

The sunny side of Asia

Solar generation helped avoid at least US\$34 billion in seven Asian countries in the first half of 2022.



Publication date
10 November 2022



About

This study explores the growth of solar power in seven key Asian countries, the potential for future growth and the avoided fossil fuel costs due to solar electricity generation between January and June 2022.

The report was jointly developed by Ember, [CREA](#) and [IEEFA](#). It combines electricity generation analysis, energy generation cost estimates and in-depth policy assessments across China, India, Japan, South Korea, Viet Nam, the Philippines and Thailand.

Avoided fossil fuel costs for each country were estimated using actual power generation data from January to June 2022 from [Ember's Data Explorer](#). The report also estimates the potential cost of additional fossil fuel abatement if solar generation is expanded in line with each country's solar power goals contained in their respective 2030 National Action Plans.

Finally, this analysis outlines the key policy challenges and opportunities for expanding solar power across the region, using a country-by-country policy assessment.

Lead authors

Achmed Shahram Edianto, Isabella Suarez, Norman Waite

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Highlights

US\$34bn

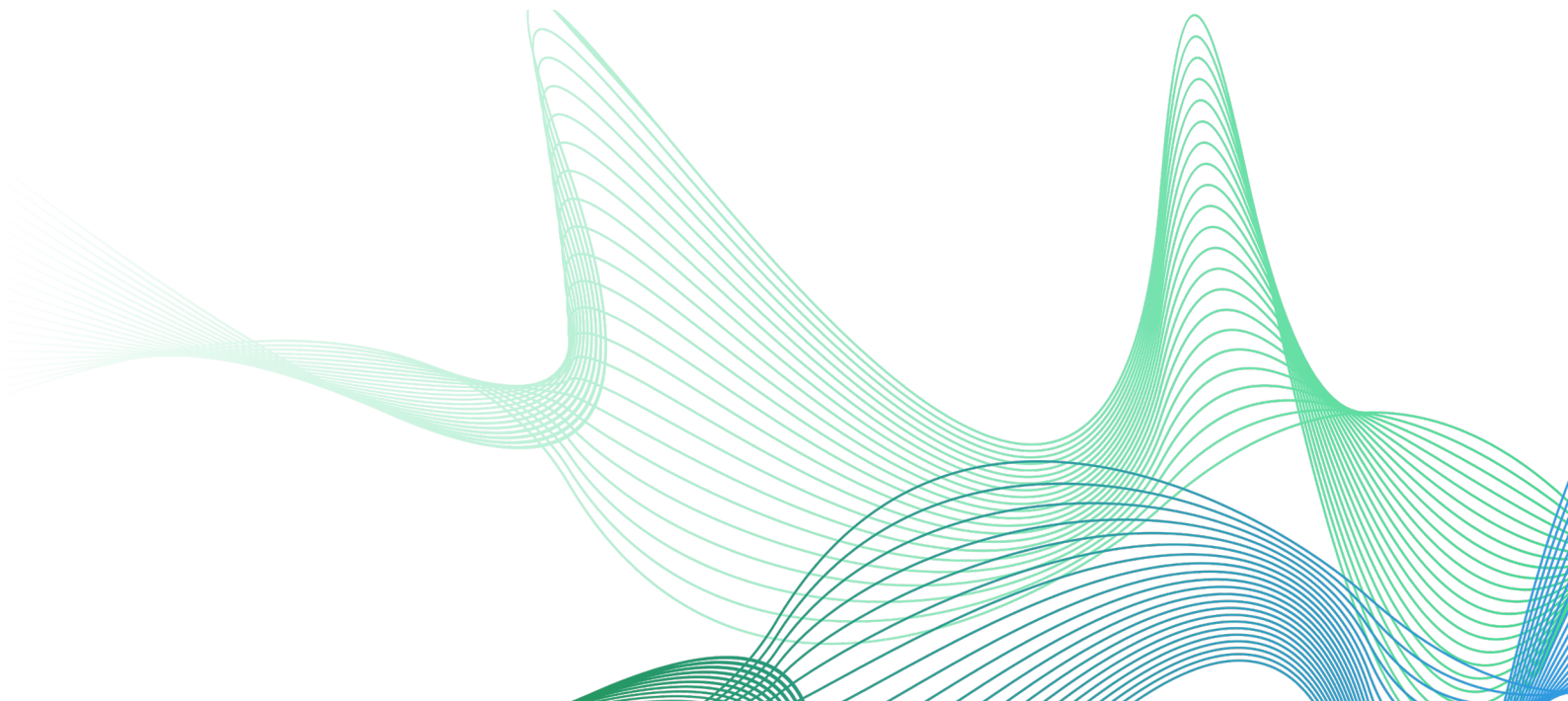
Estimated fossil fuel costs avoided by 7 key Asian countries in the first half of 2022 due to solar generation.

5

Asian countries in top 10 for solar capacity globally in 2021

+22%

Estimated average annual growth of solar capacity across 5 key Asian economies between 2021 and 2030.



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Executive summary

Solar generation helped avoid billions in costs for seven Asian countries

While gas and coal prices soared in 2022, the growth of solar power across China, India, Japan, South Korea, Viet Nam, the Philippines and Thailand helped avoid using costly fossil fuels.

01

US\$34 billion of fossil fuel costs avoided

The contribution of solar generation in seven key Asian countries – China, India, Japan, South Korea, Viet Nam, the Philippines and Thailand – avoided potential fossil fuel costs of approximately US\$34 billion from January to June 2022. This is equal to 9% of total fossil fuel costs these countries incurred over the same period in 2022.

02

Five Asian countries among top ten solar powered economies globally

A decade ago, only two countries in Asia made it to the list, while European countries dominated the top of the global solar capacity ranking. Since then, India, Viet Nam and South Korea have joined the top ten.

03

Solar capacity is likely to grow at 22% per year

Solar power is expected to experience exponential growth at an average annual growth rate of 22% until 2030 across 5 key Asian economies (China, India, the Philippines, Japan and Indonesia).

Asia's growing energy demand has often been framed through the lens of its coal, gas or nuclear dependence, but solar power is growing rapidly across the region. Over the last decade China, India, South Korea, Viet Nam and Japan have significantly increased the share of solar power in their respective energy mixes.

China began the decade with only 1 GW of solar power in 2010, and has increased this capacity to 307 GW by the end of 2021, including a record installation of 53 GW of new solar power that year. In 2022, China is expected to smash last year's record, and it could add between [75 and 90 GW](#) of new solar to the grid. If that happens, this single year roll out would come close to matching the total existing solar capacity across the US, 1.5 times that of Germany, and over four times that of Australia.

India has also seen incredible growth, increasing its share of solar capacity from 0.07 GW in 2010 to 50 GW in 2021. This has led to significant shifts in how much electricity is being generated by solar power each year.

Japan has long been a solar leader – consistently ranking in the top five for solar capacity globally in the past 11 years. However, its solar capacity still increased from 4 GW in 2010 – only 0.3% from total electricity generation – to 74 GW in 2021, generating 9% of its electricity.

While solar capacity has also grown in the Philippines and Thailand, the increase is marginal. Currently, solar power generates less than 3% of Thailand's electricity and less than 2% of that in the Philippines.

However, solar power in Asia has the potential to grow rapidly over the next decade. According to existing national targets across the five major economies (China, India, Indonesia, the Philippines, Japan), we expect to see solar capacity across the region growing at an average of 22% per year until 2030.

This growth will be most pronounced in China, where solar capacity installations alone are expected to reach 1,200 GW by 2030. However, we also expect to see significant growth in India, Indonesia and the Philippines.

This will require tailored national policy innovation, investments in energy storage and flexibility, and collective economic and technological [cooperation](#) on a grand scale.

“Asian countries have shown that rapid solar deployment is possible, setting a remarkable example and providing valuable lessons learned for their peers in the region. As the prices of solar and storage plummet, and the potential cost savings have started to materialise, solar dominance in Asia now looks to come much sooner than previously expected.”

Dr Achmed Shahram Edianto
Electricity Analyst, Ember, Asia



Why Asian solar is crucial

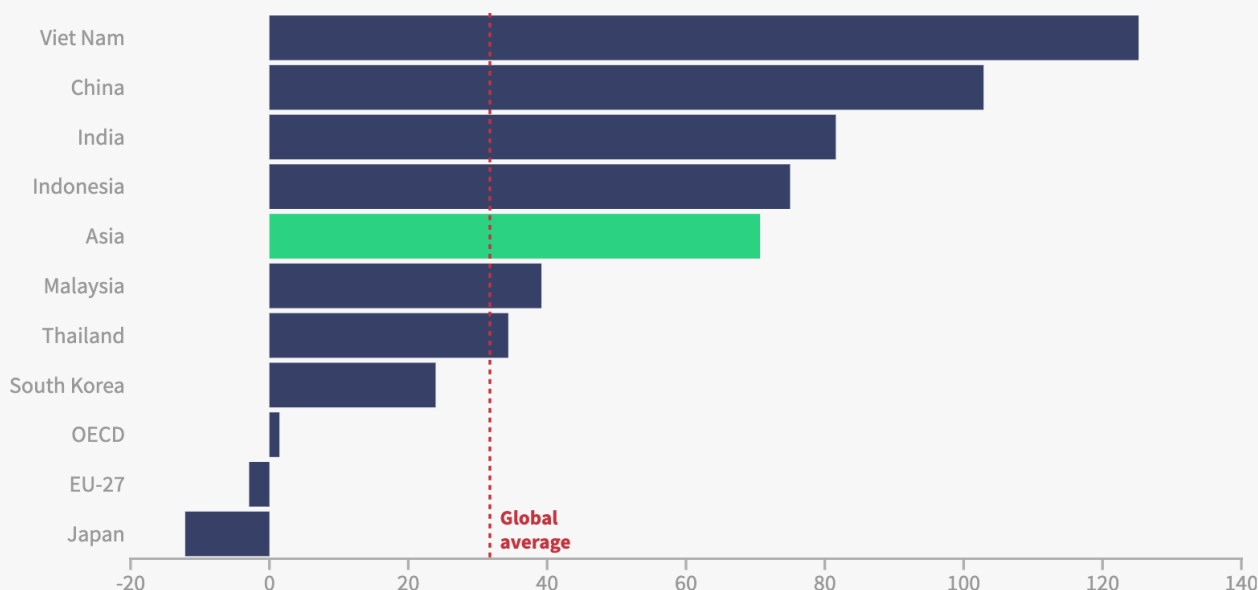
Meeting Asia's growing demand

Electricity demand is increasing more rapidly in Asia than anywhere else in the world.

Accounting for almost half of the global energy demand, Asia is the world's highest emitting region. In January, the IEA published a [report](#) showing the increase in electricity demand is expected to come from Asia-Pacific region, making Asia's clean energy transition more critical than ever.

Electricity demand growth in major Asian economies is above the global average

Change in electricity demand, 2010-2021 (%)



Source: Ember database

From 2010 to 2021, global electricity demand rose by 31.8%, growing at a compounded annual growth rate of 3%. During this time, Asia's emerging economies experienced electricity demand growth at a much faster rate. Viet Nam had the highest growth (+125%), followed by China (+102%), India (+82%), Indonesia (+75%), Malaysia (+39%) and even Thailand experienced energy demand growth of 34%.

Global energy demand is almost certain to continue to increase for the foreseeable future, although the rate is expected to slow, with future energy growth likely to come from [non-OECD countries](#), particularly in Asia.

If the world is to move towards a net zero electricity system by 2040, equipping these rapidly growing economies to meet their energy demand with clean energy will be one of the most crucial challenges of the next decade.

A key step to ensure future energy security

The global fossil fuel market has always been subject to volatility. After a period of relative stability, importing countries are now paying exorbitant prices to secure their energy supply. This highlights the dangers of continued reliance on fossil fuels.

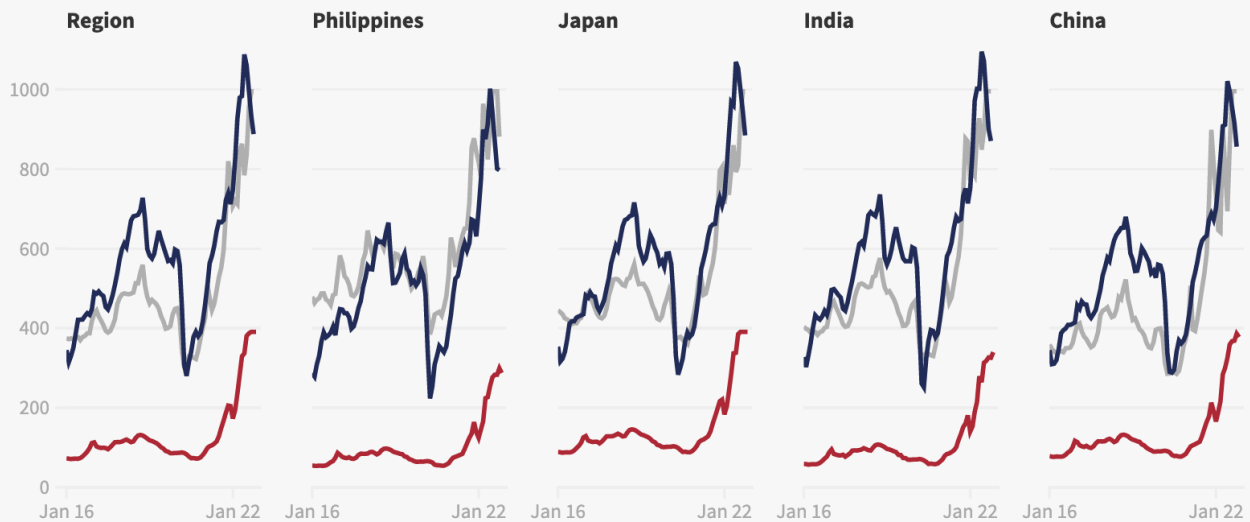
With the exception of Indonesia and India, most of Asia's major fossil fuel consumers import a significant amount of coal, oil and gas to meet their electricity demand. This has left many of the region's major economies vulnerable to the resulting sky-high commodity prices in the global market.

As the last 12 months have shown, reliance on fossil fuels reduces energy security by exposing countries to the volatility of the market. This vulnerability has directly contributed to a rise in energy poverty and a slowdown in economic growth.

Fossil fuel import costs in key Asian geographies have more than tripled in 2022, placing increasing pressure on countries' spending

\$/tonne

Coal Gas Oil



Source: UN Comstat; spot market e.g Brent crude oil, TTF gas, Asian LNG, Newcastle coal

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Solar capacity expansion is largely being driven by cost efficiency. According to [IRENA](#), the levelised cost of electricity (LCOE) of new utility-scale solar panels fell by 88% over the last decade, with an average year-on-year reduction of 13%.

Renewables must be the cornerstone of cost-efficient, future resilient electricity systems. Given the region's massive potential for solar, the growth of solar needs to be the priority in Asia's energy transition and economic expansion.

Promising progress

Asian solar in the spotlight

Asia's solar growth has happened under the radar, making quiet but substantial progress.

While much attention has been given to the expanding use of coal and gas in Asia, [five Asian countries](#) are now among the top ten countries with largest solar capacity in the world.

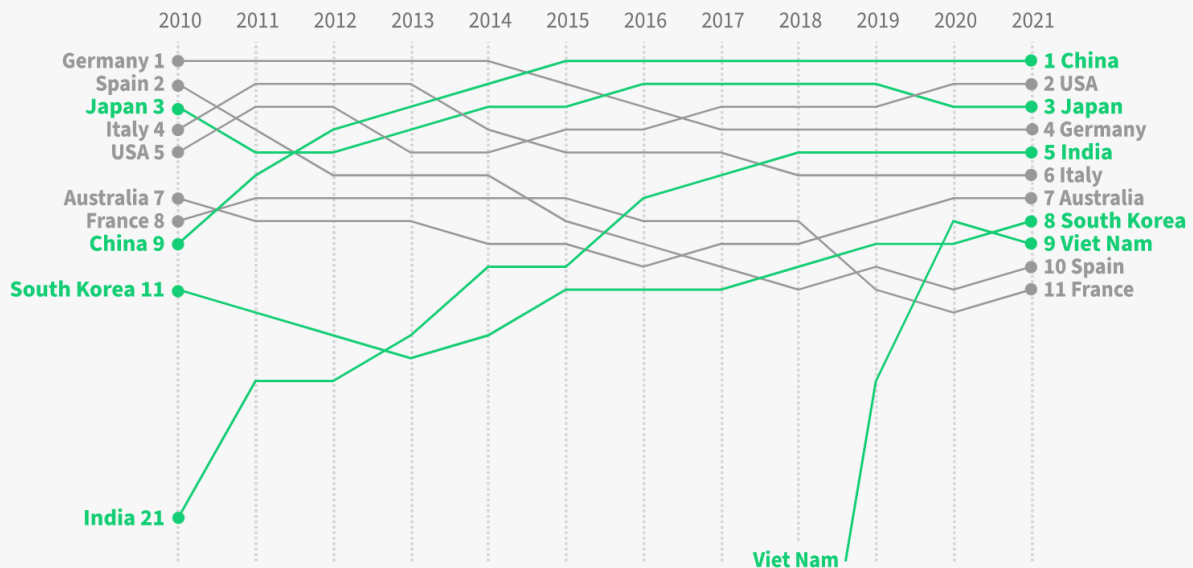
As solar is a major player in the future of the world's energy system, it is clearly becoming Asia's future as well. The question is, how fast?

A decade of growth (2010–2021)

China, Japan, India, South Korea and Viet Nam slid into the top ten countries with the highest solar capacity in 2021. A decade ago, only two countries in Asia made it to the list, while European countries dominated the top of the solar capacity ranking.

Of the top 10 countries with the largest solar capacities, five are in Asia

Global rankings



Source: IRENA (2022), Ember's Global Electricity Review 2022

EMBER

In 2010, India ranked 21st in the world for solar capacity, while Viet Nam ranked 196th. Currently, India and Viet Nam are ranked 5th and 9th, respectively. At the same time, Japan stands in third place, having increased capacity from 2.6 GW in 2010 to 74.2 GW in 2021.

Solar power is expected to continue growing exponentially across the five key Asian countries (China, India, Japan, the Philippines and Indonesia), with an average of 22% growth each year, positioning the region to become a global hub of solar power. The fastest growth rates are expected in the Philippines and Indonesia.

China currently has a goal to install a total of 1,200 GW of wind and solar by 2030. Experts project that the country's actual renewable energy (RE) deployment will far outpace this target with [one study estimating](#) that solar alone could amount to 1,000 GW capacity by 2030. While the country does not have an isolated goal for its future solar capacity additions, solar power has accounted for a 50% share of solar and wind capacity additions on average between 2012 and 2021.

India has established a good track record on solar capacity additions and is well positioned to make a sprint towards its target of 280 GW by 2030, a six fold increase on current levels. If achieved, this would make India home to one of the world's largest solar fleets by the end of the decade.

The Philippines also has notable ambitions for solar. In 2019, the Philippines legislated plans to increase their solar capacity to 20 GW by 2030, reaching 46 GW by 2040. If achieved, the 2030 mark would be almost 15 times more than the current level (1.4 GW).

Rapid solar deployment is possible in Asia

With the exception of Thailand and the Philippines, which have yet to maximise their solar potential, the other five Asian countries highlighted here show that rapid solar deployment is possible. Their solar trajectories set a remarkable example and provide valuable learnings for their peers in the region.

The share of solar generation in three of Asia's emerging economies is also growing. From 2010 to 2021, Viet Nam, India and China's solar share increased from close to zero to 11%, 4% and 4%, respectively.

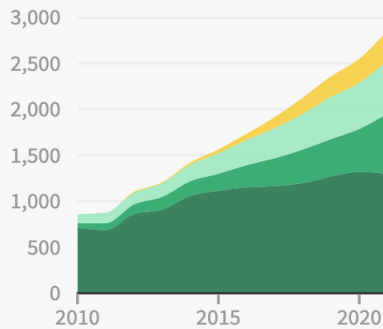
By 2021, Japan and South Korea, two of Asia's most advanced economies, increased the share of solar to 9% and 4% respectively, up from a near-zero share in 2010.

Clean electricity generation in Asia continues to rise; solar is expanding

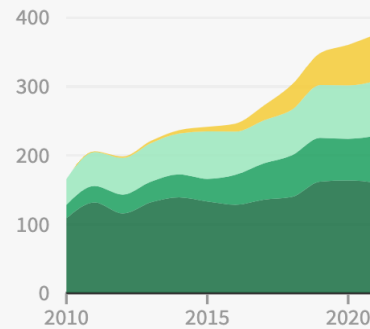
Clean electricity generation 2010-2021 (terawatt hours)

Hydro Wind Other clean electricity Solar

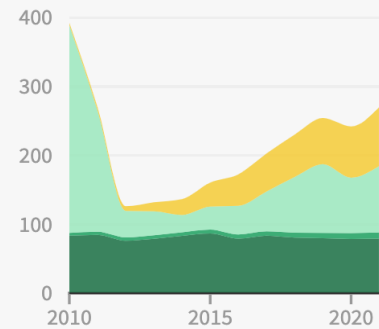
China



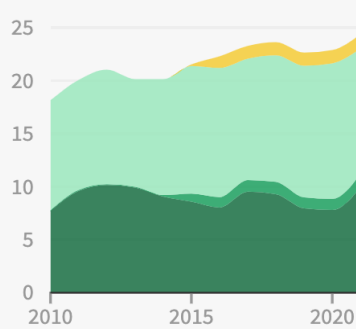
India



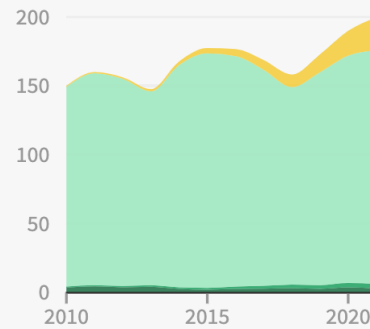
Japan



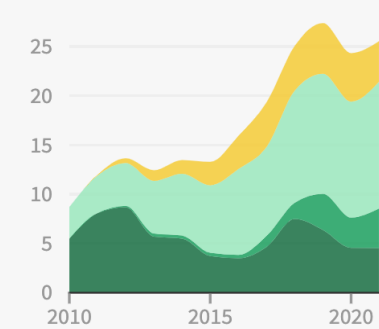
Philippines (the)



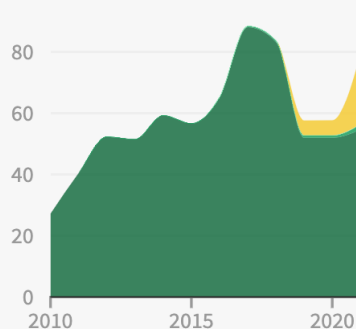
South Korea



Thailand



Viet Nam



Source: Ember database • 'Other' clean energy dropped significantly in Japan following the 2011 Fukushima nuclear disaster; Other clean electricity includes nuclear, bio and geothermal

Rapid solar expansion is possible, but it needs to be partnered with a focus on transmission and distribution

Viet Nam has shown it is possible to deploy solar at scale within only three years. Between 2018 and 2021, solar power generation rose from basically 0 to 22.65 TWh.

However, Viet Nam's quick ramp up of solar has led to grid and policy challenges.

Attractive feed-in tariffs successfully boosted solar in the country, but the grid expansion could not keep up with rapid solar deployment. At its peak in 2019, the average time for construction and commissioning a solar PV project in Viet Nam was around [nine months](#). On the other hand, grid expansion needs [at least three years](#). This has led to high curtailment rates in Viet Nam solar uptakes.

In order to unlock the full potential of solar power, rapid deployment needs to be followed with investment to improve the transmission and distribution system.

The start of solar dominance

Solar continues to demonstrate its potential to become a promising primary energy source for Asia's future electricity. This positive development is expected to continue, particularly under the high uncertainty of fossil energy prices that threaten energy security fossil-dependence countries.

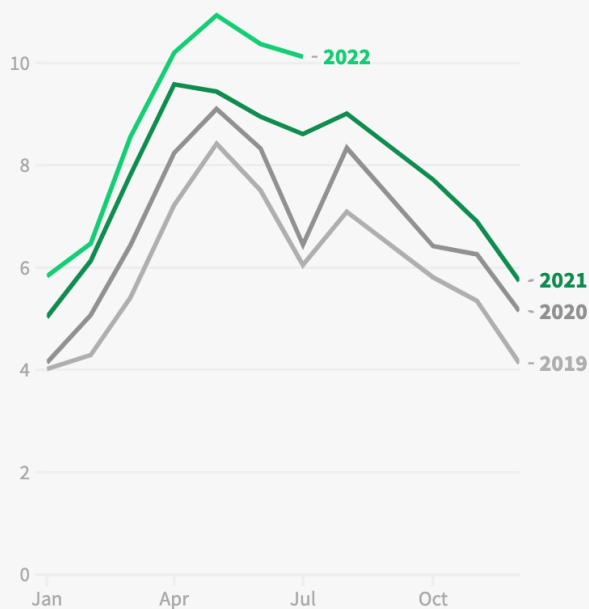
In the first six months of 2022, solar power generated 338.6 TWh, 6% of total electricity in seven key Asian countries – a 26% increase from the same period in 2021. This included solar power generation records in [Japan and South Korea](#) in May 2022.

In the same period, Japan generated more than 10 TWh from solar in May 2022 for the first time ever, reaching 16% of total electricity generation. In South Korea, solar generated more than 7% of the nation's electricity as May's electricity demand reached the highest levels since 2005, with solar generation also reaching an all-time high for the month.

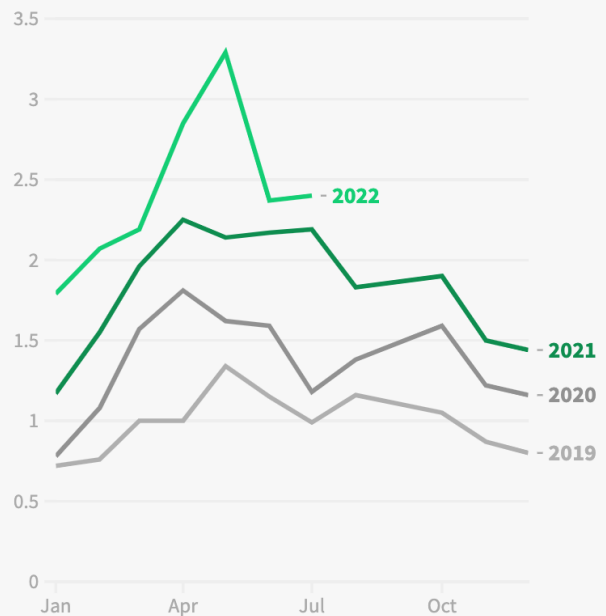
Solar records were reached in Japan and South Korea in May this year

Electricity generation (TWh)

Japan



South Korea



Source: Ember database

Cost-saving potential of solar

US\$34 billion in fuel costs avoided January to June 2022

Solar generation in seven Asian countries helped avoid billions of dollars in fossil fuel costs during the first half of 2022.

In many geographies, solar power now offers the [cheapest electricity in history](#). In the wake of soaring fossil fuel prices, the importance of diversified and domestic renewable energy has only become clearer. The cost of continued reliance on expensive fossil fuels is evident in the supply crunches and increasing electricity prices that many countries are seeing today.

2022 savings

Solar on the grid is already contributing meaningfully to meeting electricity demand. Assuming solar replaced the most expensive fossil based electricity (i.e. either coal, gas or oil), our analysis found that the **contribution of solar generation in seven Asian countries – China, India, Japan, South Korea, Viet Nam, the Philippines and Thailand – avoided fossil fuel costs of approximately US\$34 billion from January to June 2022.**

“Asian countries need to tap into their massive solar potential to rapidly transition away from costly and highly-polluting fossil fuels. The potential savings from existing solar alone are enormous. Expediting their deployment alongside other clean energy sources such as wind, will be crucial for energy security in the region. While ambitious targets are important, follow through will be the key thing to watch moving forward.”

Isabella Suarez

Southeast Asia analyst, CREA



The majority of these estimated savings are in China, where solar met 5% of the total electricity demand and avoided approximately US\$21 billion in fossil fuels imports from January to June 2022.

Japan saw the second biggest contribution with US\$5.6 billion in avoided fuel costs thanks to solar power generation alone, which [reached record levels for the country in May this year](#).

In India, where the high price of coal is one of the main factors in the [ongoing power crises](#), solar generation avoided US\$4.2 billion in fuel costs in the first half of the year. It also avoided the need for an additional 19.4 million tonnes of coal that would have further stressed the already strained domestic supply.

Viet Nam's solar power avoided US\$1.7 billion in potential fossil fuel costs. Notably, Viet Nam's solar generation was close to zero TWh in 2018. In 2022, solar accounted for 11% (14 TWh) of electricity demand from January to June.

In Thailand and the Philippines, where the growth in solar has been slower, the avoided fuel cost is still notable. While solar only accounted for 2% of Thailand's electricity in the first six months of 2022, an estimated US\$209 million of potential fossil fuel costs were avoided. Similarly, the Philippines avoided US\$78 million in fuel costs, despite solar accounting for only 1.7% of generation.

In South Korea, solar had a 5% generation share in the first half of the year, avoiding potential fossil fuel use costing US\$1.5 billion.

As many countries continue to revise their energy development plans, the volatility in commodity markets and the record breaking fuel costs affecting the price of electricity everywhere must serve as a warning against continued fossil fuel dependence. This needs to be translated into more ambitious solar deployments, capitalising on the massive solar potential in the region.

Unleashing solar in Asia

Raising solar investments

Enabling policies are needed to attract investors, which in turn will drive solar capacity.

Over the last decade, we have seen incredible growth in solar utilisation across Asia. This has been made possible through both dramatic cost reductions in solar installation, as well as innovative policies that have enabled the industry to expand.

This trend looks likely to continue. However, policy shifts will be the key to unlocking solar investment and unleashing the full potential of solar power in Asia.

“A key challenge for successful solar expansion in Asia will include investments in grid stabilisation and energy market reform which, in turn, depend on how attractive solar is to investors. In the short-term though, cost elements such as capital costs, fuel costs as well as operations and maintenance costs will be critical to realise the region’s solar potential.”

Norman Waite

Energy finance analyst, IEEFA



Unlocking investment

Bloomberg New Energy Finance highlights that [prices](#) for photovoltaic (PV) modules are currently in a brief upswing, since bottoming out during the summer of 2020. But despite that, global investment and demand for solar power is growing significantly.

Many European countries have [responded to higher energy prices](#) with increased solar investment. China's solar capacity growth may also reach an all-time high this year, close to 100 GW.

Producers are responding as quickly as possible by increasing solar supply chain capacity, but it is not arriving fast enough to fill higher demand. There is also a significant bottleneck in polysilicon, with pricing six times higher than 2020's summer low. This spike in solar's most fundamental input adds to global pressure on its more minor materials like aluminium, silver and copper.

However, these increases are marginal compared to the dramatic cost inflections we have seen across the energy sector, especially when it comes to coal and gas.

While solar investors may be cautious right now, once new supply chain capacity comes online, it is reasonable to assume that solar prices would return to their downward trend. However, investors will need policy clarity, which will determine whether Asia's solar wave can grow over the next decade.

Solar investment – success stories and cautionary tales

While capex prices are currently firmer, solar investment across Asia will be driven by policy opportunities and challenges, existing infrastructure and clear commitments to decarbonisation.

China, India, Japan, South Korea, Viet Nam, the Philippines and Thailand all have varying advantages and disadvantages on these non-cost factors, and each country has had their own recent history of successes and failures.

We assessed each country's efforts to add solar capacity and shift their power generation mix away from carbon energy volatility and toward renewable PV, based on data from [Bloomberg New Energy Finance](#) (BNEF).

China

Chinese solar installations are set to continue to lead the world, as China is the country best equipped for solar capacity growth.

China's solar supply chain has grown since the early 2000s to dominate every subsector aside from thin film. [This was made possible](#) through government mandates, feed-in-tariff regimes and preferential financing to promote solar investment.

[Early curtailment issues](#) were quickly brought down via pressure on state-owned grid operators and utilities, and [investments in long-distance transmission lines](#) have turned deserted areas such as Xinjiang, Qinghai and Gansu into utility solar powerhouses.

Chinese solar power has become so cheap that it remains competitive against coal and gas, even when equipped with onsite storage. Solar installations reached a record 53 GW last year, and could nearly double this year to over [100 GW](#). This has been made possible through the combination of incentivised policies for distributed rooftop solar and investment through China's [targeted financial facility](#).

Japan

To reverse the decline in solar installations, Japan needs to address factors which make it so expensive.

Currently, Japan is the world's third largest market for solar installations and produces around 10% of its power from the source. However, [Ember data](#) shows that solar installations peaked in 2015 at around 11 GW that year, and have since dropped to just 4.4 GW in 2021.

The latest BNEF estimates for the Levelized Cost of Electricity (LCOE) show Japanese solar as the second most expensive in the world, due mostly to construction, land and labour costs. While previously Japan was able to overcome

this cost through a feed-in-tariff, this has now been replaced by a [less favourable feed-in-premium](#). At the same time, capex costs are elevated by both [supply chain issues and a weaker Yen](#).

While Japan continues to introduce new [policies to grow distributed and rooftop capacity](#), there is a lot more that could be done, and larger scale projects have become less common.

India

India is the world's fifth largest country for solar installations, but it needs to work through impediments, especially to distributed solar, if it is going to reach its solar targets.

Solar power is now the cheapest source of power in the country, and India's large solar players such as [Adani](#), the [National Thermal Power Corporation \(NTPC\)](#) and [ReNew](#), have found ample space to invest in solar projects across Rajasthan, Karnataka and Andhra Pradesh. Overall, India's solar capacity should come within 2 GW of its 60 GW, utility-scale solar target by the end of 2022.

However, [India looks set to miss its distributed and rooftop solar target for 2022](#), by up to 25 GW, or 63%.

The country's [efforts to encourage large scale solar projects](#) have included feed-in-tariff programs, improved land availability, streamlined grid access and access to standardised 25-year power purchase agreements (PPAs). By contrast, India's rooftop and distributed solar investment [has been inhibited](#) by national and subnational policy conflicts, inconsistent net metering options and a lack of financing.

Since April this year, India's push for a domestic solar supply chain has also resulted in the [imposition of a customs duty](#) on imported solar cells and modules, as well as a precipitous decline in solar imports from China since then.

South Korea

South Korea has the dubious distinction of having the most expensive solar power in the world, but can do more to ease solar investment.

Due to its high construction, [limited land availability](#) and labour costs, South Korean solar is the most expensive in the world at US\$116/MWh. Unfortunately, this makes it higher than solar with storage in India and China.

South Korea can benefit from increasing solar capacity. Unfortunately, uneven regulations and grid connection issues with the country's monopoly utility have [kept much of this distributed capacity unconnected at times](#). This presents a critical opportunity to drive further solar investments, but it will require significant policy shifts, and far greater cooperation from KEPCO.

Viet Nam

Viet Nam has become a rising star in Asia for its rapid solar expansion, but also provides a cautionary tale on grid readiness for other countries looking to rapidly expand solar capacity.

Solar has become the cheapest form of energy generation in the country, and provided over 10% of the country's power in 2021. This was made possible through a successfully employed [generous feed-in-tariff in long-term power purchase agreements](#) with Viet Nam Electricity (EVN), which increased its installed solar capacity from around 100 MW in 2018 to 16.7 GW by the end of 2020. As a result, Viet Nam has built the fifth largest domestic solar capacity in Asia in 2021.

However, [Viet Nam's grid wasn't ready for this increase](#), and curtailment rates reached 30–40% in some areas.

While curtailment rates have since fallen, investments into new solar capacity since 2020 have dropped dramatically due to grid instability and continued delays to the country's eighth power development plan (PDP8).

International commercial and industrial companies have begun to take matters into their own hands, [driving distributed and microgrid solar investments to feed their demand for cleaner power sources](#).

The Philippines

The Philippines is a country to watch as a new government and more favourable policies toward solar may provide an inflection point.

While the country has lagged in the region, the recently revised [Philippine Energy Plan \(PEP\)](#) may change that. The PEP requires utilities to increase their renewable energy mix, includes net metering provisions for distributed solar, and enables PPAs directly between large consumers and solar generators.

Solar Philippines and Ayala's ACEN are the two leading solar players, and both have substantial capacity permitted and/or under construction. [The current environment has even gained the attention of solar equipment manufacturers](#), who now consider the need for local production.

Overall there appears to be a new tone to the Philippines' efforts to expand solar capacity, which could be a gamechanger for the country. But the country's energy policies have often proven fragile, and smaller rooftop and distributed solar players still find it challenging to access finance.

Thailand

Thailand's solar installations have stagnated recently, and the government has done little to turn that around.

In 2016, Thailand led ASEAN on solar investments, but has failed to keep pace with the rest of the region at just under 600 MW of new solar since then.

With a fairly robust grid, ample solar endowment, space, and a reasonably large domestic supply chain, solar power is on par with biomass incineration as the lowest cost energy in the country. This is especially true of [floating solar power in the north](#) of the country, which could easily connect to existing high voltage transmission lines.

But without a conducive policy environment, progress on installations has been slow, and many of the early leaders have gone on to become regional players in the solar market, such as B. Grimm and Thai Solar.

Thailand's solar capacity is likely to expand, but without a concerted decarbonisation shift, [any new capacity is likely to be additive, rather than replace the dominance of gas in the country's energy mix](#).

The case for upping ambition

Making Asia's electricity more accessible and secure

Solar power has the potential to help reduce expensive fossil fuel costs and imports, and increase energy security.

Rapidly building out solar capacity can provide an additional buffer for countries against fluctuations in fuel costs, as well as supporting climate commitments. **Meeting current targets for solar capacity could save the seven highlighted countries at least US\$44 billion in fuel costs in 2030 – US\$10 billion more than the first half of this year.**

If fuel prices remain within the range of record high 2022 prices, meeting solar generation targets could see an additional US\$ 58 billion in avoided fuel costs across the seven Asian countries.

China's [target](#) to add more than 1,200 GW of renewables by 2030 is [projected](#) to be within reach by 2025, with solar capacity installations alone expected to reach 1,000 GW by 2030. If such capacity is met in 2030 and connected to the grid, **it could avoid at least US\$26 billion in fuel costs for the country.**

If India's 2030 solar target is achieved to provide 19% of the country's electricity generation in 2030, it could avoid at least US\$11 billion fuel costs.

Depending on future fuel prices, South Korea's avoided fuel costs would be at least US\$1.2 billion if the 2030 target to add 34 GW of solar is achieved. With a target to increase the share of solar generation to 16% in 2030, Japan could also see its avoided fuel costs and imports increase to at least US\$3.9 billion.

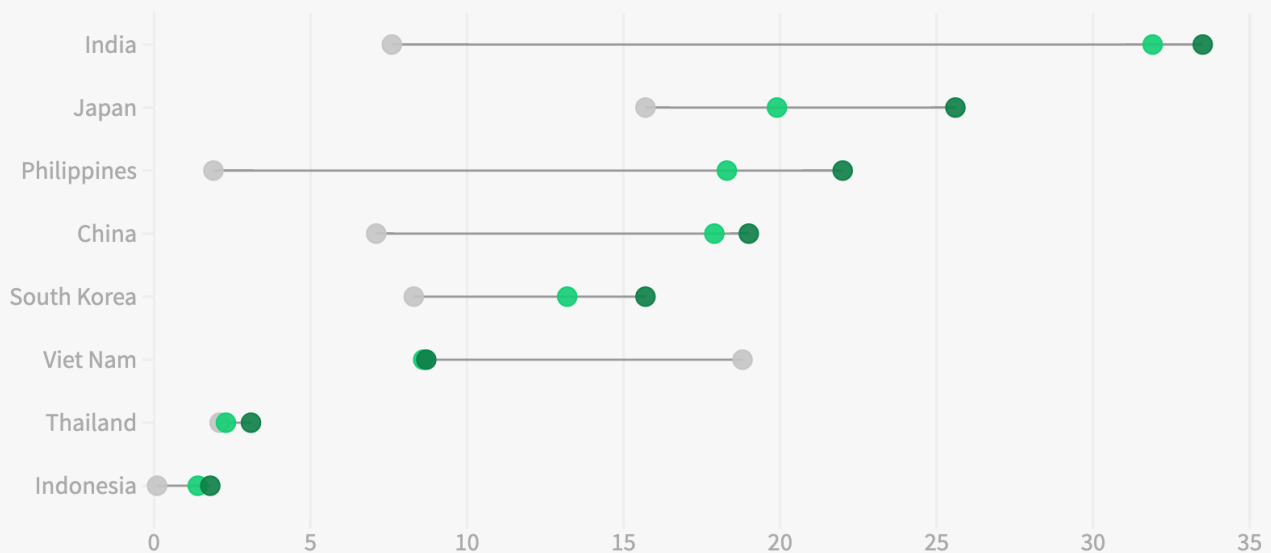
In the Philippines, where the share of renewables has been decreasing in the last decade, solar should account for a 15% share of the new Renewable Portfolio Standards (RPS) by 2030. If this target is achieved, the country could avoid at least US\$580 million in fuel costs.

Viet Nam has announced that it will not build additional solar infrastructure until 2030. However, with plans to modernise and expand the country's grid, the 18 GW of its existing solar capacity can be better utilised, potentially contributing at least US\$790 million in avoided fuel costs in 2030.

Share of fossil fuel import costs avoided due to solar

Cost of imported coal, gas and oil circumvented in the first half of the year (% of total)

● 2022 ● 2030 (assuming 2019 prices) ● 2030 (assuming 2022 prices)



Source: CREA analysis of data from IEA, Comtrade and various national sources • Electricity generation mix assumed to remain constant (at the exception of solar); since Viet Nam's capacity is not increasing, but fuel costs are, the share of costs avoided is decreasing

While ambitious targets are important, they require implementation. There are many barriers preventing the rapid deployment of solar in many Asian countries. Developers in the Philippines face permit bottlenecks, and several other countries exceed the legally binding limits of project development times. Viet Nam's grid infrastructure is insufficient and has been [hampering](#) existing solar generation. In South Korea, the main barriers to growth are a recently [downscaled target](#) for renewable energy, combined with [a lack of clear rules](#) and adequate incentives to support the staggering growth of the nascent solar power industry.

With skyrocketing fuel prices [expected to remain a factor](#), stepping up the deployment of solar, removing the existing barriers and creating the enabling environment for new solar could ease the pressure on its energy system and government budgets.

Beyond Asia's solar leaders

There is huge potential for growth and benefits from solar build out in Asia, even outside of the countries highlighted in this report that are already seeing a sizable payback.

Indonesia could lead Asia by tapping into its solar potential

With solar consistently accounting for 0.06% of Indonesia's electricity generation — the lowest of any country in the G20 — the country misses out on an opportunity to tap into its massive solar potential. Installed solar capacity in Indonesia is one of the lowest in Southeast Asia. **Despite its small share, actual solar generation in Indonesia avoided US\$10 million in fuel costs from January to June 2022.**

Last year, the country committed to net zero by 2060 and a coal phaseout by 2050. To achieve this, renewables like solar will need to be built out rapidly.

At present, state-utility PLN's National Electricity Supply Business Plan ([RUPTL](#)) has allocated only 4.6 GW of additional solar capacity between 2021 and 2030. If this target is implemented, Indonesia would need to build 23 times more capacity than the current level (210 MW). The planned increase in solar generation could already avoid at least US\$788 million in fuel cost in 2030. However, this is a target that remains below existing solar capacity in Viet Nam (16 GW), the current leader of solar in Southeast Asia, and only slightly higher than Thailand's (3.1 GW) current solar capacity.

With [200 GW of solar potential](#), Indonesia's solar ambitions should be raised. According to the latest [report](#) by IRENA, Indonesia needs around 7 GW of additional solar capacity annually until 2030 to align with a 1.5C global heating scenario — more than 14 times of the current target. **If Indonesia achieves this milestone, the country could avoid potential fuel costs of at least US\$2.4 billion in 2030.**

Coal has been the mainstay of Indonesia's power mix and its economy, and the sector is a recipient of enormous regulatory and financial support. But such dependence has been costly.

From 2018 to 2021, the government provided [subsidies](#) to PLN amounting to IDR 197 trillion (roughly US\$1.4 billion) and compensation funds of IDR 87.7 trillion (US\$626 million) to cover the cost of electricity sales for non-subsidized groups. With record high commodity prices, the government's estimated subsidy to PLN in the first quarter of 2022 alone was [IDR 4.7 trillion](#) (US\$336 million).

Regardless of its significant domestic supply of fossil fuels, such subsidies are a significant portion of the national budget, which renewables can help alleviate as the country is becoming increasingly vulnerable to the fluctuations in global market prices.

Significantly raising the country's solar target and investing in its implementation would be critical to achieving net zero in the electricity sector in Indonesia which, in turn, could offer reduced fuel costs and more affordable power bills for a lifetime.

Conclusion

Asia's solar future

Asia's major economies have ended the decade with a significant shift towards solar, and there are incredible savings to be made if the region can unlock its future potential.

While much of the region began the decade slow to realise the potential of solar power, a real shift over recent years has led to incredible savings in the first half of 2022 alone. By the end of the decade, China was not only on top of the world's solar rankings, but five out of seven of Asia's major economies made the top ten.

Thanks to the **incredible growth of solar power**, seven of Asia's major economies **avoided potential fossil fuel costs of US\$34 billion** over the first half of 2022. Considering the continuation of high coal, oil and gas prices in recent months, these savings are likely to have significantly increased.

Going forward, we expect solar's growth curve to continue to increase this decade. While there are considerable challenges ahead, and a real need to transform the policy ecosystem across the region, solar capacity across five major economies could increase by 22% per year until 2030.

If this happens, and is balanced out with storage capacity and considerable investments to support grid interconnectivity and flexibility, we believe the cost savings opportunities are significant.

Based on current 2030 solar targets and the likely volatility of fuel prices, we predict that these major Asian economies could avoid at least US\$44 billion — which is an additional US\$10 billion — if this capacity is met in 2030. While realising these goals will require innovative reforms and collaboration with the private sector, it is clear that solar power is set to play a considerable role in Asia's energy story over the next decade.

Supporting materials

Methodology

The data for this report is based on Ember's yearly and monthly electricity dataset.

You can find the full methodology for underlying emissions, generation and capacity data [here](#). Yearly and monthly electricity data is available for download in [Ember's data catalogue](#).

Fuel Savings Estimate

The amount of fossil fuel saved by solar energy under various scenarios was estimated using the following formula:

$$saved = \sum_i \left(add_{gen_{solar}} \times subshare_i \times \frac{1}{\eta_{th,i}} \times \frac{price_i}{ncv_i} \times 3.6E9 \right)$$

- *saved*: money saved on fossil fuels by the additional solar electricity generation (US\$)
- *i, j*: fossil fuel (i.e. coal, oil and gas)
- *add_gen_solar*: additional solar electricity generation (TWh)
- *subshare_i*: share of additional solar electricity generation replacing fuel *i*
- *η_{th,i}*: average thermal efficiency for power plants using fuel *i*
- *price_i*: price of fuel *i* in (US\$/tonne)
- *ncv_i*: net calorific value of fuel *i* (kJ/kg)

The avoided costs are estimated based on each country's actual power generation data for January to June 2022 from [Ember's Data Explorer](#). The potential avoided costs in 2030 uses the target solar generation of each country in 2030, as presented in their National Energy Plans.

Country	Target share for solar in 2030	Source
Thailand	3%, calculated from target to add 8 GW solar by 2030	Power Development Plan 2018
The Philippines	15%	Power Energy Plan 2020–2040
Viet Nam	11%. No additional solar capacity expected between 2021–30; share of solar is capped at H1 2022.	Power Development Plan VIII, May 2022 draft
South Korea	8%, calculated from 34 GW solar target by 2030.	9th Basic Plan for Long-Term Electricity Demand & Supply 2020–34
India	20%	CEA Report on Optimal Generation Capacity Mix 2029–30
Japan	16%	Sixth Strategic Energy Plan
China	11%	Yuan Jiahai (Dec 2021). Pathway and policy for peaking CO2 emission in China's power sector.
Indonesia	Scenario 1: Additional 4.68 GW of solar	PLN RUPTL 2021–30
	Scenario 2: Additional 66 GW between 2021–30	IRENA Indonesia energy transition outlook 2022

The *thermal efficiency* of power plants is extracted from IEA World Energy Balances, and detailed in the table below:

Country	Coal	Gas	Oil
China	38.0%	56.6%	35.0%
India	36.8%	40.6%	16.8%
Malaysia	34.0%	43.1%	14.3%
The Philippines	31.9%	54.1%	41.9%
South Korea	38.3%	55.1%	39.3%
Thailand	36.9%	46.0%	32.9%
Viet Nam	30.9%	50.7%	49.6%

Thermal efficiencies in Japan were not available in the original dataset; the thermal efficiency of plants in South Korea was used.

Net calorific value (NCV) of imported fuels is also considered, as the volume of imports would have likely had to increase if additional solar was unavailable. These NCVs are obtained from IEA World Energy Statistics, and detailed below.

Country	Coal Bituminous Coal	Natural Gas	Oil Diesel Oil
China	20.9	46.9	44.6
India	23.6	49.9	44.6
Japan	23.8	47.6	44.6
Malaysia	26.4	47.3	44.6
The Philippines	22.1	46.5	44.6
South Korea	23.7	50.3	44.6
Thailand	26.4	43.9	44.6
Viet Nam	23.4	46.6	44.6

Assumed Net Calorific Value of fossil fuels in MJ / kg.

According to the UN Comtrade Database, most of the steam coal (i.e. excluding coking coal) imported in these countries is bituminous coal. We therefore used the NCV of bituminous coal. We also assume that oil power generation is using diesel oil, with a NCV of 44.6 MJ/kg.

Solar/fossil fuel substitution

To estimate the amount of fuel saved by solar electricity generation, one needs to build a counterfactual scenario where the solar electricity generation is generated by other fuels instead. Here we assume that solar has replaced incumbent fossil fuel based electricity generation. For our estimation to be conservative, we assume solar has replaced the cheapest form of fossil-fuel based generation during that period (i.e. either coal, gas or oil) and for each country independently.

However, we use different assumptions for Indonesia. We assume solar has replaced oil first, then the cheapest form of fossil-fuel based generation during that period, as stated by the [Ministry of Energy and Mineral Resources and PLN](#) (state-owned utility company).

Fossil fuel prices

Fossil fuels are sold on a variety of contracts including fixed-price, indexed to average oil prices and indexed to other spot prices. This means that the price of fossil fuel is not directly proportional to the current spot price, and it may vary from one country to another.

UN Comtrade database provides trade data in both physical and monetary terms, allowing us to derive a monthly commodity price for each country separately. Commodities considered for t.

However, at the time of writing, 2022-H1 trade data is not available for every country (see table below).

Country	Coal	Gas	Oil
China	March 2022	March 2022	March 2022
India	July 2022	July 2022	July 2022
Indonesia	March 2022	March 2022	March 2022
Japan	August 2022	August 2022	August 2022
Malaysia	December 2021	December 2021	December 2021
The Philippines	June 2022	June 2022	June 2022
South Korea	December 2019	December 2019	December 2019
Thailand	December 2020	December 2020	December 2020
Viet Nam	December 2020	December 2020	December 2020

Latest available dates in UN Comtrade Database at the time of writing.

To estimate prices of displaced fossil fuel trades in 2022, we build linear regression models between historical prices and average monthly spot prices for the current month and with lags (Brent crude oil, TTF gas, Asian LNG, Newcastle coal futures). Models are built for countries individually (see Figure 2).

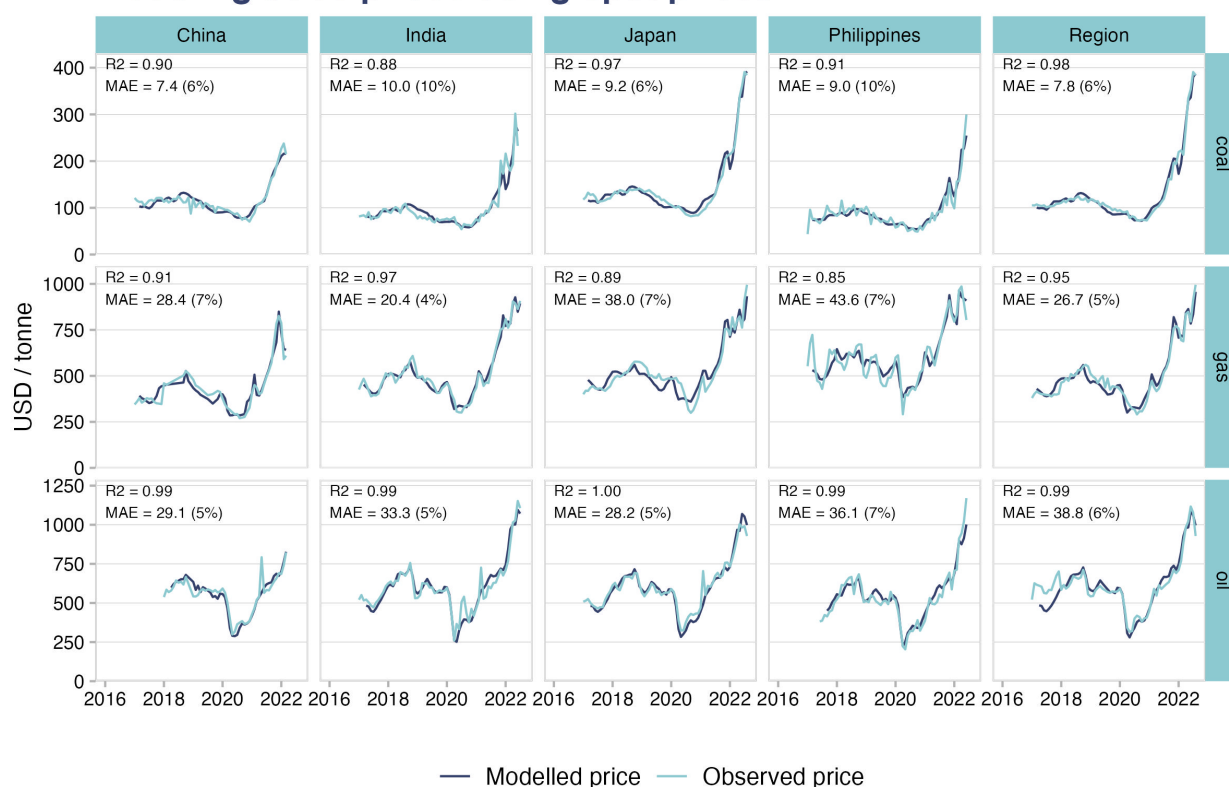
Commodities considered and their corresponding HS code are listed in the table below:

	HS code	HS description
Coal	270112	Coal, bituminous.
Gas	2711	Petroleum gases and other gaseous hydrocarbons.
Oil	2710	Petroleum oils and oils from bituminous minerals, not crude.

Malaysia, South Korea, Thailand and Viet Nam have not yet reported 2022 data. Therefore, the models for these countries did not capture the unusually high prices in 2022-H1. To prevent this from affecting results, the average fuel prices for the region was assumed for these countries. To further prevent model drift (i.e. model prediction beyond the domain it was trained on), we cap commodity pricing using the highest observed prices in the region.

The quality of model fitting is relatively good, with typical R squared greater than 0.9 and median absolute error within 10% of average price.

Modeling trade prices using spot prices



MAE: Mean Absolute Error.

Source: CREA analysis based on UN Comstat, spot market e.g. Brent crude oil, Asian LNG, Newcastle coal.

Prices in 2030

Avoided fuel cost estimates in 2030 use 2019 (low) and 2022 (high) commodity pricing as a reference for 2030 prices.

Bloomberg New Energy Finance

BNEF datasets were used in the financial and investment section of this report, which are available on [this link](#). This is a paid service and will need a subscription to access. To subscribe, please contact BNEF on <https://about.bnef.com/>.

Acknowledgements

Lead authors

Achmed Shahram Edianto, Isabella Suarez, Norman Waite

Contributors:

- Analysis: Uni Lee, Aditya Lolla, Mui Yang
- Data and data-viz: Hubert Thieriot, Chelsea Bruce-Lockhart
- Editorial: Rini Sucahyo, Chris Wright, Hannah Broadbent, Alison Candlin, Hannah Ekberg

Header image

Workers on the roof of a solar panel assembly factory, Solar Valley, Dezhou, China

Credit: [Mick Ryan](#) (Alamy Stock Photo)



Ember

The Fisheries, 1 Mentmore Terrace, London Fields, E8 3PN

Email

info@ember-climate.org

Twitter

[@EmberClimate](https://twitter.com/EmberClimate)

LinkedIn

[/company/ember-climate](https://company/ember-climate)



Centre for Research on Energy and Clean Air (CREA)

Email

getintouch@energyandcleanair.org

Twitter

[@CREACleanAir](https://twitter.com/CREACleanAir)

LinkedIn

[/company/energyandcleanair](https://company/energyandcleanair)



**Institute for Energy Economics
and Financial Analysis**
IEEFA.org

Institute for Energy Economics and Financial Analysis (IEEFA)

14900 Detroit Avenue Suite 206 Lakewood, OH 44107

Email

staff@ieefa.org

Twitter

[@ieefa_institute](https://twitter.com/ieefa_institute)

LinkedIn

[/company/institute-for-energy-economics-and-financial-analysis](https://company/institute-for-energy-economics-and-financial-analysis)