The Global Future of Solar Energy Explored: A Short Note

Given the recent politics of global climate emergency, there is now a worldwide emphasis on renewable energy. In 2021, renewable electricity generation is forecast to increase year-on-year by 6% and reach over 7 900 TWh, slightly higher than the average annual growth rate observed during 2015-2020. Conversely, the expansion rate of cumulative capacity in 2021 is faster over the same time. This decoupling is mainly due to weather conditions in key markets affecting wind and hydropower generation. Without these conditions, renewable electricity generation would be up by almost 9% in 2021 compared with 2020.[1]

In IAE's report, renewable electricity generation is forecast to increase by almost 52% in the next five years, reaching over 11300 TWh by 2026, two-thirds faster than the growth seen during 2015-2020. As a result, renewables are expected to account for almost 37% of global electricity generation by 2026 to become the largest source of generation. While hydropower remains the largest source of renewable generation, its share of global electricity generation has declined slightly to 15.6%. Over the forecast period, non-hydro renewables are expected to account for most of the renewable generation globally for the first time. Meanwhile, output from variable renewables (solar PV and wind) will more than double, reaching almost 18% of global generation to surpass hydropower. Offshore wind will see the fastest growth in the next five years (240%) among all renewables, reaching 1.5% of total generation by 2026.[2]

Renewables are on track to set new records in 2021. Renewable energy use increased 3% in 2020 as demand for all other fuels declined. The primary driver was an almost 7% growth in electricity generation from renewable sources. Long-term contracts, priority access to the grid, and continuous installation of new plants underpinned renewables growth despite lower electricity demand, supply chain challenges, and construction delays in many parts of the world. Accordingly, the share of renewables in global electricity generation jumped to 29% in 2020, up from 27% in 2019. [3]

Renewable electricity generation in 2021 is set to expand by more than 8% to reach 8 300 TWh, the fastest year-on-year growth since the 1970s. Solar PV and wind are set to contribute two-

thirds of renewables growth. China should account for almost half of the global increase in renewable electricity in 2021, followed by the United States (US), the European Union, and India.

Wind is set for the largest increase in renewable generation, growing by 275 TWh, or almost 17%, which is significantly greater than 2020 levels. Policy deadlines in China and the US drove developers to complete a record amount of capacity late in the fourth quarter of 2020, leading to notable increases in generation already from the first two months of 2021. Over the course of 2021, China is expected to generate 600 TWh and the US 400 TWh, together representing more than half of global wind output.[4]

Increases in electricity generation from all renewable sources could push the share of renewables in the electricity generation mix to an all-time high of 30% in 2021. Combined with nuclear, low-carbon sources of generation well and truly exceed output from the world's coal plants in 2021.[5]

The most promising source of renewable energy is solar energy which is abundant. Therefore, it is a great part of our energy future. Solar power is the most abundant natural resource on the planet. It isn't going to run dry anytime soon. The amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year.[6] The Sun emits enough power onto Earth each second to satisfy the entire human energy demand for over two hours.[7] Solar energy is the most abundant energy resource on earth -- 173,000 terawatts of solar energy strikes the Earth continuously. That's more than 10,000 times the world's total energy use.[8] Solar energy is the technology used to harness the sun's energy and make it useable. Solar energy is perhaps the most effective solution to our energy needs. The sun blasts our planet's surface with more than enough energy to keep us going forever. The US government estimates that the Earth receives over 173,000 terawatts of energy every year, which is more than 10,000 times what humanity needs.[9]

Solar energy has become cheaper over the years. The high cost was perhaps the reason why solar energy wasn't as widely discussed until recently. Prices for solar cells have fallen 99 percent

since 1977, bringing this power source within reach for a much wider range of consumers.[10] The solar industry is changing rapidly as it experiences unprecedented growth.

Solar energy is both good for our daily use and good for emergency relief. Solar panels are relatively easy to set up and connect to a power grid, and that makes them a good choice for disaster relief. Organizations that contributed to disaster relief in the wake of Puerto Rico's 2017 hurricane crisis mostly used solar power as part of their aid efforts.

To date, we have only scratched the surface of the sun's true potential. The sun deploys more energy to the planet's surface than what's used every year. While the costs have reduced drastically over the years, the technology has improved. Researchers across the globe are working tirelessly to further improve the way sunrays are collected and converted into energy. Solar energy is clearly the future.

Meanwhile, annual additions to global renewable electricity capacity are expected to average around 305 GW per year between 2021 and 2026. This implies an acceleration of almost 60% compared to renewables' expansion over the last five years. Continuous policy support in more than 130 countries, ambitious net zero goals announced by nations accounting for almost 90% of global GDP, and improving competitiveness of wind and solar PV are all driving this expansion.[11] Nonetheless, despite this growing support, renewables face a range of policy uncertainties and implementation challenges, including those relating to financing, permitting, social acceptance, and grid integration. Current increases in commodity prices have put upward pressure on investment costs while the availability of raw materials and rising electricity prices in some markets pose additional challenges for wind and solar PV manufacturers in the short term. However, the impact of volatile commodity and transport prices on demand are expected to be limited, as high fossil fuel prices improve the competitiveness of wind and solar PV further.[12] Our accelerated case assumes that governments address policy, regulatory, and implementation challenges in the next couple of years. The stabilization and eventual decline of commodity prices to levels observed over 2015-2019 and more affordable financing from the private sector also contribute to the accelerated growth of renewable electricity in this case. Accordingly, annual renewable capacity additions are a quarter higher than in our main case, reaching over

380 GW on average over 2021-2026. However, the gap between both our main and accelerated case forecasts and the trajectory necessary to meet Net Zero by 2050 remains significant. Annual capacity growth under the IEA Net Zero Scenario during 2021-2026 needs to be 80% faster than in our accelerated case, implying that governments need to not only address policy and implementation challenges, but also to increase their ambition.[13]

Globally, the IAE anticipates renewable capacity to expand by over 1800 GW, or over 60%, in our main case forecast to 2026, accounting for almost 95% of the increase in total power capacity worldwide. Overall, China remains the leader, accounting for 43% of global growth, followed by Europe, the US, and India. These four markets alone provide almost 80% of renewable capacity expansion worldwide. We have revised the forecast up from last year, with China alone accounting for about 60% of the revision. For China, last year's forecast reflected the phase-out of subsidies at the end of 2020 and the resulting policy uncertainty for onshore wind and solar PV. However, China's subsequent commitment to net zero by 2060 has led to new targets, such as 40% of all electricity consumed to be from non-fossil generation by 2030 and a capacity target of 1 200 GW wind and solar PV by the same year, as given in the IAEA forecast.[14]

In Europe, the upward revision stems from larger auction volumes in most EU member countries to accelerate deployment towards 2030 renewable energy targets, a growing market for corporate power purchase agreements (PPAs) and the increasing attractiveness of self-consumption for distributed PV. The economic recovery plan for Europe, which will provide over $ 940 billion in the form of loans and grants, should partly contribute to facilitating the financing of renewables. Our main case renewable capacity growth trajectory shows that the European Union is set to overachieve the country plans for 2030 stated in current National Energy and Climate Plans (NECPs), supporting higher targets under the "Fit for 55" program (55% emissions reduction by 2030), which is expected to be finalized in 2023 or 2024. [15]

An improved policy environment and higher targets in multiple countries in Asia Pacific result in more optimistic renewable capacity growth in the region. In Latin America, resumed competitive auctions following delays due to the Covid-19 crisis remain a key driver for utility-scale wind

and solar PV development. In addition, deployment outside government policy schemes through bilateral contracts is rising in the region, especially in Brazil and Chile, leading to upward revisions for variable renewables.

In sub-Saharan Africa, faster commissioning of large hydropower plants to meet financing and construction deadlines, new auctions and project announcements lead to a higher forecast. In the Middle East and North Africa our forecast is slightly higher compared with last year. Although solar PV's competitiveness drives renewables expansion in the region, the faster pace is challenged by slower electricity demand and insufficient grid infrastructure.[16]

Despite rising prices, solar PV is breaking new records, according to IAE forecasts. Additions of renewable power capacity are on track to set yet another annual record in 2021, driven by solar PV. Almost 290 gigawatts (GW) of new renewable power will be commissioned this year, which is 3% higher than 2020's already exceptional growth.[17]

In IAE's forecast for 2021-2026, we expect annual average renewable capacity additions to reach 305 GW, 58% higher than the figure for the last five years. Despite surging commodity prices increasingly affecting solar PV investment costs, we expect the annual market to grow by 17% year-on-year to almost 160 GW in 2021 with additions reaching almost 200 GW in 2026. In most countries worldwide, utility-scale solar PV provides the lowest cost of adding new electricity capacity, especially in the context of increasing natural gas prices.[18]

Overall, solar PV alone accounts for almost 60% of all renewable capacity additions, with almost 1100 GW becoming operational over the forecast period in our main case. The expansion of solar PV capacity in the next five years is expected to be almost double that of the previous five years. Utility-scale projects continue to provide over 60% of all solar PV additions worldwide. Annual additions of distributed PV are increasing thanks to policy initiatives in China, the EU, and India stimulating the deployment of commercial and residential projects.

Under the accelerated case, total growth of global solar PV capacity could be 22% higher with annual additions growing continuously, reaching almost 260 GW by 2026. The upside is largest

in key markets such as China, Europe, the US, and India, but considerable growth potential remains in nascent markets such as sub-Saharan Africa and the Middle East. However, reaching the accelerated case will require the major markets to address their persistent challenges.[19]

Solar energy has a very bright future because of its abundant availability. However, the challenge has always been collecting that energy. Even though most people are aware of photovoltaic cells, solar panels have been expensive enough to keep them firmly in the luxury bracket. For years, the low efficiency of solar panels and the high costs per square inch of these panels made solar power economically unviable. That has now changed. Between 2008 and 2013, the cost of solar panels fell by over 50 percent. Between 2015 and 2017, experts estimated costs fell another 40 percent. Researchers in the United Kingdom say they are surprised by how quick solar adoption is growing. They estimate that the costs will fall fast enough to allow solar to contribute 20% of our energy consumption by 2027. That benchmark would have been unimaginable a few years back.

There is likely to a be a lot of demand for real estate for solar energy. Landowners and farmers can lease out their land for the construction of new solar farms. Demand for medium voltage cable could rise since solar farms will need to be freshly connected to the grid. All the new opportunities will drive prices lower and drive the tech further. Researchers from Israel and Germany partnered up to study if there was a better way to convert sunlight into electricity. Turns out that the most efficient way is also the most common – photosynthesis. The study confirmed that using biomass as fuel could eventually allow us to create artificial photosynthesis machines. These could convert sunlight into energy and store in a more natural way for later use. Some countries lack the space for solar farms. An elegant solution to this problem is floating solar farms. Ciel & Terre International, a French energy company, has been working on a large scale, floating, solar solution since 2011. They have already installed a trial farm off the coast of the UK and are now looking at attempting similar projects in India, France, and Japan.

There is now potential of harnessing wireless power from space. The Japanese Space Agency (JAXA) believes getting closer to the sun is the best way to drive efficiency and collect more power. The team's Space Solar Power Systems (SSPS) project is trying to send solar panels to

near-Earth orbit. The power collected will be wirelessly transmitted back to base station via microwaves. If successful, this technology could be a true game changer.

Researchers are trying to attain better efficiency which is the biggest hurdle to better solar power. At this moment, more than 80% of all solar panels have an energy efficiency of less than 15 percent. Most of these solar panels are stationary, which means they miss out on direct sunlight. Most of the sunlight that hits the panels is wasted. Better design, better chemistry and the use of sunlight-absorbing nanoparticles could drive efficiency. Some researchers believe they have found a way to capture the infrared spectrum of light for use in solar panels. Right now, infrared rays pass right through the panels and are wasted. But if this spectrum of invisible light can be captured, it could boost energy efficiency by 30 percent.

Meanwhile, IBM is trying to make individual PV cells smaller so that more of them could be squeezed into tighter spaces. The company believes it could eventually pack ten times more PV cells into the same space. The relentless drive of technology will eventually help solar energy contribute a major part in the annual energy needs. Better and more efficient devices will be powered by the sun and could store this energy for longer periods. The coming energy boom is set to change lives forever. Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.[20]

Much earlier, in 2011, the technology produced less than one tenth of one percent of global energy demand. Many are familiar with so-called photovoltaic cells, or solar panels, found on things like spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity. On a much larger scale, solar-thermal power plants employ various techniques to concentrate the sun's energy as a heat source. The heat is then used to boil water to drive a steam turbine that generates electricity in much the same fashion as coal and nuclear power plants, supplying electricity for thousands of people.[21] Solar energy is lauded as an inexhaustible fuel source that is pollution- and often noise-free. The technology is also versatile. For example, solar cells

generate energy for far-out places like satellites in Earth orbit and cabins deep in the Rocky Mountains as easily as they can power downtown buildings and futuristic cars.[22]

There are obvious disadvantages of solar energy. It doesn't work at night without a storage device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very expensive and require a lot of land area to collect the sun's energy at rates useful to lots of people. Despite the drawbacks, solar energy use has surged at about 20 percent a year over the past 15 years, thanks to rapidly falling prices and gains in efficiency. Japan, Germany, and the United States are major markets for solar cells. With tax incentives, and efficient coordination with energy companies, solar electricity can often pay for itself in five to ten years.[23]

Given that it is readily available and renewable, solar power is an attractive source of energy. However, as of 2018, less than two percent of the world's energy came from solar. Historically, solar energy harvesting has been expensive and relatively inefficient. Even this meager solar usage, though, is an improvement over the previous two decades, as the amount of power collected from solar energy worldwide increased over 300-fold from 2000 to 2019. New technological advances over the last twenty years have driven this increased reliance on solar by decreasing costs, and new technological developments promise to augment this solar usage by further decreasing costs and increasing solar panel efficiency.[24] Over the past 20 years, the costs associated with solar cells, the structures capable of converting light energy into electricity, have been steadily decreasing. In the immediate future, silicon solar cells are likely to continue to decrease in cost and be installed in large numbers. In the US, these cost decreases are anticipated to increase the solar power produced by at least 700% by 2050. Meanwhile, research on alternative designs for more efficient and less expensive solar cells will continue. Years from now, we are likely to see alternatives to silicon appearing on our solar farms and rooftops, helping to provide clean and renewable sources of energy. These improvements have and will continue to be made possible by increasing bulk manufacturing of solar cells and new technologies that make the cells cheaper and more efficient.[25]

Solar Power in India

Solar power in India is growing rapidly as part of renewal energy efforts. The country's solar installed capacity was 48.556 GW as of 30 November 2021.[26] In India the forecast is slightly revised upward, especially for solar PV, due to deployment acceleration towards the government’s ambitious renewables target of 500 GW by 2030 and additional policies introduced to improve the attractiveness of distributed PV. Higher renewable energy targets for 2030 in Japan, improved incentive schemes providing stable remuneration for solar PV developers in Korea and increased capacity targets in Viet Nam all support our higher forecast.[27]

The Indian Government had an initial target of 20 GW capacity for 2022, which was achieved four years ahead of schedule. Much earlier in 2015 the target was raised to 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022, targeting an investment of US$100 billion.[4][5] India has established nearly 42 solar parks to make land available to the promoters of solar plants. Earlier, on January 31, 2021, the Ministry of New and Renewable Energy had stated that a further 36.03 GW of solar projects were under various stages of implementation and 23.87 GW were in the tendering process.

Earlier, by the end of 2015, rooftop solar power accounted for 2.1 GW, of which 70% was industrial or commercial. In addition to its large-scale grid-connected solar photovoltaic (PV) initiative, India is developing off-grid solar power for local energy needs. Solar products have increasingly helped to meet rural needs; by the end of 2015 just under one million solar lanterns were sold in the country, reducing the need for kerosene. Some 1,18,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program; just over 1.4 million solar cookers were distributed in India.[28]

The International Solar Alliance (ISA), proposed by India as a founder member, is headquartered in India. India has also put forward the concept of "One Sun One World One Grid" and "World Solar Bank" to harness abundant solar power on global scale. With about 300 clear and sunny days in a year, the calculated solar energy incidence on India's land area is about 5,000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr). The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserves in India. The daily

average solar-power-plant generation capacity in India is 0.30 kWh per m^2 of used land area, equivalent to 1,400–1,800 peak (rated) capacity operating hours in a year with available, commercially-proven technology.[29]

In June 2015, India began a $5.3 million project to measure solar radiation with a spatial resolution of 3 by 3 kilometers (1.9 mi × 1.9 mi). This solar-radiation measuring network provides the basis for the Indian solar-radiation atlas. 121 solar radiation resource assessment (SRRA) stations have been installed across India by the National Institute of Wind Energy, Ministry of New and Renewable Energy to create a database of solar-energy potential. Data is collected and reported to the Centre for Wind Energy Technology (C-WET). Among the parameters measured are Global Horizontal Irradiance (GHI), Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI).[30]

Today, despite supply challenges, the Indian solar market is headed towards one of best years on record. This was a complete turnaround from 2021, which was one of the worst years for solar due to Covid-19. India has made significant strides in building solar power capacity in the first nine months of 2021. During the January-September period, the country added over 7.4 gigawatts of solar power capacity, a 335 per cent increase compared to the 1.73 GW installed in the same period in 2020.[31]

Installations grew despite market challenges. Increased raw materials costs, severe volatility in module availability and price, curtailment of power in several states, and high freight charges have all added to the difficulties for the developers. Despite supply challenges, the Indian solar market is headed towards one of best years on record, and a complete turnaround from 2021, which was one of the worst years for solar due to Covid-19.It is expected that next year would be a strong one despite the high price of components and uncertainties surrounding the Great Indian Bustard related transmission issue in Rajasthan, an increase in General Sales Tax, curtailment and payment issues are adding to the challenges facing developers and constraining growth. Rajasthan is now the top solar state in India in terms of cumulative installed capacity, overtaking Karnataka, which had held the position since 2018.[32]

Solar Power in China

China is the world leader in solar energy. It generates more solar energy than any other country on the planet. They've made major strides in installing solar panels across the country.[33]

China has the world's largest solar power capacity, with 253 GW of installed capacity at the end-2020 compared with about 151 GW in the European Union, according to International Energy Agency data.[34] Meanwhile, China is expected to install a record amount of solar power in 2021 as the industry continues to benefit from green policies in the country, which already has the world's largest fleet of panels. According to the China Photovoltaic Industry's Association, solar installations in China should reach 55-65 GW in 2021, up from 48.2 GW in 2020 and surpassing the record set in 2017. Globally, capacity is set to rise by 15-170 GW this year. Solar is already economically attractive today in most major markets due to policy support and cost declines, and it forecasts 2021 global installations at between 151 GW and 194 GW.[35]

The association says that most solar farms should this year be able to provide electricity as cheaply as the average grid supply as investment costs decline. Chinese production of polysilicon, wafers, cells, and modules all increased by more than 10% last year; however, its solar exports declined. This push for solar energy comes amid a concerted environmental effort in China, which has pledged to hit peak emissions by 2030 and achieve net-zero emissions by 2060. Shares of solar companies have surged since the 2060 goal was announced in September, with polysilicon maker GCL-Poly Energy Holdings Ltd. up nearly 1000% in Hong Kong. Meanwhile, the National Energy Administration said that China added almost 72 GW of wind power in 2020, more than double the previous record. The country also added about 13 GW of hydropower. Analysts with UK-based HSBC Bank wrote in a report that increased solar generation capacity will further drive down the cost of solar power, by as much as 50% from current levels by 2025.The country has not yet publicly released details of how it will achieve the 2060 goal, however analysts have said China could set a high carbon price in the carbon trading market, which could incentivize carbon-emitters to reduce coal-fired power generation.[36]

China is still expected to add up to 65 Gigawatts (GW) of solar power capacity in 2021, its solar manufacturing association said on Thursday, taking total solar installations beyond 300 GW by the end of the year. Solar power installation reached only about 13 GW in the first six months, as a supply constraint on photovoltaic raw material and soaring product prices slowed the development of new solar projects. The price of polysilicon, a key raw material for making solar cells, was three-and-a-half times higher in June than at the end of last year. read more

It was expected that there would be a boom in distributed solar projects and residential installations in the second half of the year, driven by government policies aimed boosting renewable consumption. It was forecasted that 55 GW-65 GW of new capacity this year and said average new solar capacity installation was expected at about 70 GW-90 GW a year over 2021-2025. China in May 2021 ordered power transmission firms to connect a minimum of 90 GW of wind and solar capacity to the grid this year. It wants power generation from solar and wind plants to account for about 11% of total power consumption in 2021, from 9.7% in 2020.[37]

The CPIA has forecast China's exports of solar modules to increase in 2021, following the growth of global solar power capacity. But it warned that trade and political disputes could impede sales. The United States in late June banned imports from five Chinese solar companies accused of using forced labor in Xinjiang.[38]

China's solar module exports were 36.9 GW in the first five months of 2021, up 35.1% from a year earlier, data from the CPIA showed, and the exports may have reached 44-46 GW by end June 2021. Meanwhile, the Biden administration had ordered U.S. government agencies to immediately stop financing new carbon-intensive fossil fuel projects overseas and prioritize global collaborations to deploy clean energy technology, according to U.S. diplomatic cables.[39]

China is the world’s largest CO2 emitter, China’s efforts to decarbonize its energy system will be critical to the goal of limiting the rise in global average surface temperature to 1.5 degrees Celsius. China has already made major commitments to transitioning its energy systems towards renewables, especially power generation from solar, wind and hydro sources. However, there are many unknowns about the future of solar energy in China, including its cost, technical

feasibility, and grid compatibility in the coming decades. Recent projections of the cost of future solar energy potential in China have relied on outdated and overestimated costs of solar panels and their installation, and storage technologies like lithium-ion batteries.[40]

How much will solar power really cost in China in the coming decades, including the challenges its inherent variability poses to the grid? Researchers from Harvard, Tsinghua University in Beijing, Nankai University in Tianjin, and Renmin University of China in Beijing have found that solar energy could provide 43.2% of China's electricity demands in 2060 at less than two-and-a-half U.S. cents per kilowatt-hour. For comparison, coal power tariffs in China ranged 3.6 to 6.5 cents per kilowatt-hour in 2019.

The researchers first found that the physical potential of solar PV, which includes how many solar panels can be installed and how much solar energy they can generate, in China reached 99.2 petawatt-hours in 2020. This is more than twice the country's total consumption of energy in all forms, including not only electricity but also fuels consumed directly by vehicles, factories, building heating and more. The findings show solar PV is an enormous resource for China's decarbonization. They then demonstrated its cost-competitiveness, with 78.6% of the potential in 2020 equal to or lower than current prices of local coal-fired power, a share set to grow further. This cost advantage means China can invest in storage capacity, such as batteries, and still cost-effectively supply 7.2 petawatt-hours or 43.2% of country-wide electricity demand by 2060.[41]

China's solar power industry is bound the increase rapidly in the future as the country makes a historic shift towards renewable energy, net zero transmissions, and a carbon neutral green economy.

United States

In the US, favorable wind and solar PV economics and increased ambition at the federal level drive renewables to new highs. The continuation of federal tax credits in December 2020, a growing corporate PPA market, and increasing federal and state-level support for offshore wind all drive higher capacity additions in our main case forecast.[42] While China will remain the largest PV market, expansion will continue in the United States with ongoing policy support at the federal and state level. Having experienced a significant decline in new solar PV capacity

additions in 2020 as a result of Covid-related delays, India's PV market is expected to recover rapidly in 2021, while increases in generation in Brazil and Viet Nam are driven by strong policy supports for distributed solar PV applications. Globally, solar PV electricity generation is expected to increase by 145 TWh, almost 18%, to approach 1 000 TWh in 2021.[43] 5. The first silicon solar cell, the precursor of all solar-powered devices, was built by Bell Laboratories in 1954. On the first page of its April 26, 1954 issue, The New York Times proclaimed the milestone, "the beginning of a new era, leading eventually to the realization of one of mankind's most cherished dreams -- the harnessing of the almost limitless energy of the sun for the uses of civilization."

The space industry was an early adopter of solar technology. In the 1950s, the space industry began to use solar technology to provide power aboard spacecraft. The Vanguard 1, the first artificial earth satellite powered by solar cells, remains the oldest manmade satellite in orbit -- logging more than 6 billion miles.

Today, demand for solar in the United States is at an all-time high. The amount of solar power installed in the U.S. has increased more than 23 times over the past eight years -- from 1.2 gigawatts (GW) in 2008 to an estimated 27.4 GW at the end of 2015. That's enough energy to power the equivalent of 5.4 million average American homes, according to the Solar Energy Industries Association. The U.S. is currently the third-largest solar market in the world and is positioned to become the second.

As prices continue to fall, solar energy is increasingly becoming an economical energy choice for American homeowners and businesses. Still, the biggest hurdle to affordable solar energy remains the soft costs -- like permitting, zoning, and hooking a solar system up to the power gird. On average, local permitting and inspection processes add more than $2,500 to the total cost of a solar energy system and can take up to six months to complete. The SunShot Initiative's soft costs program works to make it faster and cheaper for families and businesses to go solar. It seems the technology has caught up in terms of costs and efficiency. It's now at the brink of mass adoption. Every new technology brings new opportunities for business. Tesla and Panasonic are already planning a humongous solar panel manufacturing factory in Buffalo, New

York. Tesla's Powerwall is already one of the most popular domestic energy storage devices in the world. The big players aren't the only ones benefitting from the solar energy boom.

The single largest plant in the world is in the US. The Ivanpah Solar Power Facility is the largest solar power plant in the world. Located in the Mojave Desert in California, the plant harnesses solar power during the day and allows for energy storage and usage when the sun isn't out.[44] The Ivanpah Solar Power Facility uses concentrating solar power (CSP) technology to focus 173,500 heliostats, each containing two mirrors, onto boilers located in three power towers. The plant, which came online in 2014, has a gross capacity of 392 megawatts (MW). CSP technology is unique in that it allows for solar energy to be stored for use after the sun sets -- a key focus for our recent research and development efforts -- which addresses some of the concerns over delivering solar power when and where it is needed most.[45]

The US is pioneering solar energy in Space. The NASA got on board with solar energy technology earlier than most other organizations and agencies, using this power source for satellites and other orbiters in the 1950s. One of these solar-powered satellites, Vanguard 1, is among the oldest manmade objects orbiting the earth.[46]

The use of solar energy is gaining popularity in the US. While there are American individuals and families here and there turning to solar for all or part of their energy needs, many corporate entities are also going green in this way. Retailers like Target and Walmart are among the biggest users of solar energy in the US.

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