PV-WIND MONTHLY MARKET UPDATE

U.S. PV Capacity Additions Are 1,160 MW in February

May 2022 Issue

(Data Updates for February 2022)

U.S. PV-WIND CAPACITY **February 2022 PV and Wind Capacity Additions**

- In February, PV capacity additions total 1,160 MW.
- In February, wind capacity additions total 132 MW.

U.S. ELECTRICITY GENERATION **February 2022 PV and Wind Electricity Generation**

- PV and wind electricity production is 15.5% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 3.9% and wind is 11.6%

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

- In February, the value of U.S. PV panel imports increased 4% to $439 million
- Vietnam, Malaysia, Thailand are the top suppliers of U.S. PV panel imports

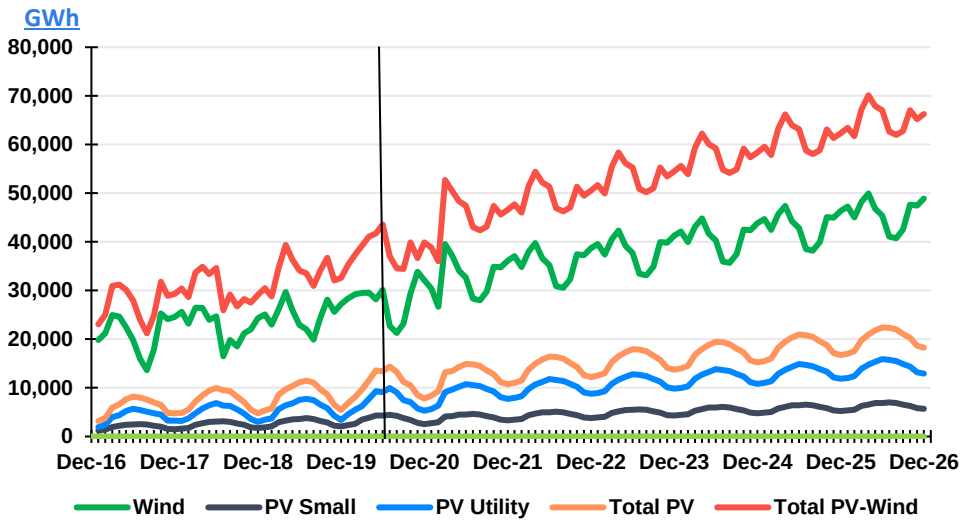
WORLD PV-WIND CAPACITY **2022 World PV and Wind Forecast**

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

PV-WIND COMPANY FINANCI2AL PERFORMANCE **April 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%

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



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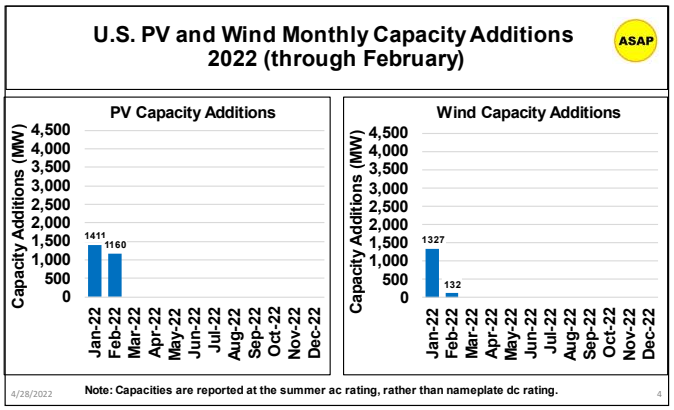
Battery Storage Analysis

Global Warming Update

U.S. PV and Wind Capacity

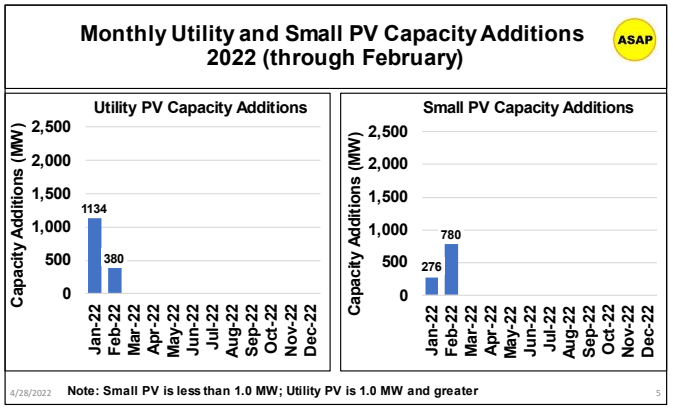
February U.S. PV capacity additions are 1,160 MW

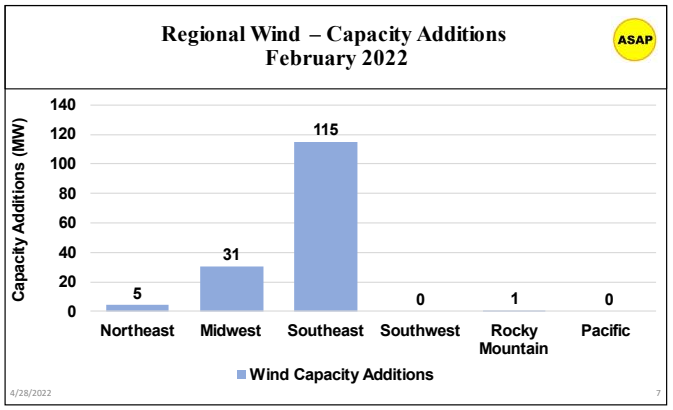
In February, U.S. PV capacity increased 1,160 MW, which brings cumulative capacity to 95.1 GW. February utility scale PV capacity additions totaled 380 MW, which is 33% of total new PV. In contrast, small PV capacity additions totaled 780 MW. The pace for full year 2022, U.S. PV capacity additions is 15.4 GW, which is shy the 2022 U.S. PV capacity additions forecast of 22.0 GW.



February wind capacity additions total 132 MW

On a regional basis, the Pacific region led in February PV capacity additions with 402 MW. The Northeast and Southeast regions followed with 331 MW and 218 MW respectively. The top three states for PV capacity additions are California, Florida, and Rhode Island with 387 MW, 129 MW, and 90 MW respectively.





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

Wind installations in February total a meager132 MW, which brings cumulative wind capacity to 133.9 GW. The pace for full year 2022 U.S. wind capacity additions is 8.8 GW, which far below ASAP's 2022 wind forecast of 15.0 GW. The Southeast and Midwest regions set the pace for February wind capacity additions with 115 MW and 31 MW respectively. The leading states for wind capacity additions are West Virginia with 115 MW and Iowa with 28 MW.

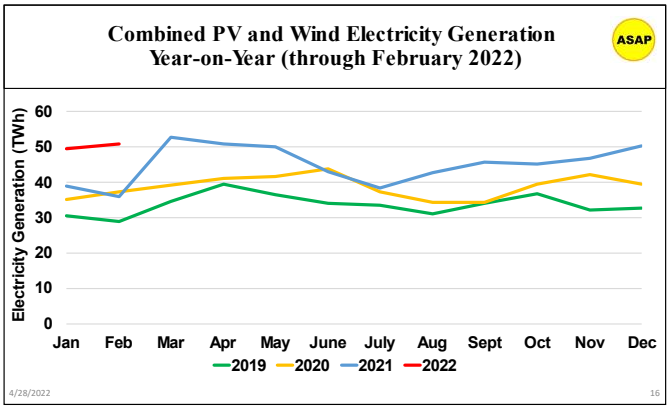
The 2022 forecast for PV capacity additions is 22 GW. The 20% increase in U.S. PV capacity additions in 2022 is supported by the solar investment tax credit (ITC). The solar ITC for 2022 is 26% for solar projects in all market segments — residential, commercial, industrial, utility-scale — that begin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

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

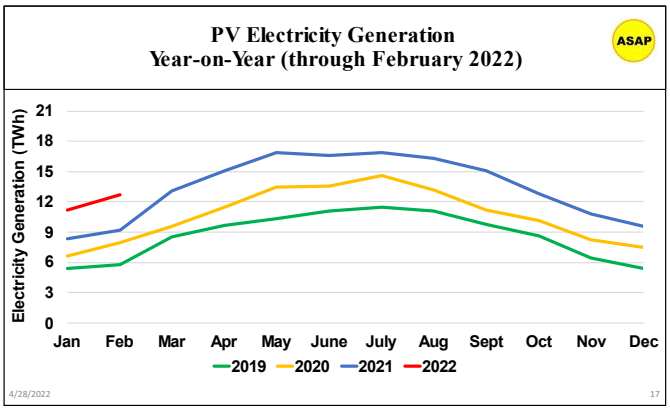
February combined PV and wind electricity generation is 15.5% of total U.S. electricity generation

In February, PV electricity generation is 12.7 TWh (+13.6% MoM), and wind electricity generation was 38.2 TWh (-0.1% MoM). For February, combined PV and wind electricity generation is 15.5% of total U.S. electricity generation. PV contributes 3.9%, and wind provides 11.6%. ASAP projects PV and wind to produce 5% and 10% of total U.S. electricity generation and wind respectively in 2022.



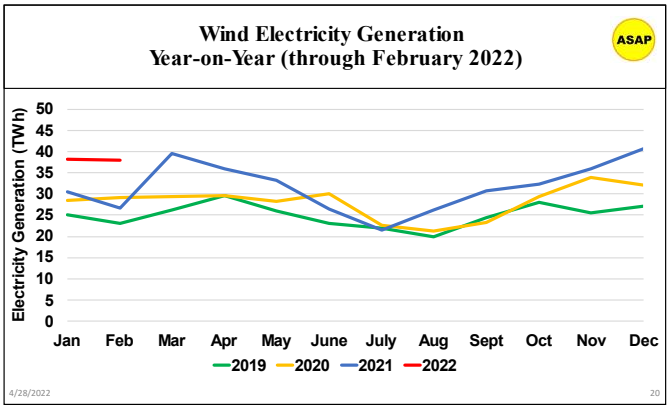
Year-on-year, February PV electricity generation increased 38.0%, and wind electricity generation increased 43.1%

Year-on-year, February-21 to February-22, PV generation increased 38.0%, and wind generation increased 43.1%. YoY, combined PV and wind electricity generation increased 41.8%.



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

In February, the Pacific region led the nation in PV electricity generation with 4.0 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 3.7 TWh of PV electricity generation, which is 29% of total PV electricity generation in February. Texas follows with 1.6 TWh, Florida with 1.0 TWh, North Carolina with 0.8 TWh, and Arizona with 0.7 TWh.



Wind electricity generation in February totaled 38.2 TWh, which is a MoM decline of 0.1%. The leading regions for wind electricity generation are the Midwest with 17.2 TWh and the Southwest with 13.3 TWh. These two regions combined produced 80% of total

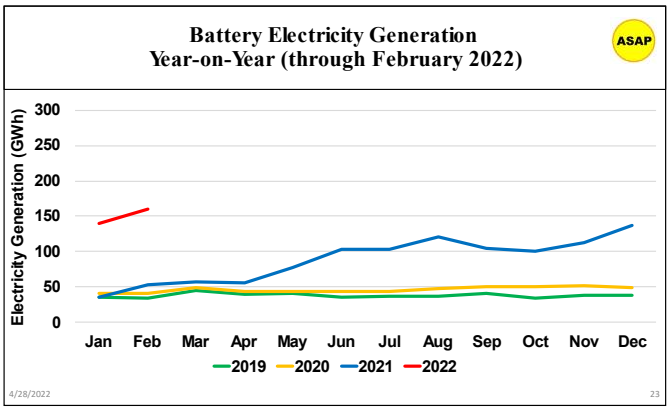
U.S. wind electricity in February. The Rocky Mountain and Pacific regions are distant third and fourth with 4.4 TWh and 3.2 TWh of electricity generation respectively. Texas is the nation's leader with 8.8 TWh of wind electricity generation and is followed by Iowa with 4.1 TWh, Oklahoma with 3.1 TWh, and Kansas with 2.6 TWh.

Year-on-year, February-21 to February-22, U.S. wind electricity generation increased 11.5 TWh (+43.1%). YoY, Midwest wind electricity generation increased 6.0 TWh (+54.0%), and Southwest wind electricity generation increased 4.1 TWh (+45.0%), and.

U.S. Utility Battery Storage

U.S. cumulative battery storage capacity increases to 4.8 GW in February

U.S. battery storage capacity additions totaled 76 MW in February, which increases cumulative battery storage capacity to 4.8 GW. The pace for full year 2022 battery capacity additions is 2.4 GW. The 2022 forecast for battery capacity additions is 5.0 GW.



The reported February average monthly battery utilization factor is 5.0%, which is an average of 1.2 hours/day. The implied battery electricity generation is 160.7 GWh. From company battery installation announcements, four hours of battery storage is becoming the norm but is not being fully realized.

The February average battery utilization factor is 5.0%

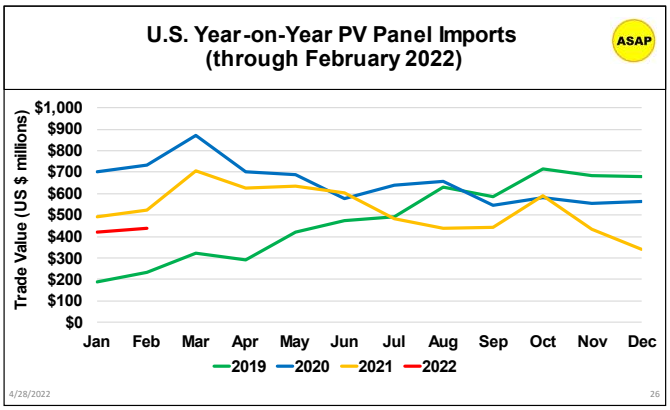
Obviously, variability in PV and wind electricity production requires electricity storage to convert PV and wind into a dependable supply of on-demand electricity. At present, the U.S. has approximately 800 GW of fossil fuel power plants, which implies the need for hundreds of GW of storage if PV and 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.

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

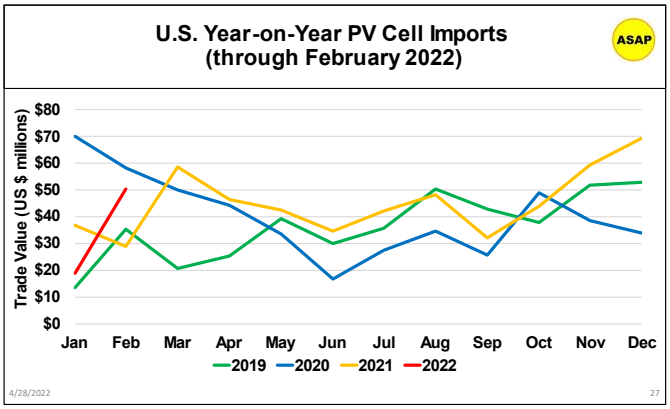
In February, the value of U.S. PV panel imports is $439 million

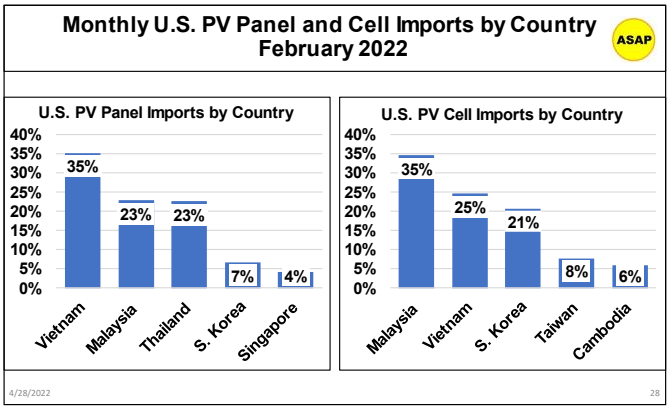
In February, the value of U.S. PV panel imports increased 4.0% month-on-month to $439 million. For full year pace of U.S. PV panel imports is $5.2 billion, which is shy the $7.0 billion forecast. PV trade continues to face headwinds caused by increasing PV prices due to increases in material and freight costs. Another factor causing the decline in PV panel imports is increases in U.S. PV manufacturing capacity.



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

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.





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

Vietnam, Malaysia, and Thailand are the top three countries for U.S. PV panel imports in February. These three countries account for 81% of U.S. PV imports. Vietnam leads the market for U.S. PV panel imports in February with a 35% market share. Malaysia has a 23% share\of the U.S. PV panel import market. Thailand rounds out the top three with a 23% share.

Turning attention to U.S. imports of PV cells, the total value of February U.S. PV cell imports increased 170.6% month-on-month to $50 million. Malaysia leads U.S. supply of imported PV cells in February with a 35% share. Vietnam and Thailand round out the top three sources for U.S. PV cell imports with 25% and 21% market share respectively.

In terms of U.S. exports, the value of U.S. PV panels exports in February increased to $1.5 million. Year-to-date, the value of U.S. PV panel exports is $2.1 million, which is an annualized pace of $12.9. This is below the $20.0 million forecast.

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

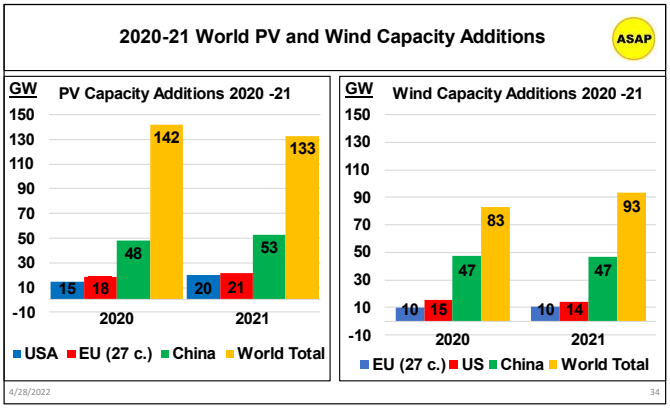
The value of February U.S. PV cell exports increased to $0.8 million. Year-to-date, the value of U.S. PV cell exports is $1.9 million, which is an annualized pace of $11.4. This is below the $15.0 million forecast.

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.

World PV and Wind

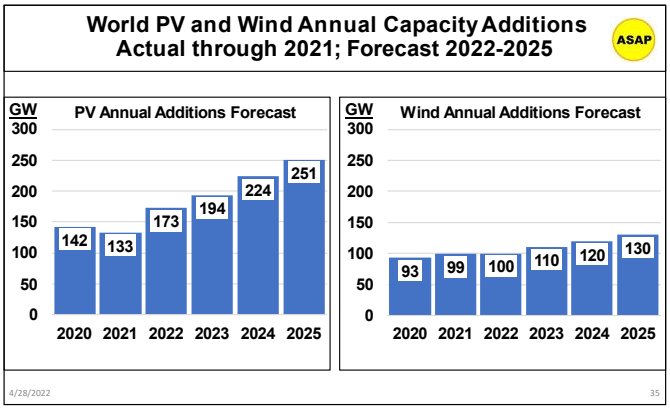
World PV capacity additions totaled 133 GW in 2021

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.



World wind capacity additions totaled 93 GW in 2021

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.



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.

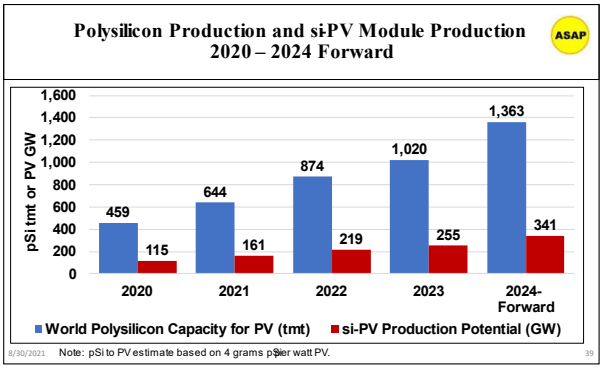
The 2025 forecast for cumulative PV capacity is 1.62 TW (terawatts). The 2025 forecast for cumulative wind capacity is 1.19 TW. The annualized growth rate, 2020-2025, for PV capacity additions is 18.1% and for wind capacity additions is 10.2%.

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.

Significant polysilicon production increases will come online 2022-2023

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.



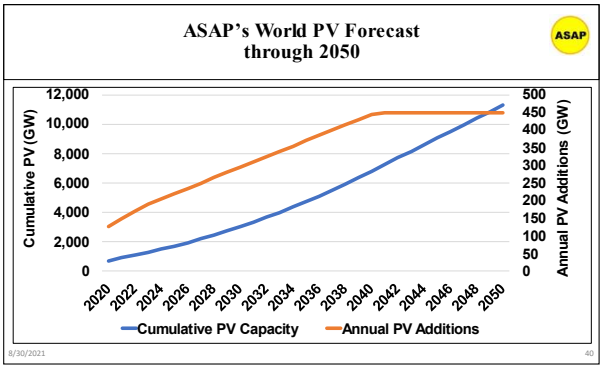
Polysilicon expansions will enable over 250 GW/year of silicon PV module production

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.

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.

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

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.

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.

IEA Pathway to Net Zero CO_2 Emissions ASAP

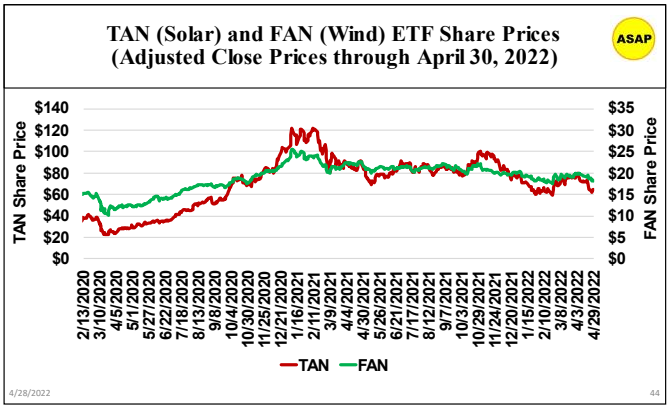
Gigawatts of Capacity	2020	2050	% of Total 2050
PV	603	14,458	45%
Wind	623	8,265	26%
Hydro	1,306	2,599	8%
Bio-Energy	153	640	2%
Concentrating Solar Power	6	426	1%
Geothermal	15	126	0%
Nuclear	415	812	3%
Hydrogen	0	1,867	6%
Marine	1	55	0%
Battery Storage	11	3,097	10%

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

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.

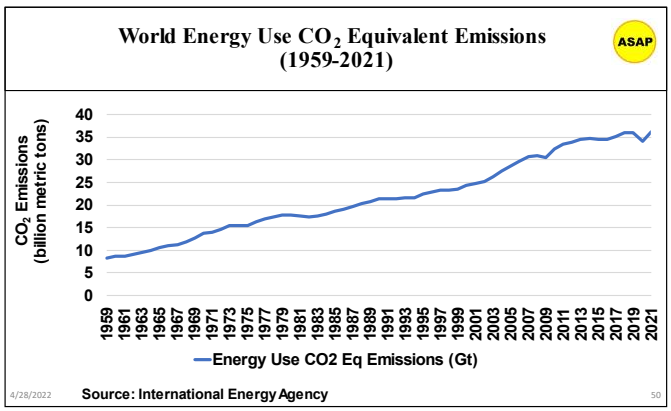


In April, the TAN and FAN ETF share prices declined

For the month of April 2022, TAN declined 14.9%, and FAN declined 8.5%. For the year of 2022, TAN is down 16.6%, and FAN is down 10.6%. 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/February 2021 highs through April 2022, the TAN share price is down 47.3%, and FAN share price is down 29.3%. 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

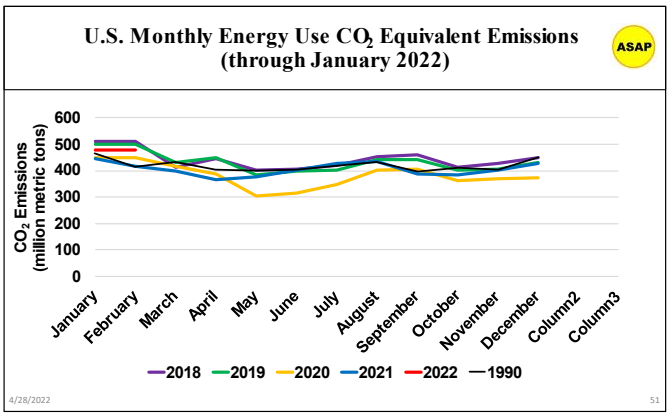
World carbon dioxide (CO_2) emissions related to energy consumption and industrial production rose to 36.3 giga-tonnes (Gt) in 2021, which is a new high mark. After a pandemic induced decline in 2020, energy consumption rebounded in 2021 causing the increase in CO_2 emissions. The atmospheric concentration of CO_2 increased 0.5% to 416 parts per million.



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

In 2021, U.S. CO_2 emissions fell below the 1990 level

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_2 emissions are 3.0% less than the 1990 level. For the past twenty-five years the goal has been to reduce energy use CO_2 emissions to 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_2 emissions.



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.