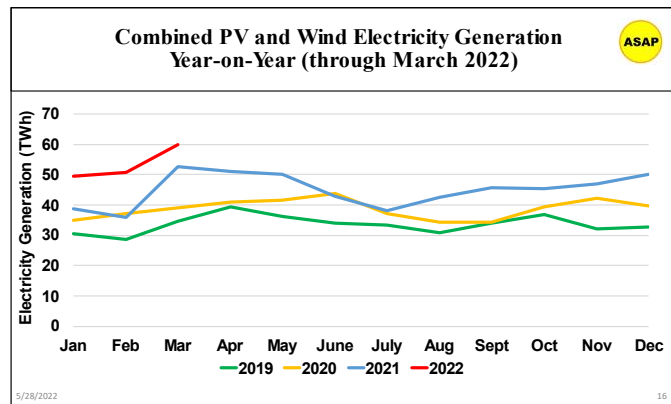
Year-on-year, March PV electricity generation increased 27.4%, and wind electricity generation increased 9.3%

The Pacific region leads the nation in PV electricity generation, and the Midwest region leads in wind electricity generation

In March, PV electricity generation is 16.7 TWh (+31% MoM), and wind electricity generation was 43.2 TWh (+13% MoM). For March, combined PV and wind electricity generation is 18.4% of total U.S. electricity generation, which is a new record high. PV contributes 5.1%, and wind provides 13.3%. ASAP projects PV and wind to produce 4% and 10% of total U.S. electricity generation and wind respectively in 2022.

Year-on-year, March-21 to March-22, PV generation increased 27.4%, and wind generation increased 9.3%. YoY, combined PV and wind electricity generation increased 13.8%.

In March, the Pacific region led the nation in PV electricity generation with 5.4 TWh and is followed by the Southeast region with 3.9 TWh and the Southwest region with 3.0 TWh. California is the leading state with 5.0 TWh of PV



electricity generation, which is 30% of total PV electricity generation in March. Texas follows with 1.9 TWh, Florida with 1.2 TWh, North Carolina with 1.0 TWh, and Arizona with 0.9 TWh.

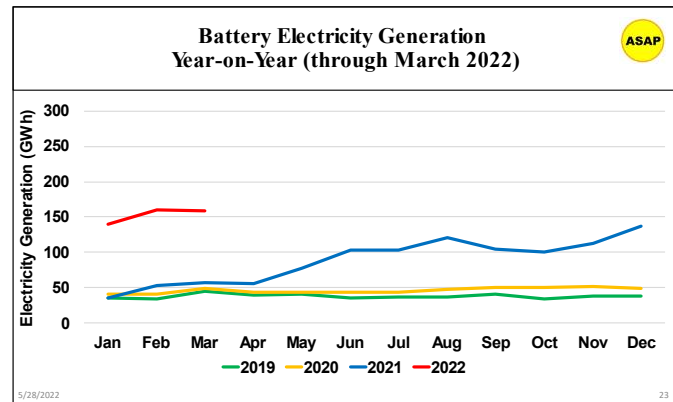
Wind electricity generation in March totaled 43.2 TWh, which is a MoM increase of 13.3%. The leading regions for wind electricity generation are the Midwest with 18.6 TWh and the Southwest with 16.1 TWh. These two regions combined produced 80% of total U.S. wind electricity in March. The Pacific and Rocky Mountain regions are distant third and fourth with 3.4 TWh and 3.3 TWh of electricity generation respectively. Texas is the nation’s leader with 11.1 TWh of wind electricity generation and is followed by Iowa with 4.5 TWh, Oklahoma with 3.5 TWh, and Kansas with 3.0 TWh.

Year-on-year, March-21 to March-22, U.S. wind electricity generation increased 3.3 TWh (+8.2%). YoY, Midwest wind electricity generation increased 2.2 TWh (+13.8%), and Southwest wind electricity generation increased 0.6 TWh (+3.8%).

### U.S. Utility Battery Storage

U.S. battery storage capacity additions totaled 80 MW in March, which increases cumulative battery storage capacity to 4.9 GW. The pace for full year 2022 battery capacity additions is 1.9 GW. The 2022 forecast for battery capacity additions is 5.0 GW.

U.S. cumulative battery storage capacity increases to 4.9 GW in February



The reported March average monthly battery utilization factor is 4.4%, which is an average of 1.1 hours/day. The implied battery electricity generation is 159.2 GWh. From company battery installation announcements, four hours of battery storage is becoming the norm but is not being fully realized.

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.

The March average battery utilization factor is 4.4%

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 2024.

**U.S. PV Trade**

In March, the value of U.S. PV panel imports is \$610 million

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

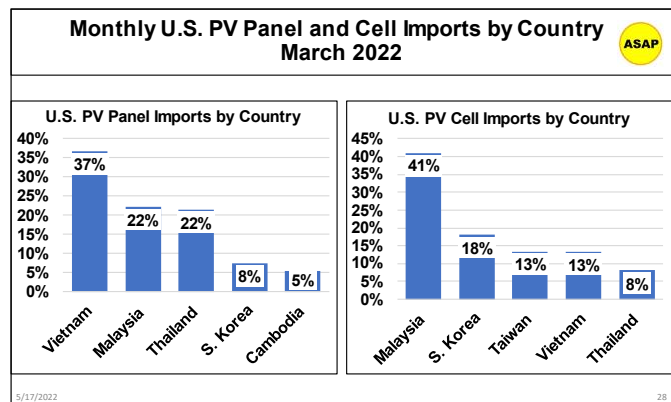
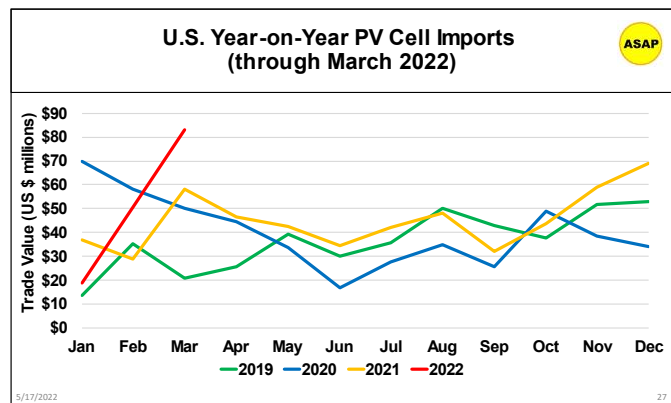
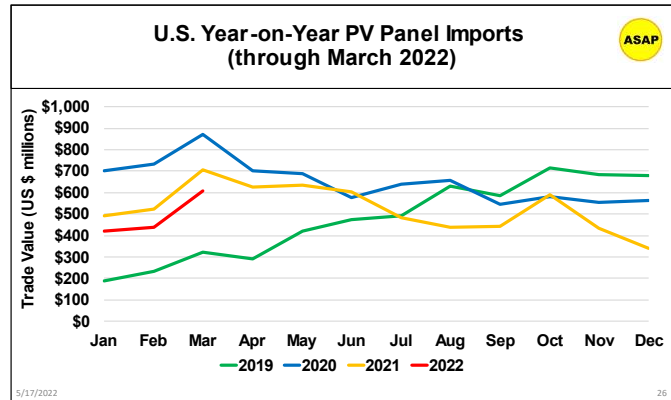
Malaysia, S. Korea, and Taiwan are the top three sources of U.S. PV cell imports in March

In March, the value of U.S. PV panel imports increased 39% month-on-month to \$610 million. The full year pace for U.S. PV panel imports is \$5.9 billion, which is shy the \$7.0 billion forecast. PV trade continues to face headwinds caused by increasing PV prices due to increases in material and freight costs. Another factor causing the decline in PV panel imports is increases in U.S. PV manufacturing capacity.

Silicon prices remain high in March, which signifies continuing tightness in silicon supply. The silicon market will remain tight until new silicon ingot production plants come online with sufficient capacity to balance supply and demand, which is not expected to occur until the second half of 2022. By the end of 2022, silicon prices will decline and support strong market demand for silicon PV, which is driven by ambitious carbon neutrality commitments by all major economies.

Vietnam, Malaysia, and Thailand are the top three countries for U.S. PV panel imports in March. These three countries account for 93% of U.S. PV imports. Vietnam leads the market for U.S. PV panel imports in March with a 37% market share. Malaysia has a 22% share of the U.S. PV panel import market. Thailand rounds out the top three with a 22% share.

Turning attention to U.S. imports of PV cells, the total value of March U.S. PV cell imports increased 84% month-on-month to \$83 million. Malaysia leads U.S. supply of imported PV cells in March with a 41% share. S. Korea and Taiwan round out the top three sources for U.S. PV cell imports with 18% and 13% market share respectively.





In terms of U.S. exports, the value of U.S. PV panels exports in March declined to \$1.2 million. Year-to-date, the value of U.S. PV panel exports is \$3.4 million, which is an annualized pace of \$14.5. This is below the \$20.0 million forecast.

The value of March U.S. PV cell exports increased to \$2.3 million. Year-to-date, the value of U.S. PV cell exports is \$4.2 million, which is an annualized pace of \$16.9. This is above the \$15.0 million annual forecast.

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 manufacturing 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.

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

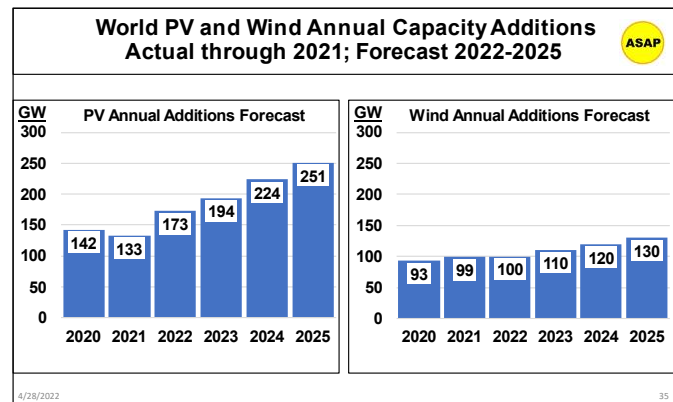
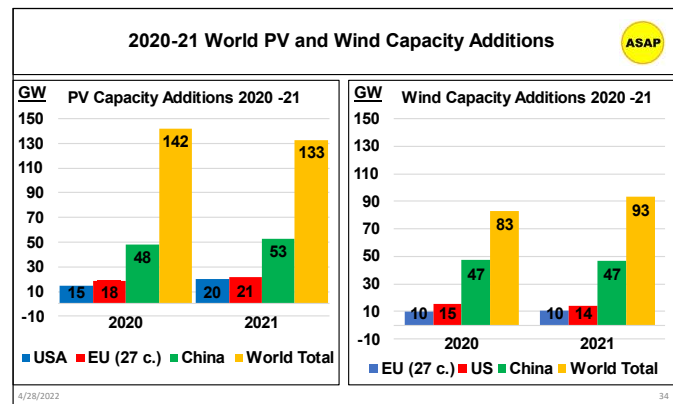
### World PV and Wind

In 2021, annual PV capacity additions totaled 133 GW, which is 6% less than the forecast. World cumulative installed PV capacity increased 18.7% to 843 GW. China, the EU (27 countries), and the U.S. led the way in PV capacity additions in 2021 with 53 GW, 21 GW, and 19 GW respectively.

Wind capacity additions in 2021 totaled 93 GW of installed capacity, which includes both onshore and offshore wind installations. China and the U.S. accounted for 65% of world wind capacity additions with 47 GW and 14 GW respectively. World cumulative installed wind capacity increased 13% in 2021 to 825 GW.

World PV capacity additions totaled 133 GW in 2021

The 2022 forecast for world PV capacity additions is 165 GW and world wind is 100 GW



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 2021, Asia PV capacity additions were 59% of world PV capacity additions. Wind capacity additions in Asia were 57% of world wind capacity additions. In terms of world cumulative capacities, Asia accounts for 57% of PV capacity and 47% of wind capacity.

The 2022 forecast for world PV capacity additions is 165 GW, which is a 20% increase in cumulative capacity. World cumulative capacity of PV should cross the terawatt threshold in 2022. China is expected to install 70 GW of new PV capacity in 2022, while the EU and the U.S. are expected to install 30 GW and 22 GW of new PV capacity respectively.

The 2022 forecast for world wind capacity additions is 100 GW, which is a 12% increase in wind cumulative capacity. China and the U.S. account for the two largest increases in wind capacity additions in 2022. The China forecast is 50 GW of new wind capacity, and the U.S. forecast is 15 GW of new wind capacity.

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.

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, which has dampened PV demand. However, polysilicon price relief is in sight by the second half of 2022.

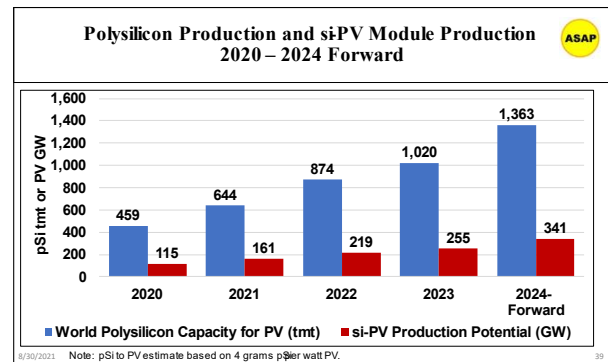
At present, there is 150 tmt (thousand metric tons) of new PV-grade polysilicon production capacity from plants in the commissioning phase. There is an additional 400 tmt of new PV-grade polysilicon production capacity scheduled to come online by the end of 2022. Even with project slippage, the polysilicon production additions should be sufficient to balance polysilicon supply with PV module demand by the middle of 2022 and ease polysilicon prices.

By the end of 2023, China’s PV-grade polysilicon production capacity is expected to be more than double 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 level PV-grade polysilicon production capacity supports about 255 GW of PV module production. Therefore, ASAP is confident that there is sufficient downstream supply to support ASAP’s world annual PV capacity additions forecast through 2024. It should be noted that polysilicon producers are planning additional expansions 2024 Forward.

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.

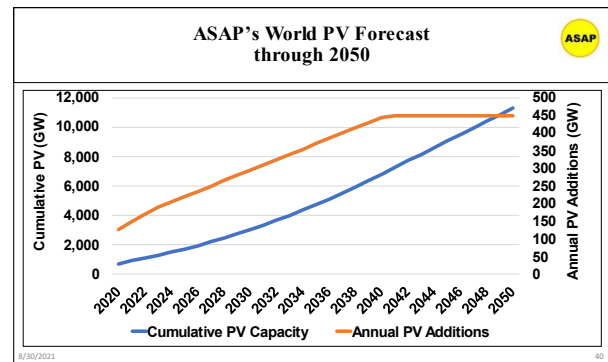
Significant polysilicon production increases will come online 2022-2023

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



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 is added to world silicon PV module production, 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.



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.

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

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.

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 (3<sup>rd</sup> revision)



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 system to be about \$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.

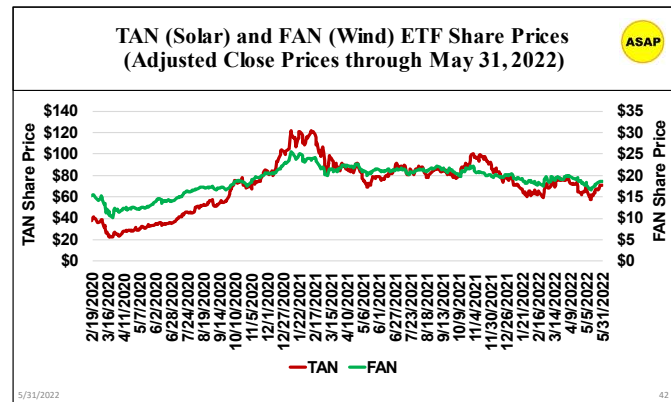
## PV and Wind Industry Financial Performance

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.

In May, the TAN and FAN ETF share prices increased

For the month of April 2022, TAN increased 10.7%, and FAN increased 2.9%. For the year of 2022, TAN is down 7.6%, and

FAN is down 8.0%. As shown in the graph, the share prices of the TAN and FAN ETFs have had disappointing performance over the past year. From the January/March 2021 highs through May 2022, the TAN share price is down 41.7%, and FAN share price is down 27.3%. The share price declines are attributable to margin squeeze caused by supply chain price increases and increases in freight costs. 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 as supply chain issues are resolved. Supply chain cost issues should be easing in the second half of 2022.

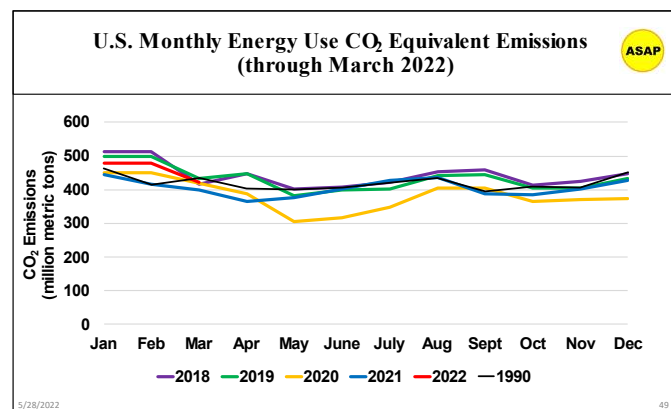


## Carbon Dioxide Emissions from Energy Consumption

U.S. energy related carbon dioxide emissions rebounded from the pandemic induced lows of 2020 as shown in the graph. On a positive note, total U.S. 2021 CO<sub>2</sub> emissions are 3.0% less than the 1990 level. For the past twenty-five years the goal has been to reduce energy use CO<sub>2</sub> emissions to the 1990 level,

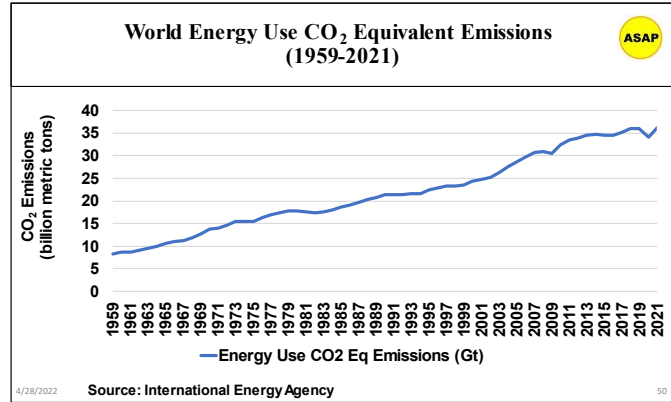
In 2021, U.S. CO<sub>2</sub> emissions fell below the 1990 level

which the U.S. appears to have finally accomplished. This is just the beginning, and it is sobering that it has taken 25 years to achieve this modest reduction in CO<sub>2</sub> emissions.



In 2021, world carbon dioxide emissions set a new record of 36.3 Gt

World carbon dioxide (CO<sub>2</sub>) emissions related to energy consumption and industrial production rose to 36.3 giga-tonnes (Gt) in 2021, which is a new high mark. After a pandemic induced decline in 2020, energy consumption rebounded in 2021 causing the increase in CO<sub>2</sub> emissions. The atmospheric concentration of CO<sub>2</sub> increased 0.5% to 416 parts per million.



### 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.