PV-WIND MONTHLY MARKET UPDATE

Net PV Capacity Additions Are 3,216 MW in March

June 2024 Issue

(Data Updates for March 2024)

U.S. PV-WIND CAPACITY **March 2024 PV and Wind Capacity Additions**

- In March, PV capacity additions total 3,216 MW
- In March, wind capacity additions total 132 MW

U.S. ELECTRICITY GENERATION **March 2024 PV and Wind Electricity Generation**

- PV and wind electricity production is 21.2% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 7.0% and wind is 14.2%

TRADE – U.S. PV IMPORTS/EXPORTS **March 2024 U.S. PV Panel Imports**

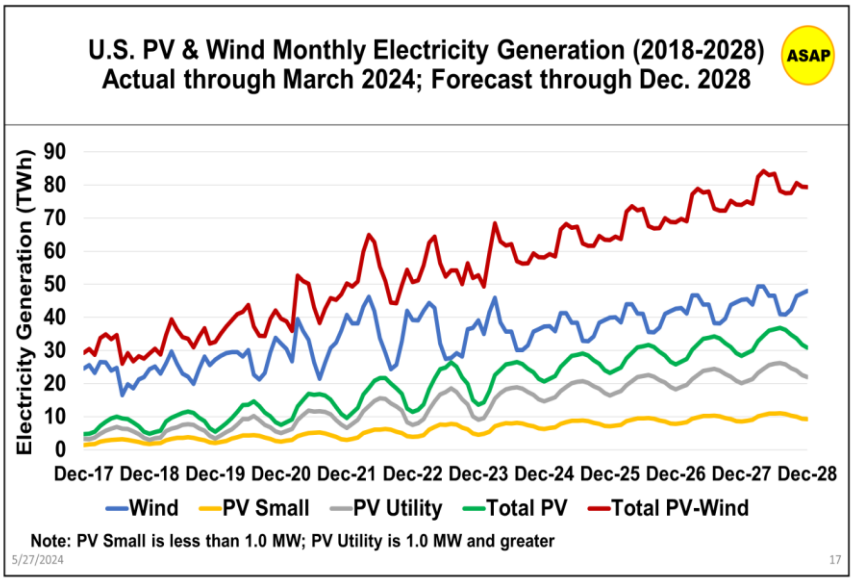
- In March, the value of U.S. PV panel imports increased 12.8% to $1.56 billion
- Vietnam, Thailand, and Malaysia are the top suppliers of U.S. PV panel imports

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

- For May 2024, TAN (solar) share price performance is a positive 19.7%
- For May 2024, FAN (wind) share price performance is a positive 14.0%

WORLD PV-WIND CAPACITY **2024 Forecast for World PV and Wind Additions**

- U.S. PV Forecast for full-year 2024 is 29 GW of capacity additions
- U.S. wind forecast for full-year 2024 is 10 GW of capacity additions
- The world PV forecast for 2024 is 400 GW of capacity additions
- The world wind forecast for 2024 is 50 GW of capacity additions



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PV-Wind Monthly Slideshow

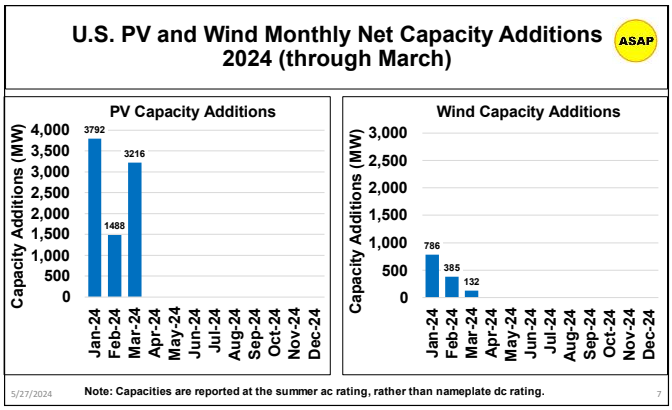
Battery Storage Analysis

Global Warming Update

U.S. PV and Wind Capacity

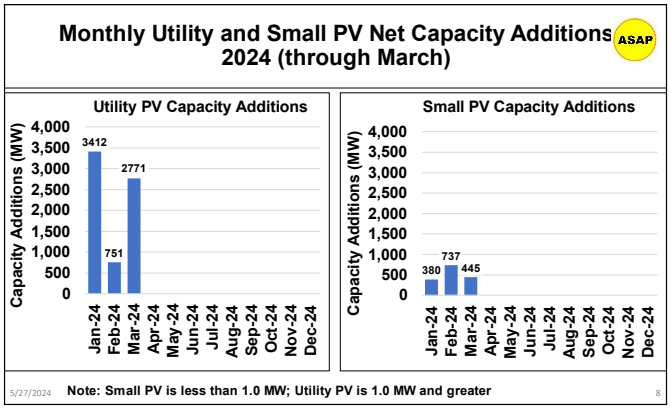
March U.S. PV capacity additions total 3,216 MW

In March, U.S. PV net capacity additions total 3,216 MW, which brings cumulative capacity to 146.0 GW. Utility scale PV capacity additions are 2,771 MW, which is 86.2% of new PV, and small PV capacity additions are 445 MW. PV capacity additions are above the pace needed to meet the full year forecast of 29 GW. Of note, PV cumulative capacity is on pace to surpass wind cumulative capacity in 2024.



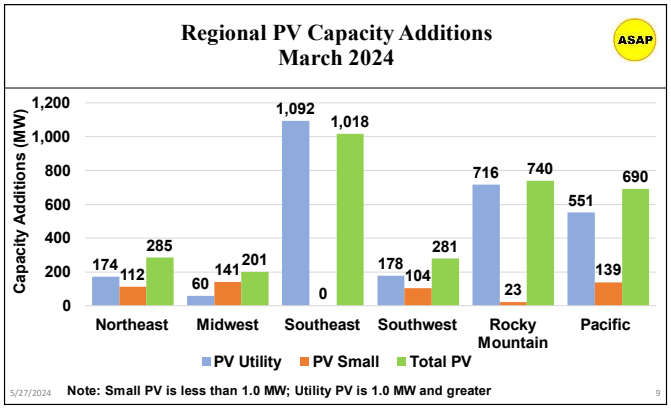
March wind capacity additions total 132 MW

On a regional basis, the Southeast region led in March PV capacity additions with 1,018 MW. The Rocky Mountain and Pacific regions followed with 740 MW and 690 MW respectively. The top three states for PV capacity additions are Florida, California, and Nevada with 879 MW, 750 MW, and 717 MW respectively.



The 2024 forecast for PV capacity additions is 29 GW, and the wind forecast is 10 GW

Wind installations in March total 132 MW, which brings cumulative wind capacity to 148.9 GW. U.S. wind capacity additions for the year are below pace to meet the 10.0 GW forecast. The Rocky Mountain region led the nation with 110 MW. There were capacity reductions in some states. Idaho led the nation with 160 MW of wind capacity additions. The wind industry is facing numerous headwinds, which include manufacturing and permitting issues, as well as general political opposition to wind installations in the Plains states.

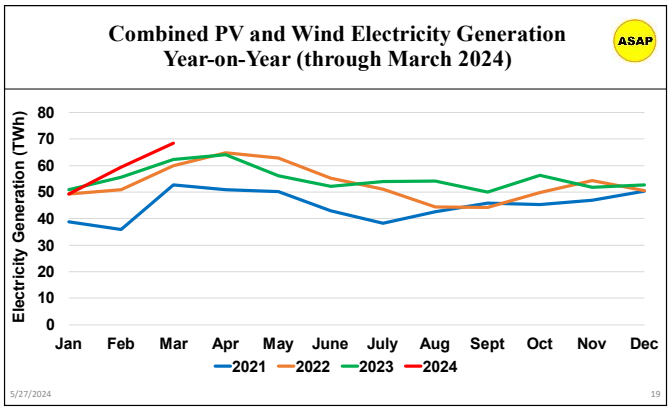


The PV forecast is supported by a two-year freeze on PV import tariffs for Malaysia, Vietnam, and Thailand. In addition, the forecast is supported by PV incentives that are included in the Inflation Reduction Act. The Southeast Asian PV import market becomes complicated when tariff exemptions expire in June 2024, and the possibility of high tariffs on PV content sourced from sanctioned Chinese companies.

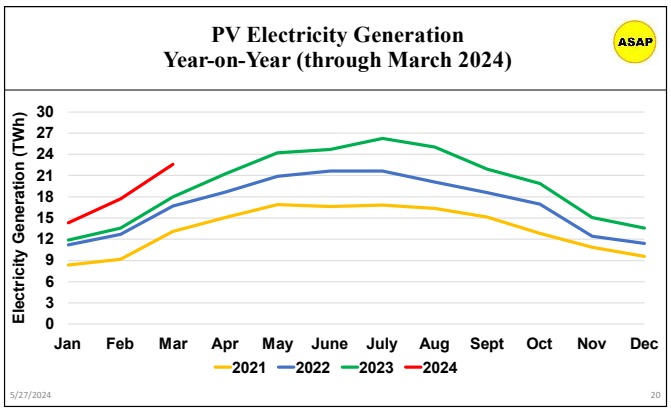
U.S. PV-Wind Electricity Generation Update

In March, combined PV and wind electricity generation is 21.2% of total U.S. electricity generation

In March, PV generated 22.6 TWh of electricity, and wind turbines generated 45.9 TWh of electricity. For March, combined PV and wind electricity generation is 21.2% of total U.S. electricity generation. PV contributes 7.0%, and wind provides 14.2%. PV is expected to produce over 6.0% of total electricity generation in 2024. Wind electricity generation dominates total PV and wind electricity generation. Wind turbines generate ~20% more electricity than PV per unit of capacity.

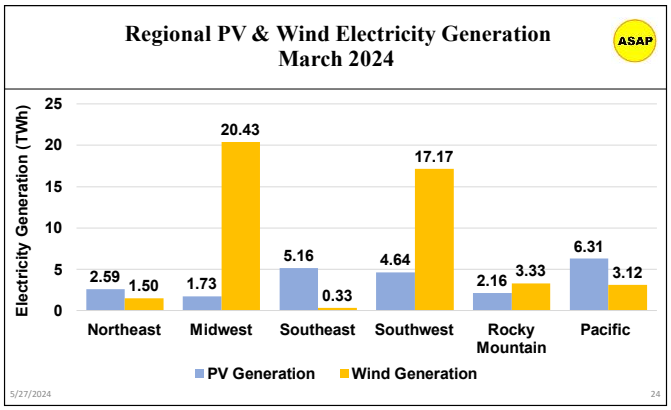


Year-on-year (YoY), March-23 to March-24, PV electricity generation has increased 25.5%, and wind electricity generation has increased 3.4%. YoY, combined PV and wind electricity generation has increased 9.8%. Note that climate variability influences annual and monthly totals.



In March, the Pacific region led in PV electricity generation, and the Midwest region led in wind electricity generation

In March, the Pacific region led the nation in PV electricity generation with 6.3 TWh and is followed by the Southeast region with 5.2 TWh and the Southwest region with 4.6 TWh. California is the leading state with 5.8 TWh of PV electricity generation, which is 26% of total U.S. PV electricity generation. Texas follows with 3.2 TWh, Florida 1.9 TWh, North Carolina 1.1 TWh, Arizona 1.1 TWh, and Nevada 1.0 TWh.

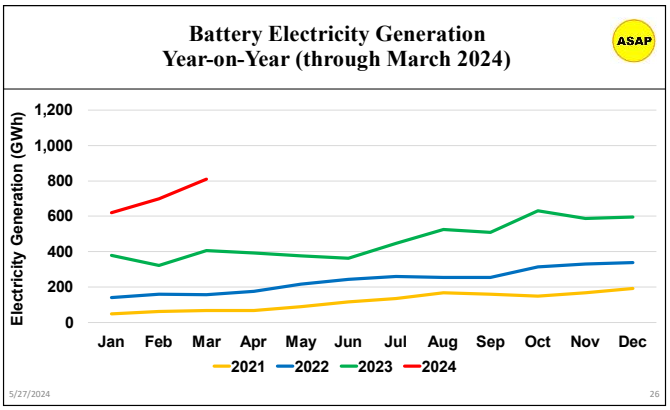


In March, the leading regions for wind electricity generation are the Midwest with 20.4 TWh and the Southwest with 17.2 TWh. These two regions combined produced 82% of total U.S. wind electricity in March. The Rocky Mountain and Pacific regions are distant third and fourth with 3.3 TWh and 3.1 TWh of wind electricity generation respectively. Texas is the leading state with 11.7 TWh of wind electricity generation and is followed by Iowa 5.1 TWh, Oklahoma 3.8 TWh, Kansas 3.1 TWh, and Minnesota 1.7 TWh.

U.S. Utility Battery Storage

In March, battery storage capacity additions are 176 MW

U.S. battery storage capacity additions declined 0.1 GW in March, which reduces cumulative battery storage capacity to 15.8 GW. Full year 2024 battery capacity additions are 1.7 GW, which is off the pace needed to reach the 8.0 GW annual forecast.



U.S. cumulative battery storage capacity decreases to 15.8 GW in March

The reported March average monthly battery utilization factor is 6.9%, which is a daily average of 1.7 hours. The implied battery electricity generation is 811 GWh. From company battery installation announcements, four hours of battery storage capacity is becoming the norm but is not being fully realized. At present, stored battery electricity is applied to shaving pe demand electricity generation rather than the replacement of fossil fuel power plants.

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.

In March, the average battery utilization factor is 6.9%

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 hydrogen fuel-cell heavy Class 8 transport trucks. Other PV and wind storage technologies are molten salt and compressed air energy storage systems. Molten salt storage at solar thermal concentrating power plants and compressed air energy storage are basically being ignored in the U.S. with only power plant of each technology in current operation. Looking ahead, one compressed air energy storage project in Texas using salt dome compressed air storage is permitted and is slated to begin construction in 2024.

PV Market Outlook 2024

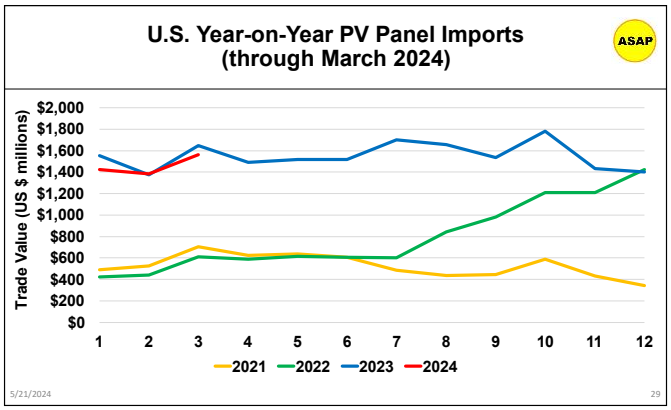
The Inflation Reduction Act is creating an opportunity to expand U.S. PV manufacturing

The U.S. PV industry installed a record 27.4 GW of new PV in 2023. This is an outstanding 52% increase over the previous high year. However, less than half of the PV panels installed were manufactured in the U.S. The majority of U.S. PV is sourced from the Asian countries of Vietnam, Thailand, Maylasia, Cambodia, and India with 37%, 21%, 13%, 12%, and 8% U.S. import market shares respectively. In the near term, the U.S. needs to ramp up domestic PV production through the incentives of the Congressional U.S. Inflation Reduction Act. Growth is essential, and the immediate question is “how soon can the U.S. top 30 GW of annual PV capacity additions? It is worth noting that China installed 217 GW of new PV in 2023.

U.S. PV Trade

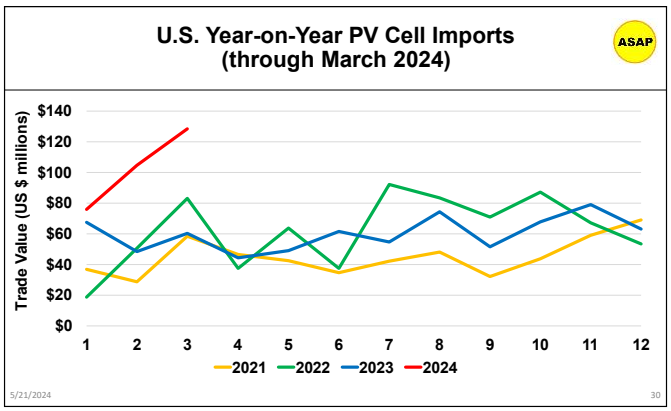
In March, the value of U.S. PV panel imports is $1.56 billion

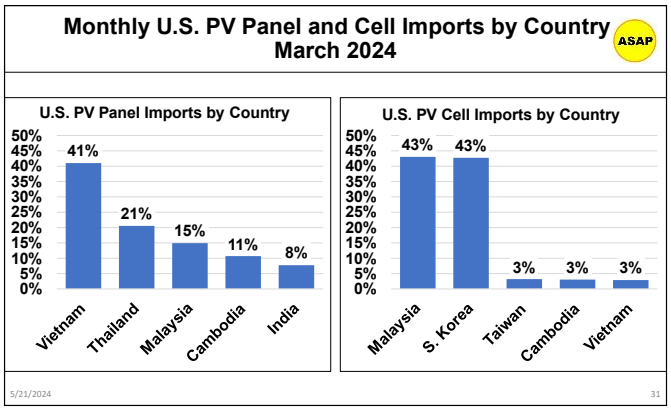
In March, the value of U.S. PV panel imports increased 12.8% month-on-month to $1.56 billion. The year-to-date value of U.S. PV panel imports is $4.37 billion, which is above pace for the $15.0 billion annual 2024 forecast. U.S. PV imports are expected to remain high in 2024 due to the freeze on U.S. import tariffs for PV modules and cells produced in the Southeast Asian countries of Malaysia, Vietnam, and Thailand that are lowing PV prices. The tariff freeze expires in June, which creates uncertainty for the second half of the year.



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

Vietnam, Thailand, and Malaysia are the top three countries for U.S. PV panel imports in March. These three countries account for 77% of total U.S. PV imports. Vietnam leads the market for U.S. PV panel imports in March with a 41% market share. Thailand follows with a 21% share of the U.S. PV panel import market, and Malaysia rounds out the top three with an 15% share. India is a newcomer to the top tier countries for U.S. PV panel importers and is expected to be a growing source in future years.





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

Turning attention to U.S. imports of PV cells, the value of March U.S. PV cell imports increased 22.7% month-on-month to $128.6 million. Malaysia leads U.S. supply of imported PV cells in March with a 43% share. S. Korea and Taiwan round out the top three sources for U.S. PV cell imports with 43% and 3% market shares respectively. These three countries account for 89% of U.S. PV cell imports in March.

In terms of U.S. exports, the value of U.S. PV panel exports in March increased 138% month-on-month to $2.5 million. Year-to-date, the total value of U.S. PV panel exports for 2024 is $7.4 million. U.S. PV panel exports are on pace to reach the $30.0 million 2024 forecast.

The value of March U.S. PV cell exports declined 61.9% month-on-month to $5.6 million. Year-to-date year, the value of U.S. PV cell exports is $20.2 million in 2024. The pace of U.S. PV cell exports in 2024 far exceeds the $30.0 million annual forecast.

The value of U.S. PV panel and cell exports have grown but essentially remain minimal

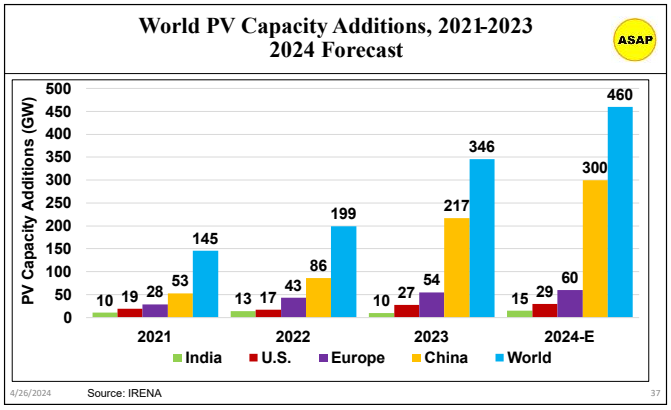
Global PV demand has been constrained by polysilicon shortages and high prices. Large additions to polysilicon production capacity are providing price relief in 2024. The Chinese spot silicon price has plummeted from $46/kg to ~ $10/kg in the first quarter of 2024. Low China silicon prices are supporting strong global market demand for silicon-based PV. Silicon PV holds a 95% share of the global PV market with only marginal growth in thin film PV technologies.

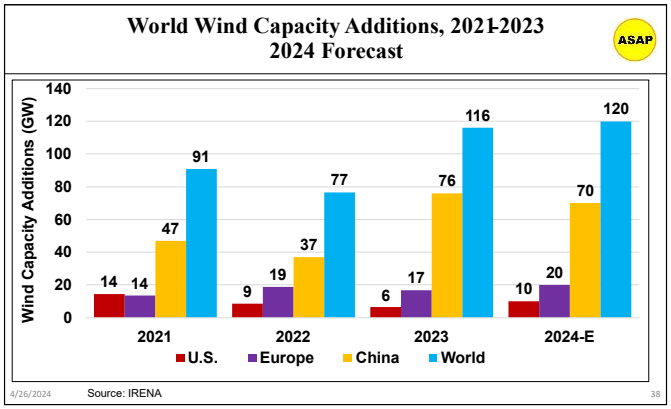
The U.S. is attempting to create a domestic PV manufacturing base to compete with China in the PV market. The U.S. Inflation Reduction Act aims to accelerate domestic solar manufacturing by offering tax credits at all stages of the solar supply chain. The tax credit incentives allow companies to front-load capital expenditures, which will enable companies to rapidly scale domestic production of PV system resources and components.

World PV and Wind

In 2023, world PV capacity additions were 346 GW, which shattered the PV forecast of 240 GW. While the U.S. set a record of 27 GW of new PV, China steals the show with 217 GW of new PV. China delivered on their projected increase in PV manufacturing capacity to over 300 GW. Wind capacity additions were a record 116 GW. China accounted for 66% of new wind capacity with 76 GW of capacity additions. Cumulative world capacity of both PV and wind are above a terrawatt, 1.4 TW and 1.0 TW respectively.

In 2023, world PV capacity additions were 346 GW, and world wind capacity additions were 116 GW.

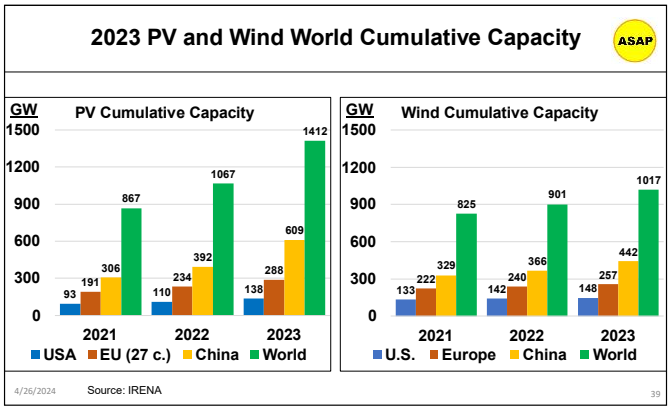


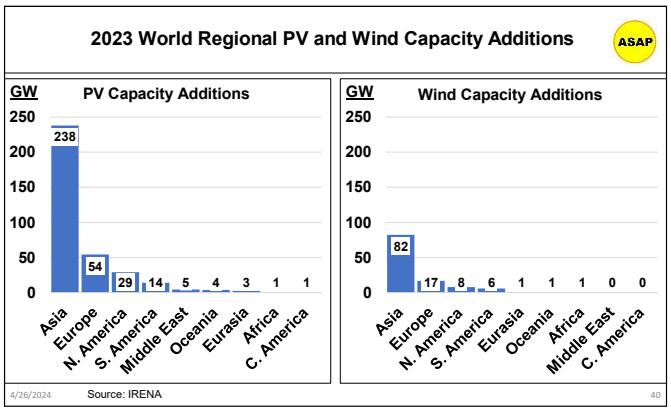


In 2023, China began applying PV and wind electricity for industrial scale electrolytic hydrogen production.

A few trends are evident as we move forward with the transition to renewable energy sources from fossil fuels. Photovoltaics (PV) and wind are proving to be the work horse in the clean energy transition. In 2023, PV cumulative installed capacity is 1.4 trillion watts (TW) of wind cumulative installed capacity is 1.0 TW. In 2023, two important global PV targets were realized. Annual PV capacity additions exceeded 300 gigawatts (GW), and China became the first country to install over 200 GW of new PV capacity. Importantly, China has begun the storage of PV and wind electricity in the form of electrolytic hydrogen production for refining, chemical and transportation end-uses.

While 346 GW of PV capacity additions in 2023 is significant, it is far short of the 600 GW of annual global PV capacity additions needed to achieve climate change mitigation targets. China is the only country that is on pace to meet climate change goals. The U.S., Europe, and India are lagging far behind.

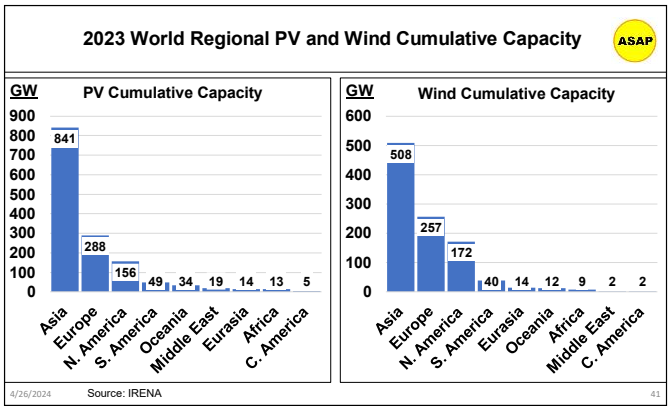




Annual global PV capacity additions need to reach 500-600 GW by 2030 to meet net zero energy emissions targets

Global PV capacity additions: Europe installed 54 GW, U.S. installed 27 GW, India installed 10 GW. Germany installed 14 GW, and Brazil installed 12 GW. The only countries to install at least 10 GW of new PV capacity are China, U.S., Germany, Brazil and India.

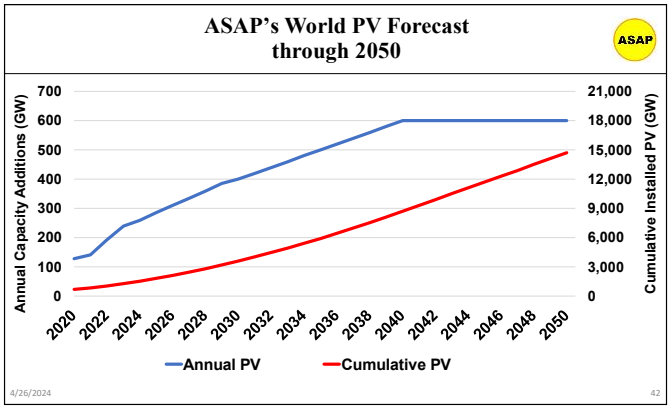
Wind capacity additions in 2023 were dominated by China with 76 GW, followed by Europe with 17 GW, and the U.S. with 6 GW. Brazil gained traction with 5 GW of wind capacity additions. Germany led the European nations with 3 GW of new wind capacity.



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 million tonnes of hydrogen for transportation and industrial end-uses.

ASAP's PV and wind annual installation forecast achieves the IEA target by scaling annual PV installations to 600 GW and wind installations to 350 GW over the 2040-2050 timeframe. 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 and wind electricity for electrolytic hydrogen production from water for transportation and chemical applications at 415 million tonnes per annum in 2050.

Storage is the primary obstacle to achieving complete zero carbon emissions electricity generation with intermittent PV and wind electricity generation. However, battery, underground compressed air energy storage, and green hydrogen offer opportunities for large-scale PV and wind storage systems. ASAP estimates the total cost of a PV and wind with storage energy system, including storage, to be about $3.0 trillion per annum over a thirty-year transition period, 2021-2050, which will comprise about 2.5% of global GDP over the thirty-year transition period. This is a tall order, but it can be done with planning commitments in the international finance industry and governments.



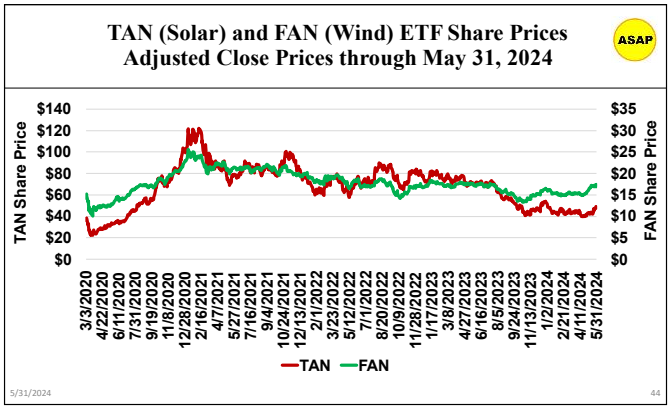
The application of electrolytic hydrogen production is gaining support. China brought the first industrial scale PV electrolytic hydrogen plant into operation in 2023 with others in the development stage. Europe is planning the SouthH2 Corridor with a hydrogen pipeline connecting North Africa to Italy, Austria, and Germany. The U.S. has several industrial scale PV and wind electrolytic hydrogen plants in the permitting stage of development. By 2030, the industrial scale production of electrolytic hydrogen using wind and PV electricity is expected to be over one million tonnes of green hydrogen.

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.

For the month of May, the share values of TAN and FAN both increased

For the month of May 2024, the TAN ETF share value increased 19.7%, and FAN increased 14.0%. Year-to-date, TAN is down 9.5%, and FAN is up 6.0%.



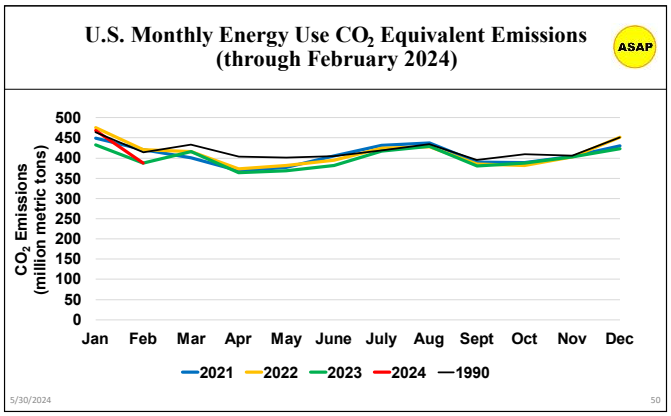
As shown in the graph, the share prices of the TAN and FAN ETFs have had disappointing performance over the past three years relative to 2021 highs. From the March 2021 highs through May 2024, the TAN share price is down 60.4%, and FAN share price is down 26.8%.

It is important to note that supply chain costs are improving with declining PV prices in 2024. 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

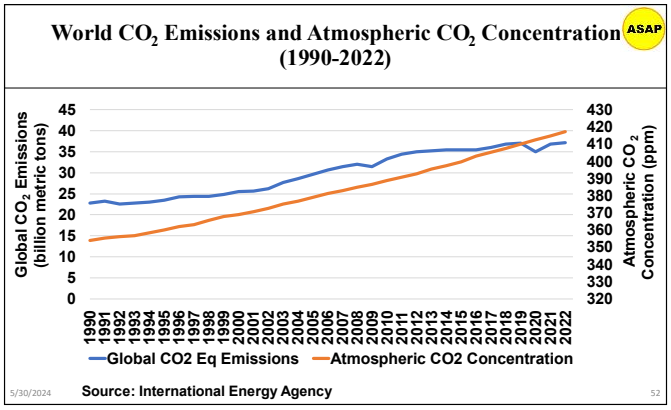
In 2023, U.S. CO_2 emissions fell 4.6% below the target 1990 level

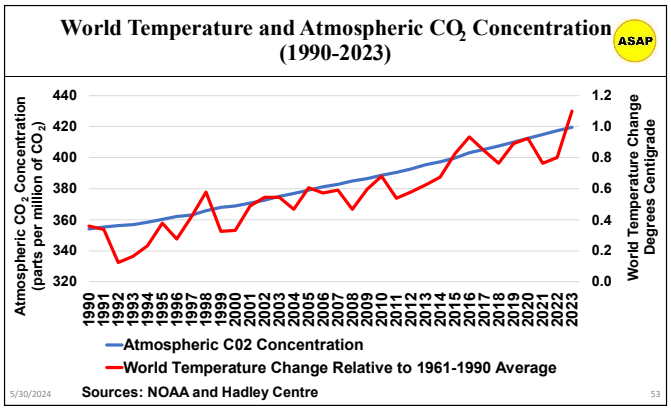
U.S. energy related carbon dioxide emissions have rebounded from the pandemic induced lows of 2020 as shown in the graph. On a positive note, total U.S. 2023 CO_2 emissions are 4.8% less than the 1990 level. For the past twenty-five years the goal has been to reduce energy use CO_2 emissions to below 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 relatively modest reduction in CO_2 emissions.



In 2022, world carbon dioxide emissions set a new record high of 37.1 Gt

World carbon dioxide (CO_2) emissions related to energy consumption and industrial production rose to 37.1 giga-tonnes (Gt) in 2022, which is a new high mark. World CO_2 emissions continue to increase and are 63% greater than the 1990 level. The atmospheric concentration of CO_2 increased to 420 parts per million in 2023. The increasing atmospheric concentration of CO2 is causing increases in the average global temperature.





The average global temperature has increased by at least 1.1° Celsius (1.9° Fahrenheit) relative to the average 1961-1990 global temperature. Most of the increase in global temperature has occurred over the past forty years. Further increases in the atmospheric concentration of greenhouse gases will result in higher temperatures. As the average global temperature continues to rise, extreme weather events will become ever more common and with ever greater intensity. This is being witnessed today as extreme weather events are increasing in frequency and intensity worldwide. Of particular concern are rising sea levels from melting ice sheets in Antarctica and Greenland. A massive reduction in global CO_2 emissions is the only way to stop rising global temperatures.

ASAP Data Sources

ASAP benchmarks U.S. PV and wind capacities and electricity generation to the estimates provided by the Energy Information Administration (EIA) of the U.S. Department of Energy. ASAP reports the EIA net summer capacity changes for PV and wind due to the high cost of supplying summer peak demand electricity. For example, summer PV net capacity is 10%-15% less than nameplate capacity due to heat losses.

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.