PV-WIND MONTHLY MARKET UPDATE

Net PV Capacity Additions Are 2,908 MW in December

March 2023 Issue

(Data Updates for December 2022)

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

- In December, PV capacity additions total 2,908 MW
- In December, wind capacity additions total 1,677 MW

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

- PV and wind electricity production is 13.9% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 3.1% and wind is 10.8% of total

TRADE – U.S. PV IMPORTS/EXPORTS **U.S. PV Panel Imports Set Record in December**

- In December, the value of U.S. PV panel imports increased 17.8% to $1.4 billion
- Vietnam, S. Korea, and Thailand are the top suppliers of U.S. PV panel imports

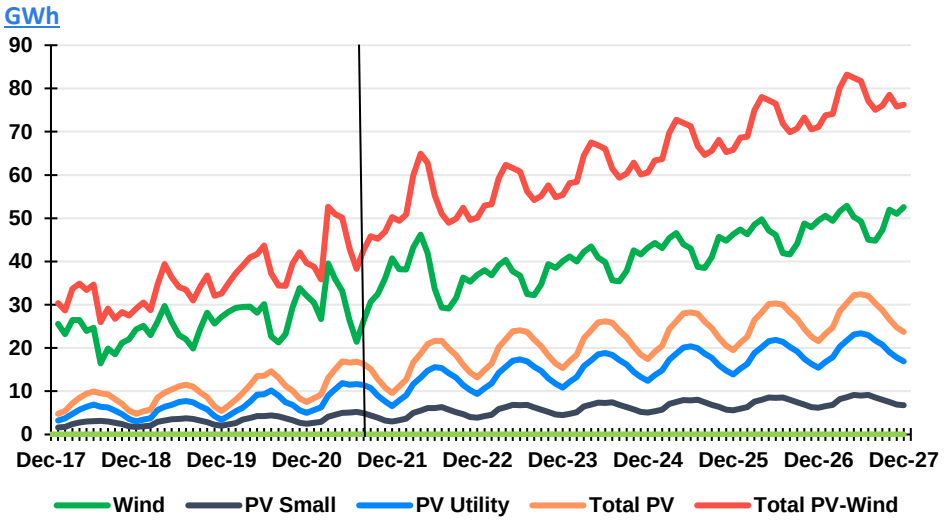
WORLD PV-WIND CAPACITY **2023 World PV and Wind Forecast**

- The world PV forecast is 205 GW of capacity additions
- The world wind forecast is 60 GW of capacity additions

PV-WIND COMPANY FINANCI2AL PERFORMANCE **February ETF Share Performance**

- For February 2022, TAN (solar) share price performance is a negative 8.1%
- For February 2022, FAN (wind) share price performance is a negative 4.6%

PV-Wind Electricity Generation: Actual to Dec-22; Forecast to Dec-27



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RELEVANT ASAP REPORTS

PV-Wind Monthly Slideshow

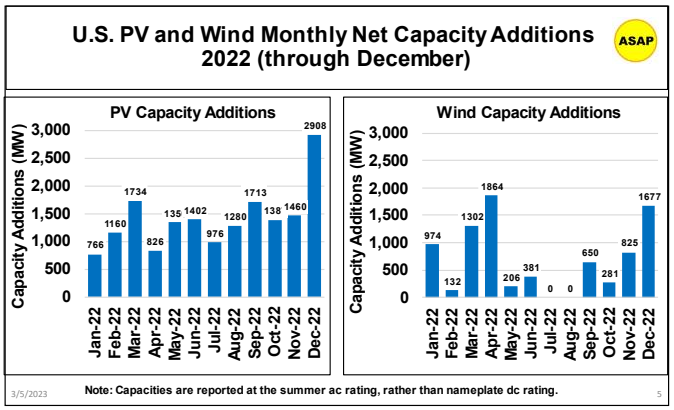
Battery Storage Analysis

Global Warming Update

U.S. PV and Wind Capacity

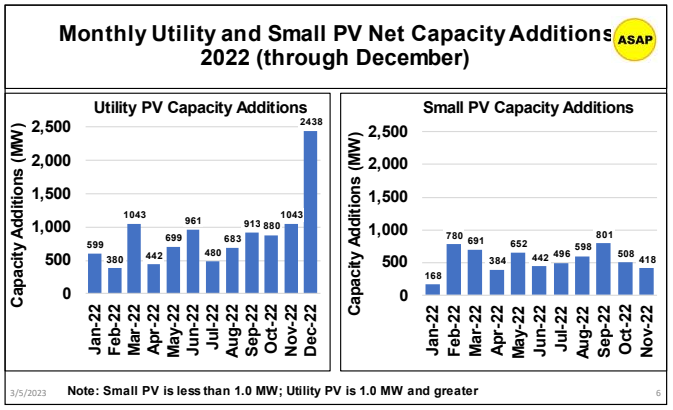
December U.S. PV capacity additions total 2,908 MW

In December, U.S. PV net capacity additions total 2,908 MW, which brings cumulative capacity to 110.1 GW. December utility scale PV capacity additions totaled 2,438 MW, which is 83% of total new PV. On the other hand, small PV capacity additions totaled 469 MW. For the full year, PV capacity additions totaled 17.0 GW, which is 23% short the 22.0 GW forecast.

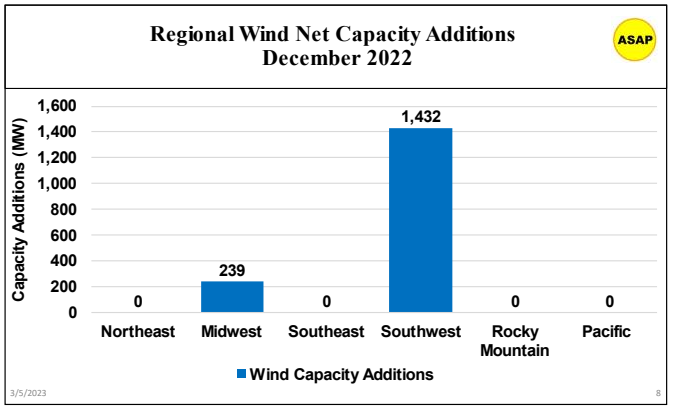


December wind capacity additions total 1,677 MW

Wind installations in December total 1,677 MW, which brings cumulative wind capacity to 140.9 GW. For the full year, U.S. wind capacity additions totaled 8.2 GW, which is 45% below ASAP's 2022 wind forecast of 15.0 GW. ASAP's 2023 wind capacity additions forecast is 10 GW.



The Southwest region set the pace for December wind capacity additions with 1,432 MW and is followed by the Midwest region with 239 MW. The leading state for wind capacity additions is Texas with 1,432 MW and is followed by Minnesota and Iowa with 134 MW and 99 MW respectively.



In 2022, PV capacity additions are 23% below the 22 GW forecast, and wind capacity additions are 45% below the 15 GW forecast

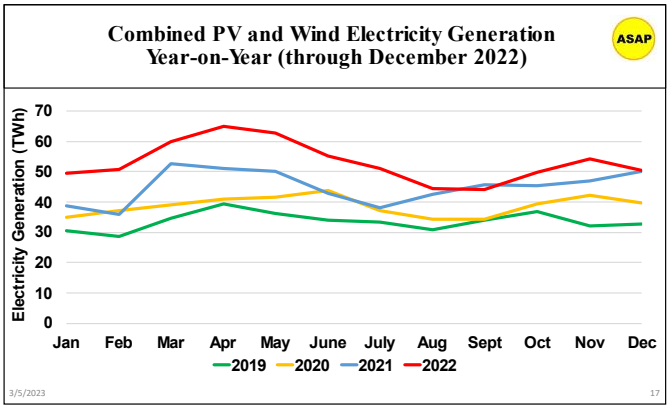
The PV forecast is supported by recent PV import tariff modifications for Southeast Asian countries imposed by President Biden and the massive renewable energy incentive package passed by Congress in December. The wind forecast is constrained by limited areas for development and transmission, i.e., the Southwest, Midwest, and Rocky Mountain regions. Atlantic offshore wind projects are beginning construction and will enable a modest increase in wind capacity additions going forward.

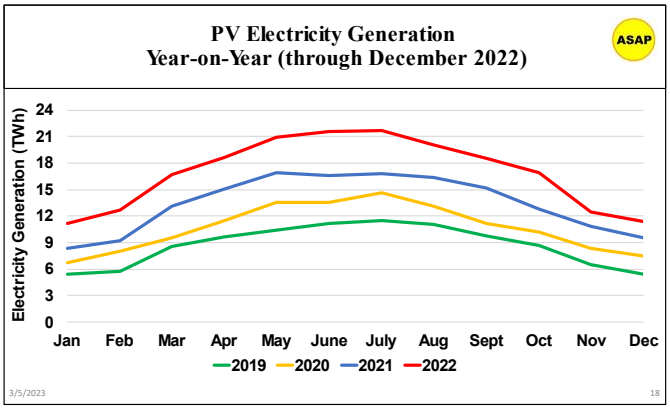
U.S. PV-Wind Electricity Generation Update

In December, combined PV and wind electricity generation is 13.9% of total U.S. electricity generation

In December, PV generated 11.4 TWh of electricity, and wind turbines generated 39.2 TWh of electricity. For December, combined PV and wind electricity generation is 13.9% of total U.S. electricity generation. PV contributes 3.1%, and wind provides 10.8%. For the full year of 2022, PV and wind produced 4.8% and 10.2% of total annual U.S. electricity generation respectively.

Year-on-year, December-21 to December-22, PV generation increased 19.3%, and wind generation declined 3.7%. YoY, combined PV and wind electricity generation increased 0.7%.





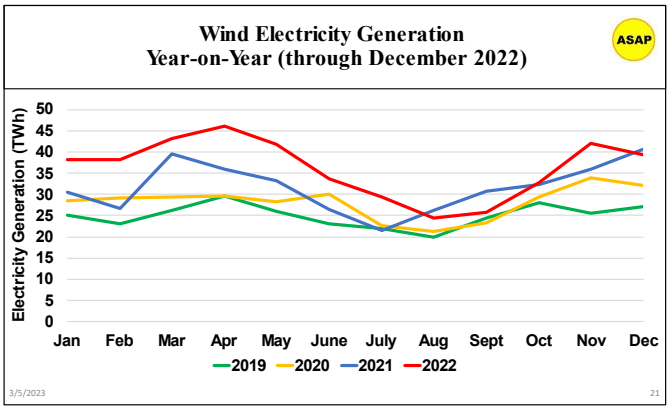
U.S. Utility Battery Storage

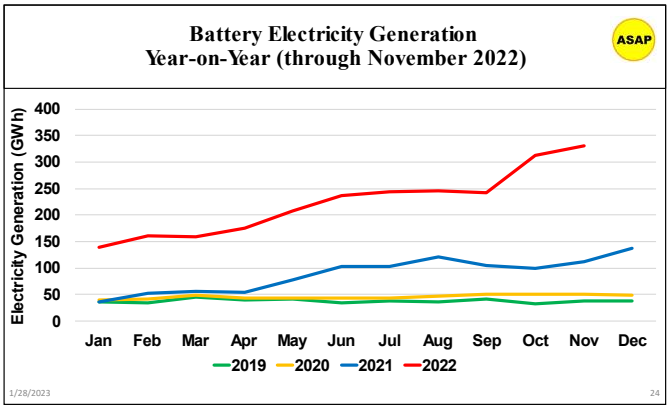
In December, battery storage capacity additions are 66 MW

U.S. battery storage capacity additions totaled 66 MW in December, which increases cumulative battery storage capacity to 8.6 GW. For the full year, battery capacity additions totaled 4.1 GW, which is 18% shy the 2022 forecast of 5.0 GW.

U.S. cumulative battery storage capacity increases to 7.8 GW in December

The reported December average monthly battery utilization factor is 5.3%, which is a daily average of 1.3 hours. The implied battery electricity generation is 331 GWh. From company battery installation announcements,





four hours of battery storage capacity 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 capacity 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 at approximately 22 GW 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.

PV Market Summary 2022-2023

Global PV prices are beginning to decline with ongoing resolution of supply chain bottlenecks

China polysilicon and PV prices are declining. Spot polysilicon prices have plunged 50% since the end of 2022, and PV prices are down 20%. These developments bode well for global PV growth in 2023.

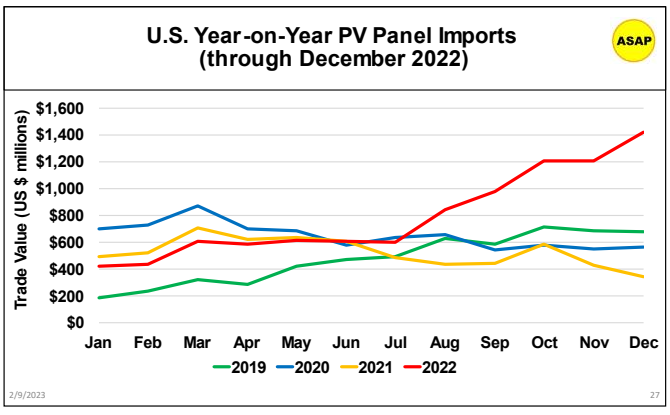
On the other hand, U.S. PV demand has slowed in the face of high prices resulting in project slippage into 2023. However, at the end of February silicon prices have declined over 20% from their highs in the fourth quarter of 2022 but are still very high at an average spot price of $35/kg (230 RMB). Chinese upstream manufacturers are searching for prices that will clear growing inventories but support continued production growth. In the final analysis, with declining supply chain prices the global PV market should experience healthy growth in 2023.

U.S. PV Trade

In December, the value of U.S. PV panel imports increased 17.8% month-on-month to $1.4 billion. For the full year, the value of U.S. PV panel imports is

In December, the value of U.S. PV panel imports is $1.4 billion

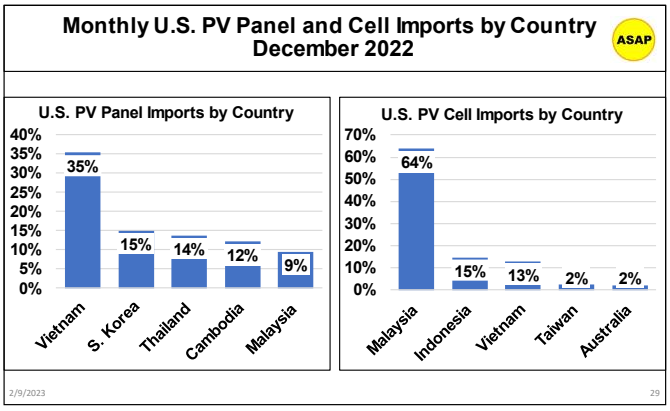
$9.6 billion, which exceeds the $8.3 billion annual forecast. While PV prices remain high due to high polysilicon and other commodity prices, price pressure has been alleviated by the two-year freeze on U.S. import tariffs for PV modules and cells produced in the Southeast Asian countries of Malaysia, Vietnam, and Thailand.



Silicon prices remain high, which signifies continuing tightness in silicon supply. Silicon capacity additions in 2022 have resulted in price relief in early 2023. Silicon prices have declined from $45/kg in the fourth quarter of 2022 to the neighborhood of $30/kg at the end of February 2023. This should step up market demand for silicon PV going forward. PV demand is strong and is driven by ambitious carbon neutrality commitments of all major economies.

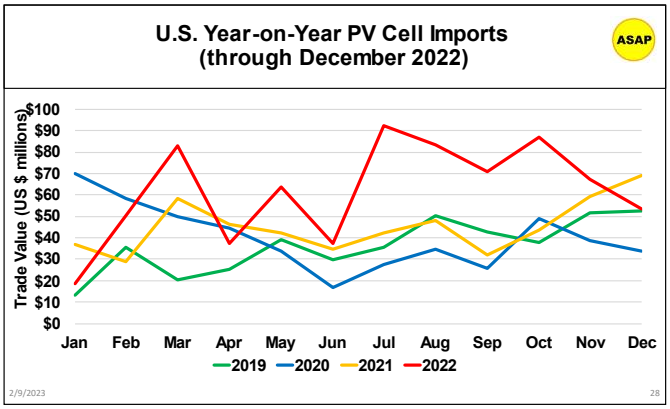
Vietnam, S. Korea, and Thailand are the top three sources of U.S. PV panel imports in December

Vietnam, South Korea, and Thailand are the top three countries for U.S. PV panel imports in December. These three countries account for 85% of total U.S. PV imports. Vietnam leads the market for U.S. PV panel imports in December with a 35% market share. S. Korea has a 15% share of the U.S. PV panel import market, and Thailand rounds out the top three with a 14% share.



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

Turning attention to U.S. imports of PV cells, the total value of December U.S. PV cell imports declined 22.9% month-on-month to $67.1 million. Malaysia leads U.S. supply of imported PV cells in December with a 64% share. Indonesia and Vietnam round out the top three sources for U.S. PV cell imports with 15% and 13% market share respectively. These three countries account for 96% of U.S. PV cell imports in December. In 2022 Malaysia has replaced South Korea as the dominant source of the U.S. PV cell imports. In turn, South Korea is a major supplier of PV panel imports.



In terms of U.S. exports, the value of U.S. PV panel exports in December declined month-on-month 69.0% to $1.6 million. Year-to-date, the value of U.S. PV panel exports is $22.2 million, which exceeds the $20.0 million forecast.

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

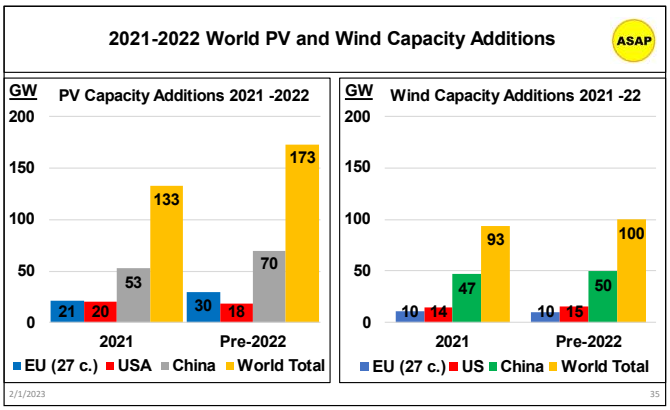
The value of December U.S. PV cell exports declined month-on-month 37.8% to $1.5 million. Year-to-date, the value of U.S. PV cell exports is $25.5 million, which far exceeds the $15.0 million annual forecast for U.S. PV cell exports.

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

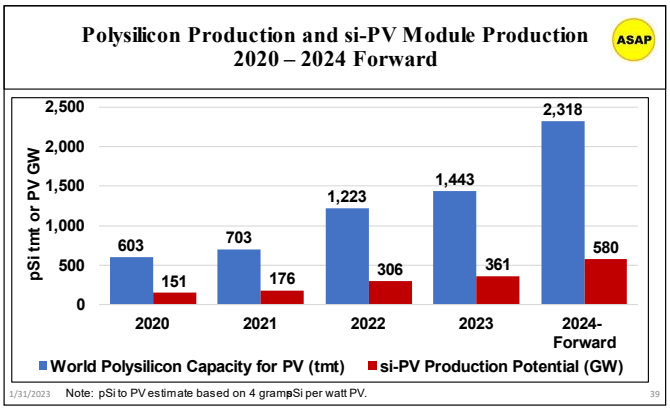
World PV capacity additions met the 165 GW forecast for 2022

Preliminary reports indicate that global PV capacity additions exceeded the 165 GW forecast for 2022. China and the EU appear to have met their PV forecast, while the U.S. is expected to fall short. The story is similar for global wind.



China increases polysilicon production capacity by over 500 MT in 2022

2022 was a pivotal year in terms of supply chain growth for expanding global PV manufacturing. For most of 2022, supply chain constraints raised PV prices, which stymied global demand. The PV industry responded with massive growth in polysilicon production and other supply chain components bringing global PV production capacity to over 300 GW by the end of 2022.



China manufacturers continue to dominate the PV market. In 2022, China commissioned about 500 MT (thousand tonnes) of new polysilicon production capacity. China's polysilicon production capacity exceeds one million tonnes and is expected to grow by another 200 MT in 2023.

With the commissioning of 500 MT, China's polysilicon inventories began to grow. This has led to a decline in polysilicon prices beginning in December of 2022. Spot polysilicon prices have declined 24% from the $46/kg high in 2022 to end February 2023 at $35/kg. This translates into declining spot PV module prices, which are down about 15% at the end of February. Polysilicon prices will likely continue to decline in 2023 to clear the polysilicon market.

Global PV module manufacturing capacity is over 300 GW and growing to 400 GW by 2024

At the end of 2022 global c-Si PV module production capacity is over 300 GW and is expected to increase another 50+ GW by the end of 2023. In other words, global PV is poised for a breakout year in 2023 with a forecast of 220 GW of PV capacity additions. The polysilicon to PV module conversion estimate assumes that PV modules consume 4.0 grams of polysilicon per watt of PV module capacity, which accounts for kerf and defect losses.

By 2026, 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 have an annual PV manufacturing base of 50 GW by 2030. If these plans materialize, then U.S. polysilicon production will need to be about 200 MT (thousand tonnes) by 2030 to support the manufacture of U.S. sourced silicon PV modules. 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.

Global PV capacity additions need to reach 500-600 GW by 2030 to meet net zero energy emissions targets

IEA Pathway to Net Zero CO_2 Emissions

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 rd 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 500-600 GW over the 2030-2050 timeframe. Annual wind installations are scaled to 350 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.

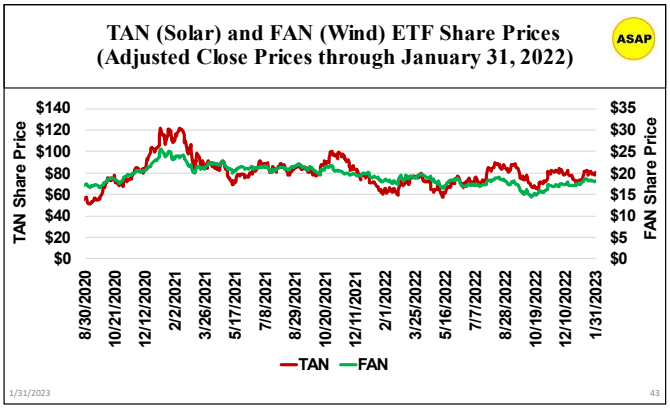
Storage is the primary obstacle to achieving complete zero carbon emissions electricity generation with intermittent PV and wind electricity generation. However, battery, hydrogen, and underground compressed air energy storage systems offer opportunities for PV and wind storage. ASAP estimates the total cost of a PV and wind with storage energy 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.

Wind companies state that they are facing headwinds that include slow permitting, electric grid constraints, and regulatory uncertainty. Such market conditions are, in turn, causing "sizeable losses" in the wind business, employment destruction and investment constraint. The companies conclude that the "sizeable gap between recent installation expectations and targets" is endangering the energy transition.

PV and Wind Industry Financial Performance

In February, both TAN ETF and FAN ETF share prices declined

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.



For the month of February 2023, the TAN ETF share price declineded 8.1%, and the FAN ETF share price declined 4.6%. For the year of 2022, TAN is up 1.9%, and FAN is down 0.5%.

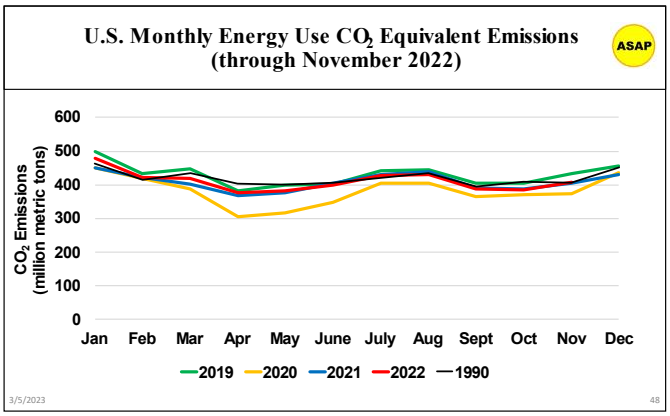
As shown in the graph, the share prices of the TAN and FAN ETFs have had disappointing performance over the past year relative to 2021 highs. From the January 2021 highs through February 2023, the TAN share price is down 39.1%, and FAN share price is down 27.7%. The share price declines are attributable to margin squeeze caused by supply chain price increases and increases in freight costs.

It is important to note that supply chain costs are improving with declining PV prices at the beginning of 2023. 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 with continuing improvement in supply chain issues.

Carbon Dioxide Emissions from Energy Consumption

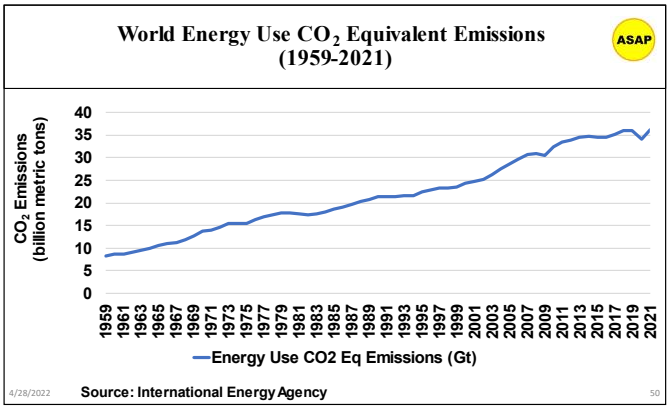
In 2021, U.S. CO_2 emissions fell below the target 1990 level

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 relatively modest reduction in CO_2 emissions.



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

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.



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, Taiwan's Infolink, and company reports.