PV-WIND MONTHLY MARKET UPDATE

Net PV Capacity Additions Are 5,845 MW in November

February 2025 Issue

(Data Updates for November 2024)

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

- In November, PV capacity additions total 5,845 MW
- In November, wind capacity additions total 0 MW

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

- PV and wind electricity production is 18.5% of total U.S. electricity generation
- Of total U.S. electricity generation, PV is 5.9% and wind is 12.6%

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

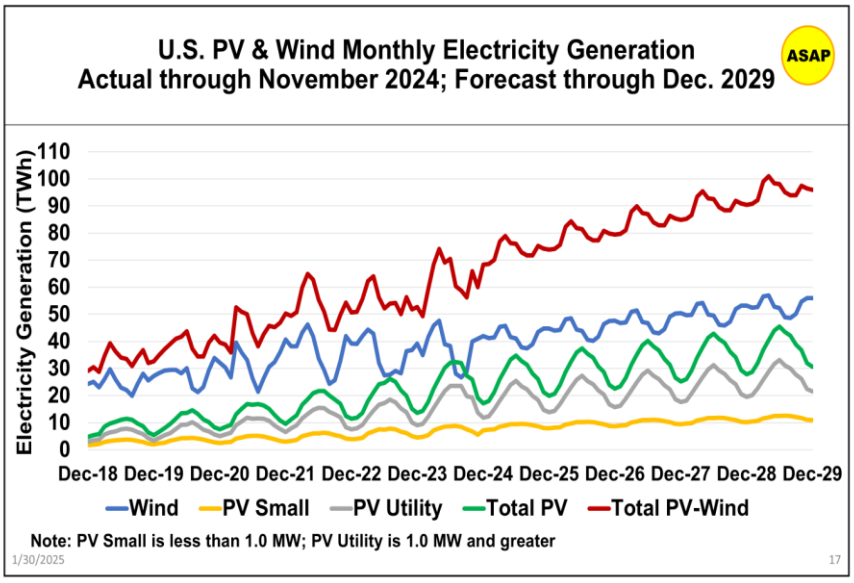
- In November, the value of U.S. PV panel imports decreased 12.2% to $623 million
- In November, the value of U.S. PV cell imports increased 49.0% to $231 million

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

- For January 2025, TAN (solar) share price performance is a positive 2.1%
- For January 2025, FAN (wind) share price performance is a negative 0.2%

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

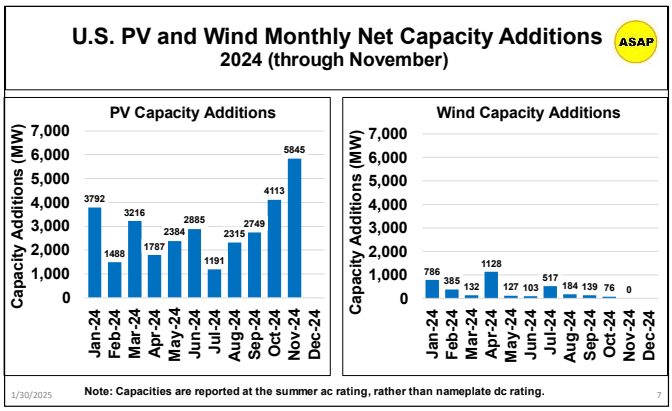
Battery Storage Analysis

Global Warming Update

U.S. PV and Wind Capacity

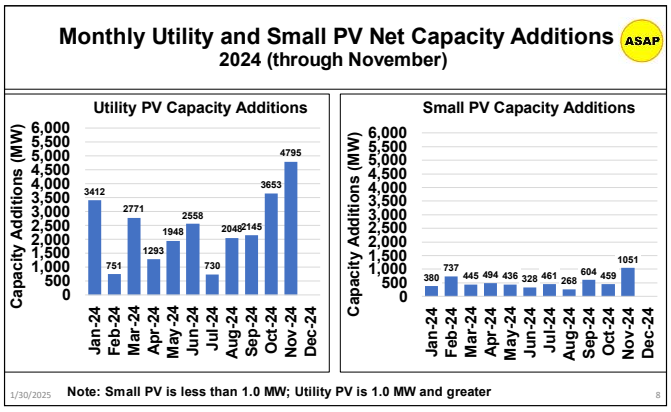
November U.S. PV capacity additions total 5,845 MW

In November, U.S. PV net capacity additions total 5,845 MW, which brings cumulative PV capacity to 169.3 GW. Utility scale PV capacity additions are 4,795 MW, which is 82% of new PV, and small PV capacity additions are 1,051 MW. PV capacity additions are on the pace needed to meet the full year forecast of 29 GW. Of note, this year, PV cumulative capacity surpassed wind cumulative capacity.

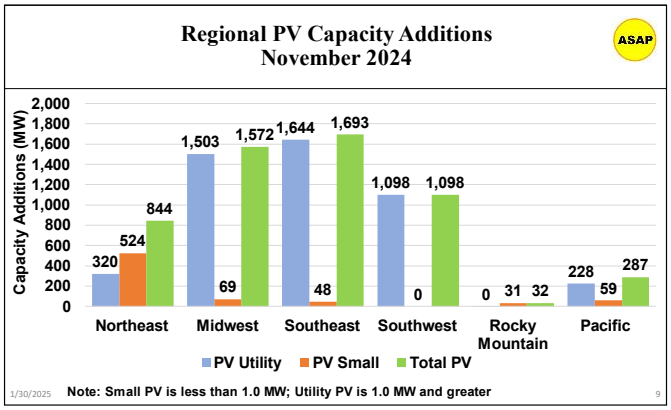


November wind capacity additions total 0 MW

On a regional basis, the Southeast region led in November PV capacity additions with 1,693 MW. The Midwest and Southwest regions followed with 1,572 MW and 1,098 MW respectively. The top three states for PV capacity additions are Illinois, Florida, and Texas with 1,036 MW, 815 MW, and 699 MW respectively.



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



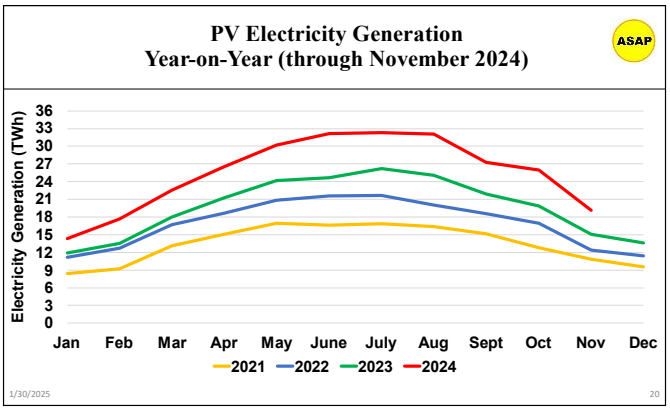
Wind installations in November are 0 MW, which brings cumulative wind capacity to 151.2 GW. U.S. wind capacity additions for the year are below pace to meet the 10.0 GW forecast. The wind industry is facing numerous headwinds, which include manufacturing and permitting issues, as well as general political opposition to wind installations in the Plains states.

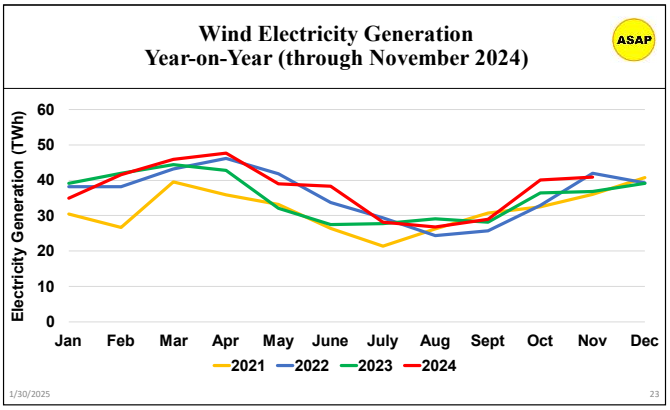
With new import tariffs going into effect, there has been a decline in PV panel imports as expected. However, new PV manufacturing capacity in the U.S. is increasing the demand for imported of PV cells. New U.S. PV manufacturing capacity is about 15 GW. Most of this new capacity is PV module assembly with the wafers and cells coming from Southeast Asian countries. One PV manufacturer is expanding its mono-crystalline silicon PV manufacturing capacity by sourcing U.S. polysilicon from REC Silicon.

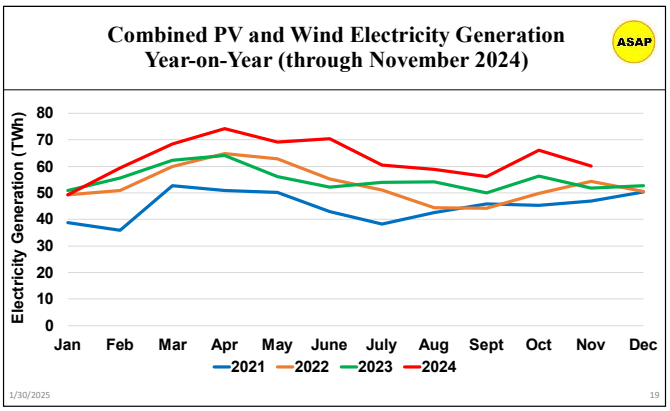
U.S. PV-Wind Electricity Generation Update

In November, combined PV and wind electricity generation is 18.5% of total U.S. electricity generation

In November, PV generated 19.2 TWh of electricity, and wind turbines generated 40.9 TWh of electricity. For November, combined PV and wind electricity generation is 18.5% of total U.S. electricity generation. PV contributes 5.9%, and wind provides 12.6%. At present, monthly PV electricity generation is closing the gap with wind. PV electricity generation is gaining on wind due to the large decrease in wind capacity additions over the past couple of years.







Year-on-year (YoY), November-23 to November-24, PV electricity generation has increased 25.9%, and wind electricity generation has increased 11.2%. YoY, combined PV and wind electricity generation has increased 15.5%. Note that climate variability influences annual and monthly totals.

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

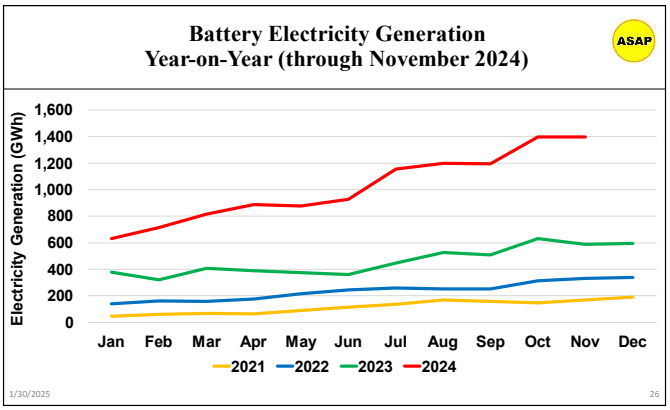
In November, the Pacific region led the nation in PV electricity generation with 5.2 TWh and is followed by the Southwest region with 4.8 TWh and the Southeast region with 4.3 TWh. California is the leading state with 4.8 TWh of PV electricity generation, which is 25% of total U.S. PV electricity generation. Texas follows with 3.3 TWh, Florida 1.6 TWh, Arizona 1.1 TWh, Nevada 0.9 TWh, and North Carolina 0.8 TWh.

In November, the leading regions for wind electricity generation are the Midwest with 16.9 TWh and the Southwest with 16.0 TWh. These two regions combined produced 80% of total U.S. wind electricity in November. The Rocky Mountain and Pacific regions are distant third and fourth with 3.4 TWh and 2.8 TWh of wind electricity generation respectively. Texas is the leading state with 11.0 TWh of wind electricity generation and is followed by Iowa 4.0 TWh, Oklahoma 3.3 TWh, Kansas 2.7 TWh, Illinois 2.5 TWh, and North Dakota 1.3 TWh.

U.S. Utility Battery Storage

In November, battery storage capacity additions are 724 MW

U.S. battery storage capacity additions increased 724 MW in November, which increases cumulative battery storage capacity to 23.4 GW. Year-to-date 2024 battery capacity additions are 9.1 GW, which is above the pace to reach the 8.0 GW annual forecast.



U.S. cumulative battery storage capacity increases to 23.4 GW in November

The reported November average monthly battery utilization factor is 8.3%, which is a daily average of 2.0 hours. The implied battery electricity generation is 1.4 TWh. 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 November, the average battery utilization factor is 8.3%

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

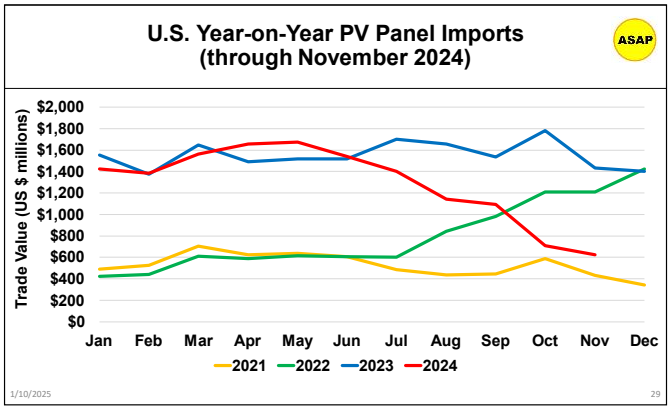
The Inflation Reduction Act is creating an opportunity to expand U.S. PV manufacturing

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, Malaysia, 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

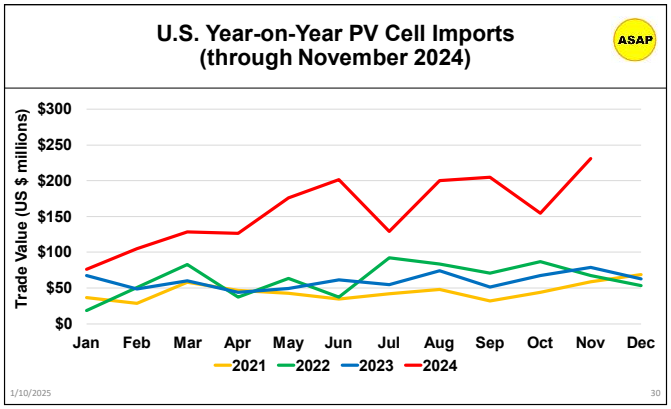
In November, the value of U.S. PV panel imports is $623 million

In November, the value of U.S. PV panel imports decreased 12.2% month-on-month to $623 million. The year-to-date value of U.S. PV panel imports is $14.2 billion, which is on pace for the $15.0 billion annual 2024 forecast. Import tariffs have been reimposed on solar products produced in the Southeast Asian countries of Malaysia, Vietnam, and Thailand, which creates uncertainty about the strength of PV imports going forward.

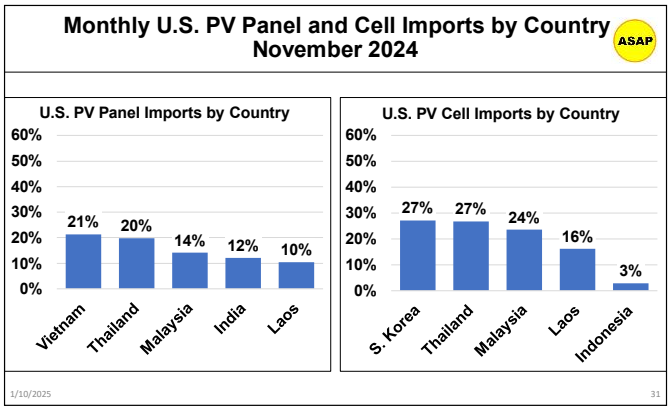


Vietnam, Thailand, and Malaysia are the top three sources of U.S. PV panel imports in November

Vietnam, Thailand, and Malaysia are the top three countries for U.S. PV panel imports in November. These three countries account for 55% of total U.S. PV panel imports. Vietnam leads the market for U.S. PV panel imports in November with a 21% market share. Thailand follows with a 20% share and Malaysia rounds out the top three with a 14% share. India and Laos follow with 12% and 10% market shares respectively.



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



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

Turning attention to U.S. imports of PV cells, the value of November U.S. PV cell imports increased 49.0% month-on-month to $231 million. S. Korea leads U.S. supply of imported PV cells in November with a 27% market share. Thailand and Malaysia round out the top three sources for U.S. PV cell imports with 27% and 24% market shares respectively. These three countries account for 77% of U.S. PV cell imports in November. The large year-to-date increase in PV cell imports is due to a ramp up in U.S. PV panel manufacturing.

In terms of U.S. exports, the value of U.S. PV panel exports in November increased 3% month-on-month to $1.0 million. Year-to-date, the total value of U.S. PV panel exports for 2024 is $21.3 million. U.S. PV panel exports are behind the pace to reach the $30.0 million 2024 forecast.

The value of November U.S. PV cell exports decreased 68.7% month-on-month to $1.0 million. Year-to-date year, the value of U.S. PV cell exports is $39.9 million in 2024. The pace of U.S. PV cell exports in 2024 far exceeds the $30.0 million annual forecast.

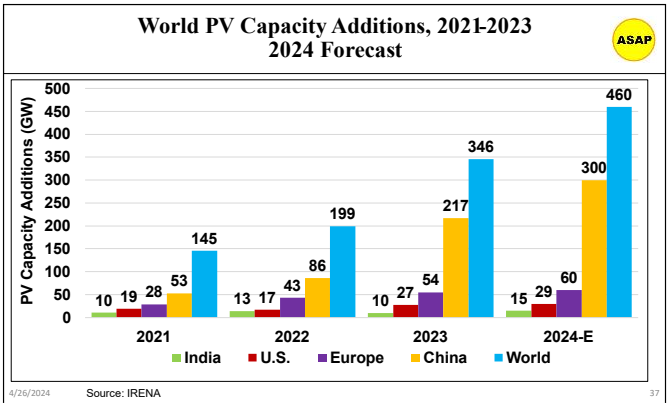
The global PV outlook is strong due to the large supply of inexpensive Chinese PV panels. Chinese PV panel prices are at an all time low with average spot prices under $0.11/watt. Silicon PV holds a 95% share of the global PV market with only marginal growth in thin film PV technologies.

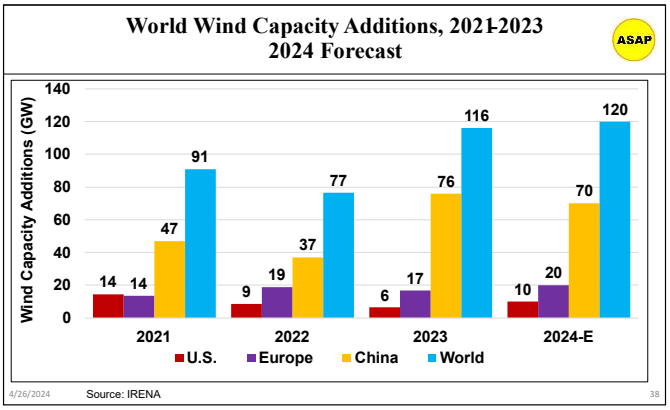
The U.S. is ramping up domestic PV manufacturing. The U.S. Inflation Reduction Act aims to accelerate domestic solar manufacturing by offering tax credits at all stages of the solar supply chain. The tax credit incentives allow companies to front-load capital expenditures, which will enable companies to rapidly scale domestic production of PV system resources and components. By the end of 2026 First Solar will have 14.0 GW of U.S. PV panel manufacturing, and Q Cells has increased manufacturing capacity by 3.3 GW for a total PV manufacturing capacity of 8.4 GW.

World PV and Wind

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

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.

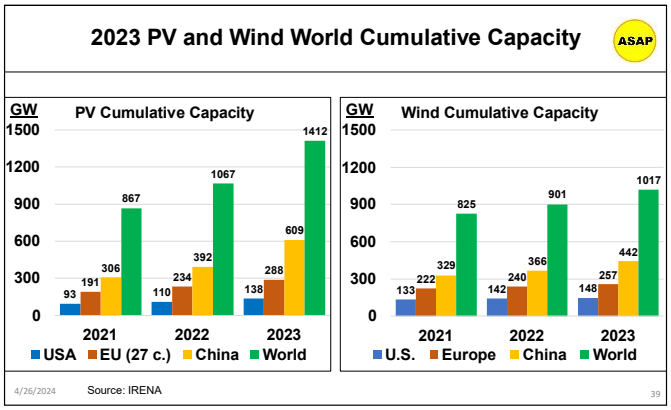




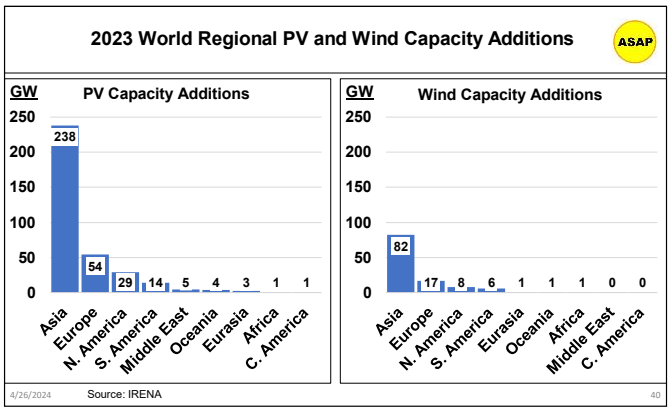
A few trends are evident as we move forward with the transition to renewable energy sources from fossil fuels. Photovoltaics (PV) and wind are proving to be the work horse in the clean energy transition. In 2023, PV cumulative installed capacity is 1.4 trillion watts (TW) of wind cumulative installed 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.

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

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.

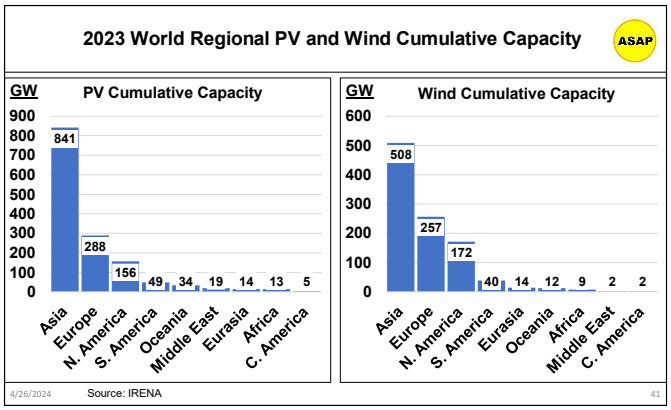


Global PV capacity additions: Europe installed 54 GW, U.S. installed 27 GW, India installed 10 GW. Germany installed 14 GW, and Brazil installed 12 GW. The only countries to install at least 10 GW of new PV capacity are China, U.S., Germany, Brazil and India.



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

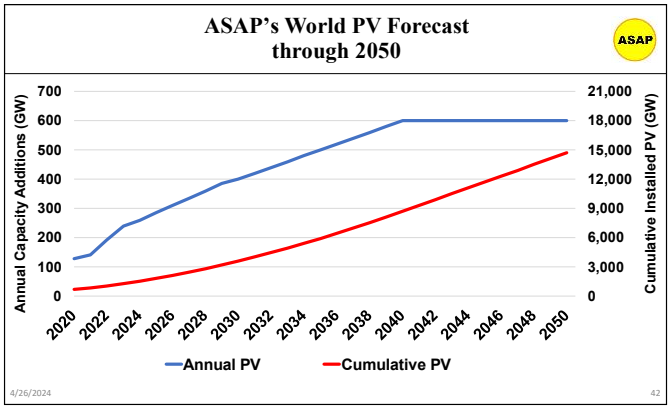
Wind capacity additions in 2023 were dominated by China with 76 GW, followed by Europe with 17 GW, and the U.S. with 6 GW. Brazil gained traction with 5 GW of wind capacity additions. Germany led the European nations with 3 GW of new wind capacity.



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.



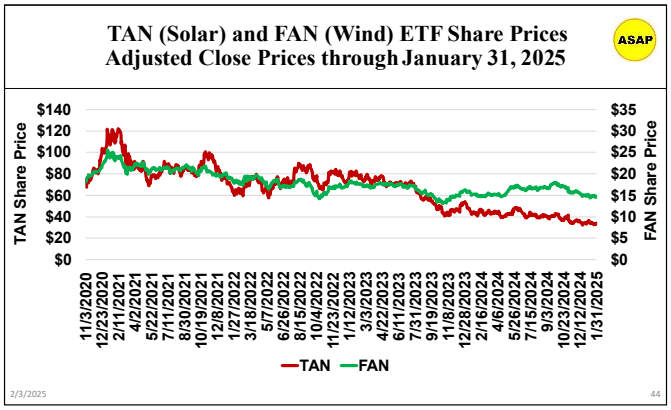
The application of electrolytic hydrogen production is gaining support. China brought the first industrial scale PV electrolytic hydrogen plant into operation in 2023 with others in the development stage. Europe is planning the SouthH2 Corridor with a hydrogen pipeline connecting North Africa to Italy, 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 January, the share values of TAN increased and FAN declined

For the month of January 2025, the TAN ETF share value increased 2.1%, and FAN decreased 0.2%. Year-to-date, TAN is up 2.1%, and FAN is down 0.2%.



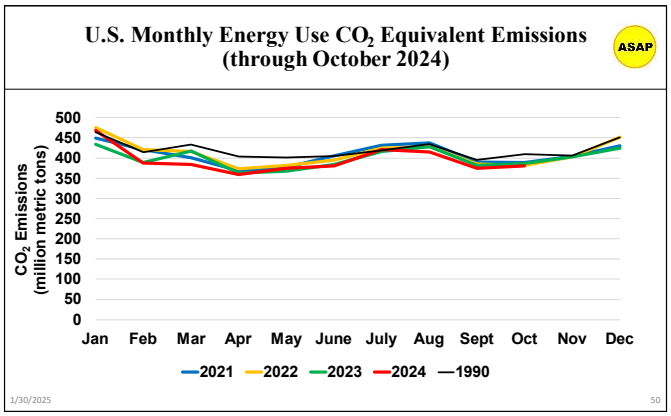
As shown in the graph, the share prices of the TAN and FAN ETFs have had disappointing performance over the past three years relative to 2021 highs. From the high share prices in February and February 2021, the TAN share price is down 72.3%, and FAN share price is down 38.0% through January 2025.

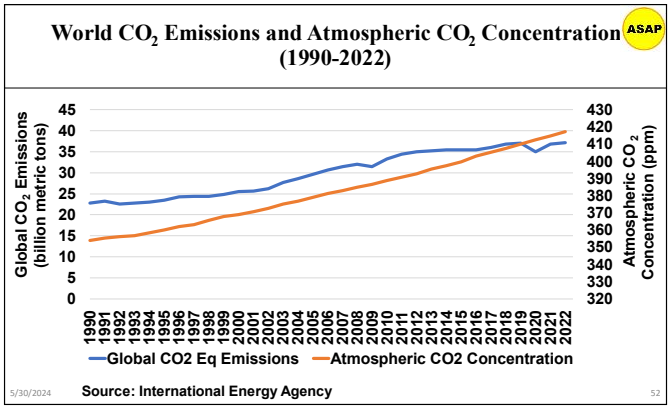
It is important to note that supply chain costs are improving with declining PV prices in 2025. Global demand for PV and wind installations is growing at a healthy rate, which should translate into share price increases for solar and wind companies going forward with continuing improvement in supply chain issues.

Carbon Dioxide Emissions

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

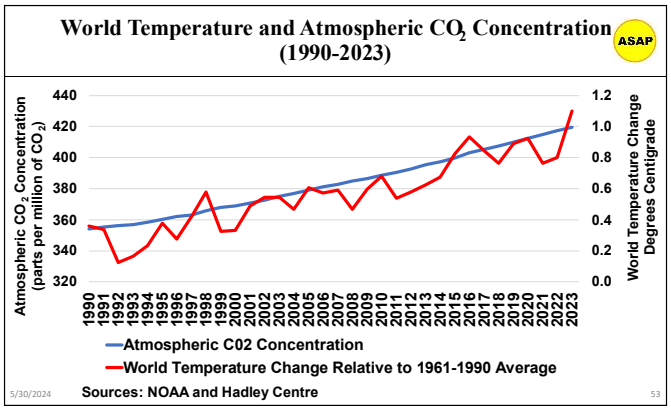
U.S. energy related carbon dioxide emissions are now lower than the pandemic induced lows of 2020 as shown in the graph. On a positive note, total U.S. 2023 CO_2 emissions are 4.8% less than the 1990 level. For the past twenty-five years the goal has been to reduce energy use CO_2 emissions to below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