Reach for the sun

The emerging market electricity leapfrog

Report

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The Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's capital markets. Our research to date on unburnable carbon and stranded assets has started a new debate on how to align the financial system in the transition to a low carbon economy.

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The cover photo from Scatec shows part of the 390 MW Benban solar project located near Aswan in Upper Egypt. The project is part of the 1.8GW Benban Solar Park and is Egypt's first utility-scale PV plant which will consist of almost 7.2 million photovoltaic panels. It is the world's largest solar plant to utilise bi-facial solar modules, capturing the sun from both sides of the panel to increase the clean energy generation.

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Key Findings

This is the leapfrog decade. Emerging markets are about to leapfrog fossil fuels to generate all the growth in their electricity supply from renewables. That means peak global fossil fuel usage for electricity generation was probably 2018.

The emerging markets are key to the global transition. 88% of the growth in electricity demand between 2019 and 2040 is expected to come from the emerging markets. If they do not leapfrog to renewables, there will be no global energy transition.

Leapfrog means growth. Whilst a total transition is hard, the leapfrog is more achievable because it requires emerging markets to generate the increase in their domestic demand from renewable electricity, improving energy security.

There are four key groups of emerging markets. These are: China, which is nearly half the electricity demand, and 39% of the expected growth; other importers of coal and gas such as India or Vietnam, which are a third of the demand and nearly half the growth; coal and gas exporters such as Russia or Indonesia, which are 16% of demand but only around 10% of the growth; and 'fragile' states such as Nigeria or Iraq which are 3% of demand and around the same share of growth.

Many countries have already leapfrogged. Developed market demand for fossil fuels for electricity generation peaked in 2007, and is down 20% since then; 99% of developed markets have already seen a peak. Meanwhile, South African fossil fuel demand for electricity peaked in 2007, Chile in 2013, Thailand in 2015, Turkey in 2017. India's double leapfrog — connecting nearly all households to electricity and its renewable energy rollout — is one of the most revolutionary in scale. While its fossil fuel demand for electricity has plateaued for now, it could rise again as the economy recovers unless energy storage prices fall rapidly.

Emerging markets ex-China have reached a peak. In emerging markets ex-China, fossil fuel demand for electricity has already peaked in countries with 63% of total demand. Even in 2019, 87% of the growth in electricity supply came from non-fossil sources.

China is also on the cusp of change. Chinese electricity demand per capita is about the same as in Europe, and in 2020 two-thirds of the growth in supply came from non-fossil sources. Solar and wind are already at 10% of generation, and growing capacity at over 20% a year.

Domestic drivers of change are very powerful. Renewables are the cheapest source of new electricity in 90% of the world, and the rest will soon follow. Emerging markets have massive renewable flows, 140 times greater than their energy demand. The move to renewables will save millions of lives lost to fossil fuel pollutants, reduce energy dependency for the 80% of people living in fossil fuel importer countries and drive local job creation.

Global drivers can speed up the shift. Meanwhile, leaders of the countries with over 70% of global GDP have pledged to get to net-zero by mid-century, competition between China and the US favours a rapid dissemination of renewable technologies, and capital markets are increasing the cost of fossil capital relative to renewables capital. Expect more global technical, financial and policy support, a key prerequisite of a successful COP26.

The barriers to change are all soluble. Intermittency can be managed; solar and wind are still only 4% of emerging market ex-China electricity supply, far below the current feasibility ceiling. With the right policies, system costs are lower than those of fossil fuels. The capital requirements of new renewable-based electricity systems are not necessarily higher than those of fossil fuels. Systemic barriers exist, but apply to all energy sources.

The solution of choice for access. For many electricity-deprived people, domestic renewables provide a superior new solution to drive energy access and power livelihoods. For example, 84% of the expected provision of electricity access in the IEA net zero forecast is from renewables. There is an opportunity for a double leapfrog — from no electricity to access to clean, reliable and affordable electricity for all.

Domestic policy is key. Change is nevertheless hard, and needs policy to liberalise markets, introduce auctions and attract capital. Climatescope analysis shows that countries with appropriate policies in place have attracted 16.5 times as much capital as those without.

Vested interests are holding back change. In some coal and gas exporters and fragile states, vested interests are still able to manipulate the political process to hold back change. But these laggards are too small to stop the global shift.

How the balance of forces will play out. 82% of demand comes from coal and gas importers where the balance of forces favours a leapfrog. 16% of demand comes from coal and gas exporters, some of which like South Africa are already changing. 3% of demand comes from fragile states, which are likely to need considerable external support.

EM demand will peak by 2025. Change will be phased. Given the continued rapid growth rate of solar and wind, it is highly likely that emerging markets ex-China have already plateaued or reached peak demand for fossil fuels for electricity. China is likely to peak before 2025.

How to speed up the leapfrog. Developed market policymakers need to identify those countries where the political economy favours a leapfrog, transfer policy and technology expertise and help reduce the cost of capital.

There is a moral case for access. About 770 million people still lack access to electricity. They constitute a small share of forecast growth in electricity demand until 2040. But the international community has a moral obligation to support universal electricity access as the basis for achieving many other sustainable development goals. There is critical need for financial support to drive down prices of storage technologies and cover for current gaps between renewables-plus-storage versus coal. Without such support, either the pace of the energy transition would be slower or many energy-poor people would be trapped at low levels of energy consumption. Neither is morally acceptable.

1 What is the emerging market electricity leapfrog

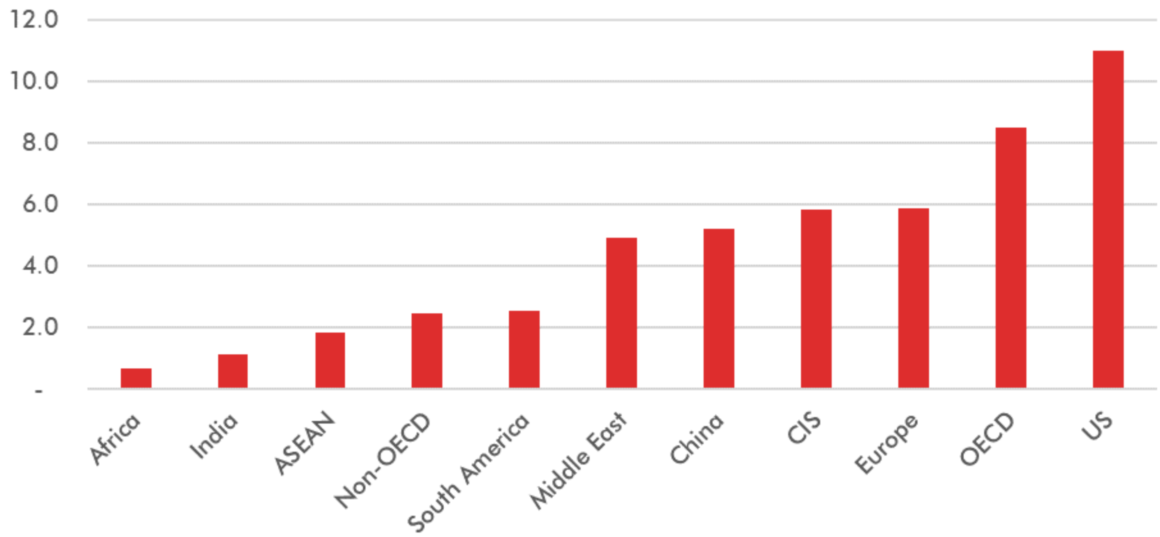
Emerging markets will not follow the same path to renewables as developed markets. They have much lower levels of electricity consumption per capita, and 770 million people still have no access to electricity. Because demand for electricity is growing, countries can leapfrog the fossil fuel system by obtaining their growth in demand from renewable sources. The third key difference is timing – countries can leapfrog at a moment when renewable costs are much lower and many of the policy solutions have been discovered.

What is different about the emerging markets

Electricity demand per person is low

Emerging market electricity demand per capita is under one third of the level of developed markets. However, a wide variety of consumption levels is concealed within that statistic. Electricity demand levels per person are especially low in Africa, India and ASEAN. However, the picture is of course not uniform; it is notable that China, the CIS and the Middle East have similar levels of per capita demand for electricity to Europe.

FIGURE 1: ELECTRICITY DEMAND PER PERSON 2019 MWH PP

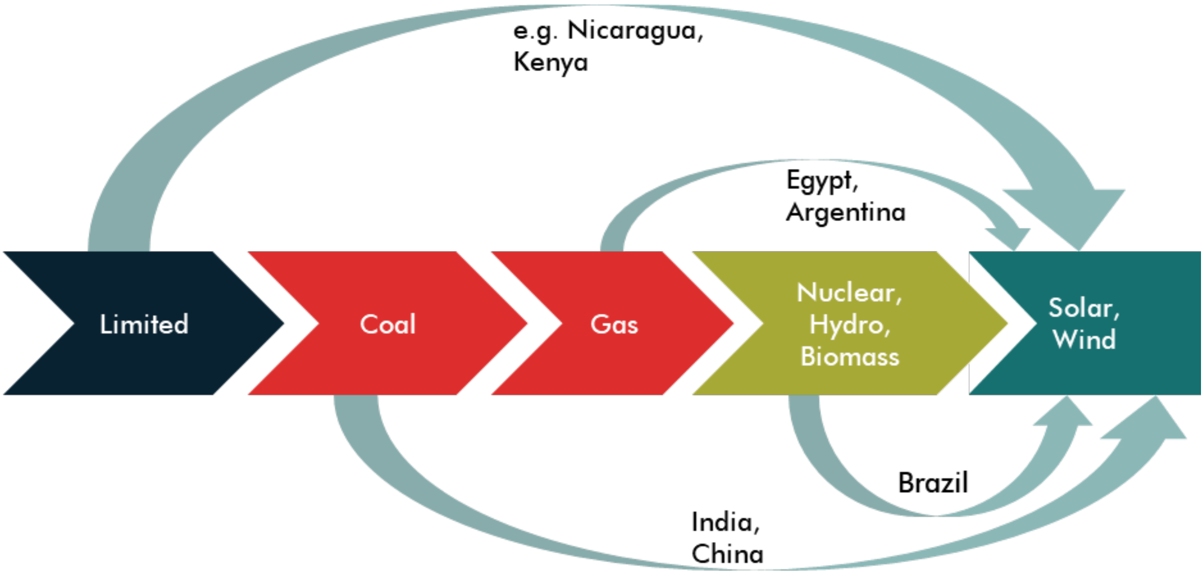


Source: BP Statistical Review

Leapfrog means growth

The emerging market electricity leapfrog is that process whereby emerging markets get their growth in electricity supply from non-fossil sources. The leapfrog is from the current system direct to modern domestic renewables without passing through the intermediary stage of building up a huge electricity infrastructure based on largely imported fossil fuels.

FIGURE 2: THE EMERGING MARKET ELECTRICITY LEAPFROG



Source: Carbon Tracker.[1]

It is important to state at the outset that this leapfrog is not the same as getting all electricity from renewables. The leapfrog is just the growth in supply. As such, this is a more feasible challenge to solve for countries that have rising electricity demand than for those with falling demand. Because it is possible to retain the existing electricity system, which then moves over time from providing baseload to providing backup.[2] Moreover, if a renewables-based electricity grid system is planned at an early stage, then it is cheaper to implement than seeking to retrofit an existing fossil fuel-based system at peak demand.

We demonstrate this below with a chart of how to get from the emerging market average of 2.5 MWh pp pa to European market levels of 5.9 MWh pp pa by 2050. By definition all of the growth is for new capacity, and it is the growth that undergoes the leapfrog, reducing the challenge to more manageable levels, and limiting the stranded asset risks in the process.

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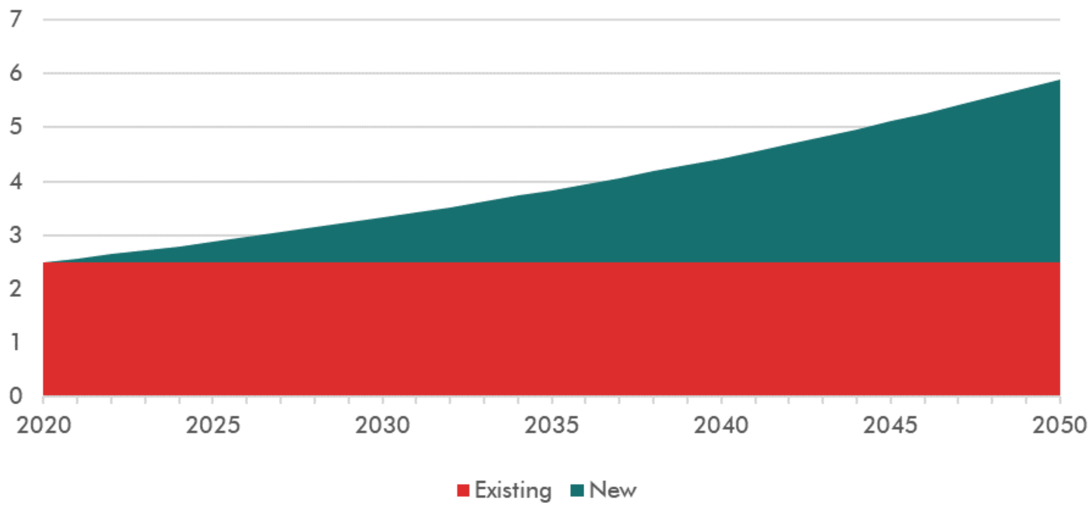
[1] *Even within this framing there are of course different narratives. China has already built out huge coal generation capacity per capita whilst India has begun its leapfrog much earlier.*
[2] *To be clear, the existing fossil fuel electricity system will also need to decline over time, but this is a separate issue as analysed by Carbon Tracker for example in: Do not revive coal, Carbon Tracker, 2021*

FIGURE 3: NON-OECD ELECTRICITY SUPPLY PER PERSON MWH PP PA: CONCEPT CHART



Source: Carbon Tracker

The analogy can be drawn from many other areas. In telecoms, emerging markets went from limited amounts of fixed line phones to mobiles without passing through widespread deployment of fixed line phones. In banking, emerging markets moved from limited banking services to mobile services without having huge branch networks. In internet provision, from limited access to mobile broadband. And so on.

As has happened in countries with large and developed electricity systems, the legacy infrastructure and incumbent industry create a political economy favouring inertia. But for emerging markets, it is the increase in demand over the next 20 years that could tilt the scales. When future demand exceeds past capacity by a margin, the political economy shifts, whereby new sources of capital, labour and revenue (from renewable energy projects) have the scope to overwhelm the existing interests in fossil fuel assets, particularly for countries tied to increasing fossil fuel imports.

Different to developed markets

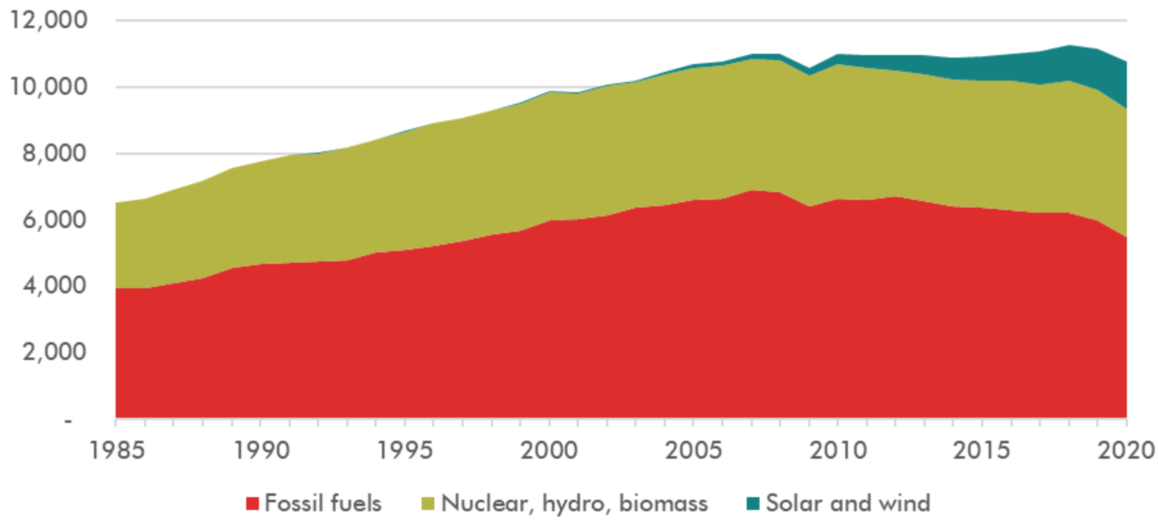
In most developed markets, electricity demand has been flat or falling. So all new renewable deployment pushes existing fossil capacity out of the system. This rapidly creates issues of declining legacy infrastructure.

In light of declining developed market demand for fossil fuels, one should be very suspicious about attempts to force upon the emerging markets those fossil fuel electricity technologies that the developed markets are abandoning. It is a little like trying to encourage countries to build canals rather than railways after 1850 or invest in coaling stations not oil terminals after 1950.

Overall

Developed market fossil fuel supply for electricity generation peaked in 2007 and has been falling steadily ever since. It is notable, as the chart below shows, that there was a recovery bounce in 2010, but demand for fossil fuels never regained the 2007 peak, and soon started to decline once more. It is fair to say that the 2008 financial crisis, therefore, brought forward the peak in the same way that the COVID-19 crisis has brought forward the peak of many aspects of fossil fuel demand. For example, it is now widely accepted that peak demand for ICE vehicles was 2017,[3] that peak coal was 2014 and that peak oil demand for cars was 2019.

FIGURE 4: OECD ELECTRICITY SUPPLY (TWH)



Source: BP Statistical Review, Ember

In the period from 2007 to 2019, OECD fossil fuel electricity supply fell by 936 TWh (14%), as solar and wind grew by 1071 TWh (678%) and nuclear, hydro and biomass were flat. In retrospect, this was a story of rising deployment of solar and wind pushing out fossil fuels from the system, with lower thermal generation utilisation rates accelerating this exit process.

By country

If we look at individual developed markets, we see a similar story. Demand for fossil fuels for electricity generation had peaked in every single developed market by 2018 except for Israel and Latvia. That is to say in 99% of developed markets by demand.

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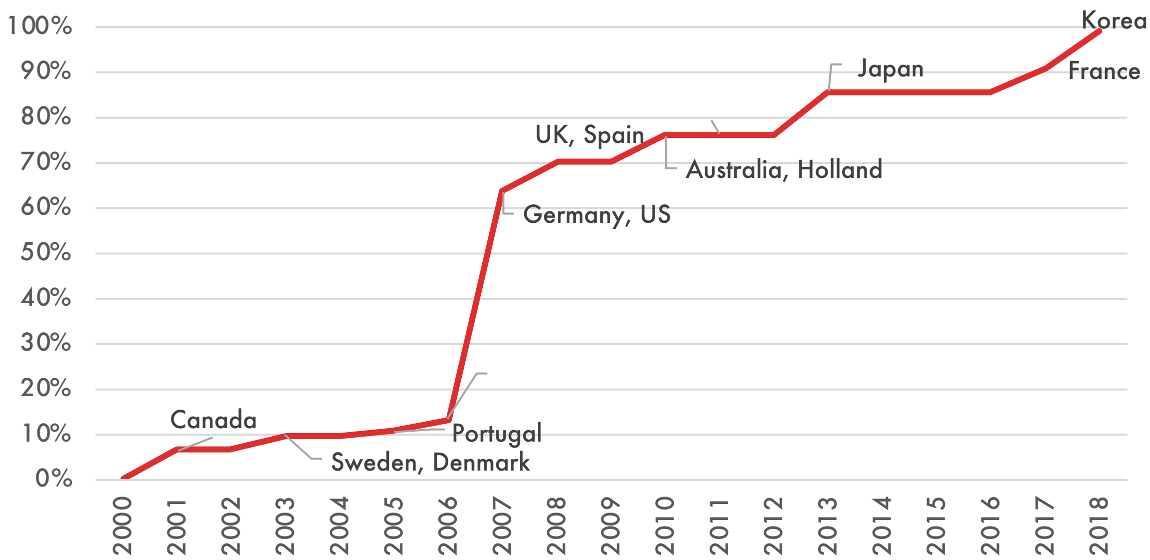
[3] *See, for example, Rocky Mountain institute (RMI) concerning peak ICE cars, IEA 2020 World Energy Outlook concerning peak coal in 2014, and BNEF EV Outlook 2021 concerning peak oil demand for cars.*

FIGURE 5: SHARE OF ELECTRICITY IN COUNTRIES WHERE IT HAS PEAKED: DEVELOPED MARKETS



Source: Ember, Carbon Tracker

For example, the big leap in 2007 in the share of developed markets that had seen peak fossil fuel demand for electricity generation came when Germany and the US reached peak fossil fuel demand, accelerated by energy efficiency gains driving a decoupling of electricity demand from GDP growth.

Types of leapfrog

The story of energy transition is more nuanced for emerging markets than for advanced economies — and offers more opportunity. Emerging markets have several energy transitions underway simultaneously. These include: a shift from traditional biomass to modern energy; a shift in patterns of energy demand thanks to rapid urbanisation and industrialisation; deeper integration into and influence in global energy markets; and the imperative of cleaning up the energy mix due to a shrinking carbon budget[4]. These developments indicate that market size and technology developments could enable a double/triple leapfrog, namely increasing access to energy, rapid electrification of productive sectors of the economy, *and* a growing share of renewables in that electricity mix. This kind of transformation has not happened in the developed world, which has historically followed a more linear trajectory in energy transitions.

It is against this backdrop of multiple energy transitions that we must assess the current positions and likely trajectories for a rapid shift to renewables. The share of coal in the electricity system varies by different emerging markets, from as low as 4% in Brazil to 86% in South Africa.[5]

Moreover, the share of coal in electricity generation has not dropped markedly in recent years. On the face of it, emerging markets might seem heavily dependent on and locked into fossil fuels for electricity generation. However, with some notable exceptions, emerging markets as a whole are in fact very close to their electricity leapfrog, and many of them are already pushing fossil fuels out of the system. We show this with regard to the total numbers and by country.

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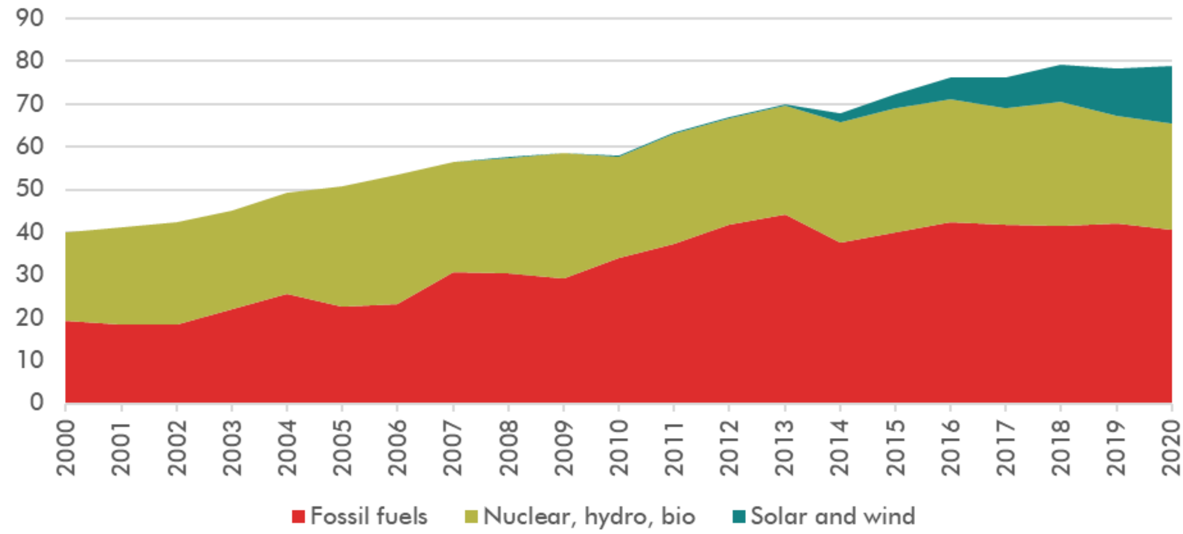
[4] *Bery, Suman, Arunabha Ghosh, Ritu Mathur et al (2017) Energizing India: Towards a Resilient and Equitable Energy System. New Delhi: SAGE*
[5] *Source: BP Statistical Review for 2019*

There are four main starting points for the leapfrog, depending on whether a country has relatively high levels of electricity consumption per capita, average levels, low levels, or the need to provide electricity to those who have none. We illustrate these below, but the key point is that a leapfrog can be undertaken at almost any level of electricity demand per person.[6]

Higher consumption per capita: Chile

Demand per person in Chile in 2019 was 4.1 MW, well above the global average of 2.5 MWh. Chile was able to achieve peak demand for fossil fuels for electricity generation in 2013, through the standard emerging market leapfrog route: rapid growth of solar and wind supply after 2013 was large enough to supply all of the growth in electricity demand.

FIGURE 6: CHILE ELECTRICITY SUPPLY (TWH)



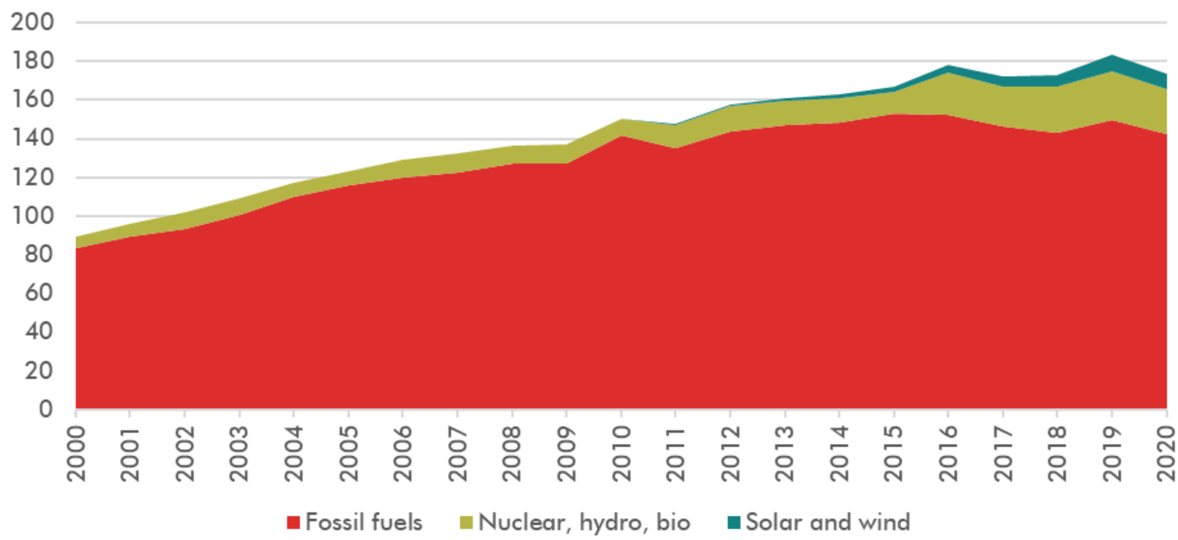
Source: Ember

Average consumption per capita: Thailand

Leapfrogs to provide all the growth from solar and wind have also been seen in countries with a starting point at the emerging market average of 2.5 MWh per person. Thailand, for example, has demand per person of 2.6 MWh. Fossil fuel usage peaked in 2016, and since then all of the growth has come from non-fossil sources.

[6] *There are certain states with extremely low levels of electricity demand per capita, and we return to these as a special case in the section on fragile states.*

FIGURE 7: THAILAND ELECTRICITY SUPPLY (TWH)

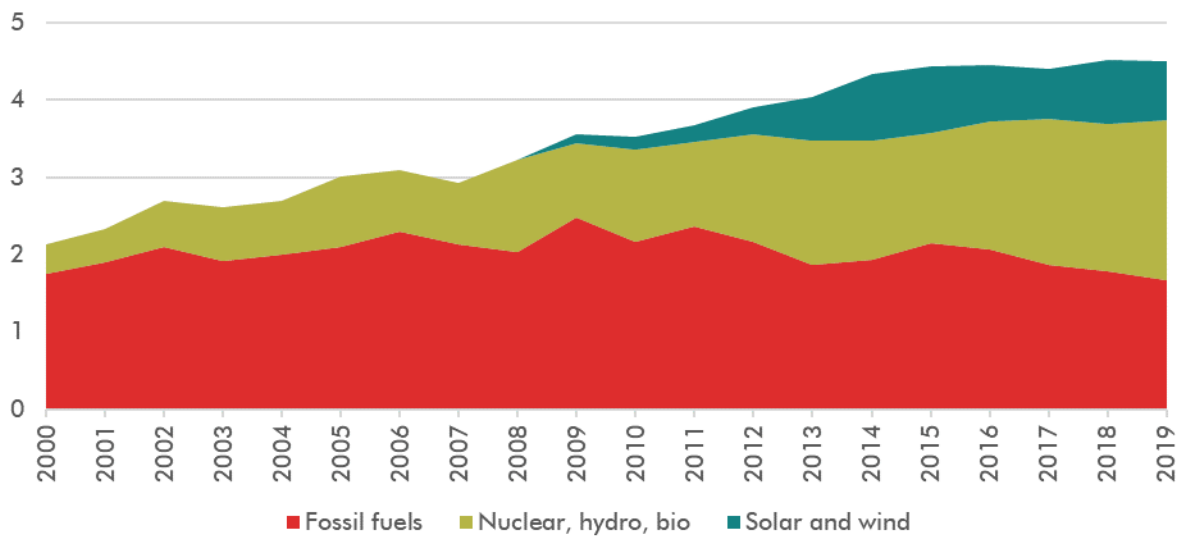


Source: Ember

Low consumption per capita: Nicaragua

Leapfrogs are also possible in countries with low levels of electricity demand per person. In 2019, Nicaragua had demand per person of 0.7 MWh, but demand for fossil fuels has been trending down since 2009 as the country installed non-fossil capacity.

FIGURE 8: NICARAGUA ELECTRICITY SUPPLY (TWH)



Source: Ember

Latent demand or lacking electricity access: India

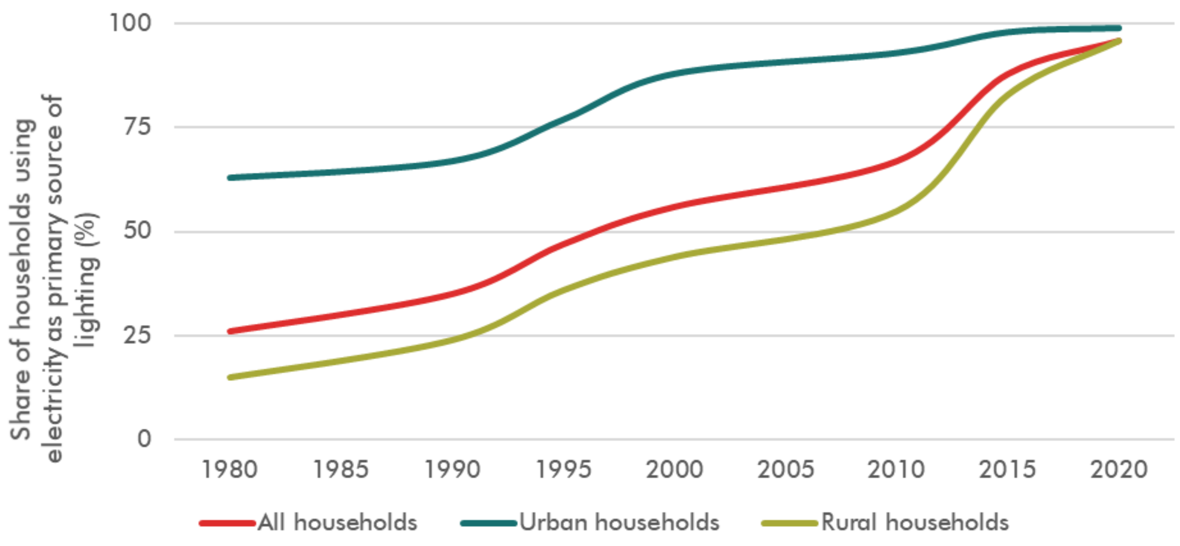
India has already decided to go for a double leapfrog. When the Sustainable Development Goals were announced in 2015, the world had about 940 million people without an electricity connection. At that time, India had 88.2% of households electrified but rural electrification was only 83.2%, making it one of the countries with the largest number of unelectrified people. From 2014, India had already started electrifying all remaining villages and hamlets, achieving the same within 917 days. By 2015, it upgraded its renewable energy ambition to 175 gigawatts by 2022 driven by considerations of energy access, energy security, energy efficiency, jobs and investment[7]. Then, in 2017 India launched a scheme (*Saubhagya*) to connect every remaining household to electricity. By 2019, 97.6% of households had been connected to the grid or to an off-grid source[8]. By March 2021, more than 28 million households had been electrified. With nearly 800 million people gaining access to electricity since 2000, India has undertaken arguably the fastest rate of electrification the world has witnessed so far (see chart).

Then once again, at the UN Climate Action Summit in 2019, India decided to up its renewable energy target to 450 GW (by 2030). Whereas India had less than 20 MW of solar in 2010 when the National Solar Mission launched, by May 2021 it had 96 GW of installed capacity in solar, wind, biomass and small hydro systems. With large hydropower included, India's renewable energy capacity already stands at more than 142 GW or 37% of the power capacity.

India's example demonstrates that it is possible to do the double leapfrog from biomass-based energy to clean electricity access — within a short period and at scale.

Since renewables are available at every scale and because they are distributed, they offer a very compelling solution to the energy access conundrum.

FIGURE 9: INDIA'S PROGRESS ON HOUSEHOLD ELECTRICITY ACCESS (1980-2020)



Source: CEEW

Indian fossil fuel demand for power generation has plateaued for now. This is not a certainty of a peak since various factors are at play. The sluggish growth in the demand for fossil fuels in the power sector has contributed to the plateauing but it must be recognised that this is an economy where latent

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[7] *Ghosh, Arunabha (2015) 'The big push for renewable energy in India: What will drive it?' Bulletin of the Atomic Scientists, 71(4), July/August, 31-42. Available at http://bos.sagepub.com/content/71/4/31.abstract*

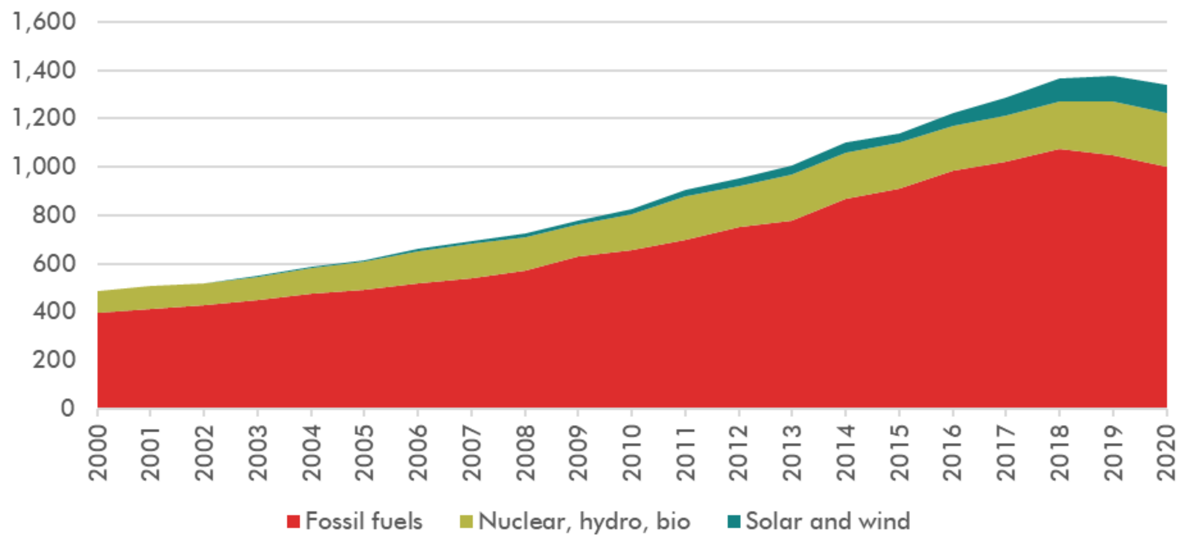
[8] *Agrawal, Shalu, Sunil Mani, Abhishek Jain, and Karthik Ganesan. 2020. State of Electricity Access in India: Insights from the India Residential Energy consumption Survey (IRES) 2020. New Delhi: Council on Energy, Environment and Water. Available at:* https://www.ceew.in/publications/state-electricity-access-india

demand for electricity is still high. Demand for fossil fuels in electricity fell in 2019 and in 2020 as the result of muted economic growth (and some degrowth) and to some extent by the must-run nature of new renewable energy assets.

On one hand, there are policies in place that promote and prioritise renewables even during an economic downturn. These include 'must-run status' giving renewables priority access to grid to avoid curtailing renewable power, exemption from inter-state transmission charges and lower corporate tax rates.

While these policies have contributed to an extent to lower plant load factors for thermal power plants, the bigger culprit for now is depressed demand. When demand surges again as the economy recovers, or when latent demand has to be met, there is likely to be an increase in coal demand as well, at least while renewables plus storage does not become cheaper than the variable cost of generating coal-based power.

FIGURE 10: INDIA ELECTRICITY SUPPLY (TWH)



Source: Ember

This is a conundrum for many other emerging economies. India's example demonstrates that strong policy push can certainly ignite a double leapfrog. But the eventual outcome — whether there will be surges in coal demand or all incremental growth in demand will be met by renewables — is not a function of domestic policy alone. Even as the general trend of technological progress in lowering cost of storage is evident, the energy poor of the world cannot wait until technology evolves organically. International financial support is critical to either speed up the cost reductions for storage technologies or to subsidise the delta between renewable energy plus storage costs and thermal power costs. This would be an imperative even for the hundreds of millions of people in Africa who have not got any connection to electricity at all.

2 What are the different groups of emerging markets

There is no universally accepted term for emerging markets. We simply use the IEA approach in their recent paper on emerging markets,[9] to take all non-OECD markets as well as Chile, Colombia, Mexico and Costa Rica.

We show how markets can be split according to current demand per capita and the share of future consumption growth, and conclude on a way to group this wide group of countries.

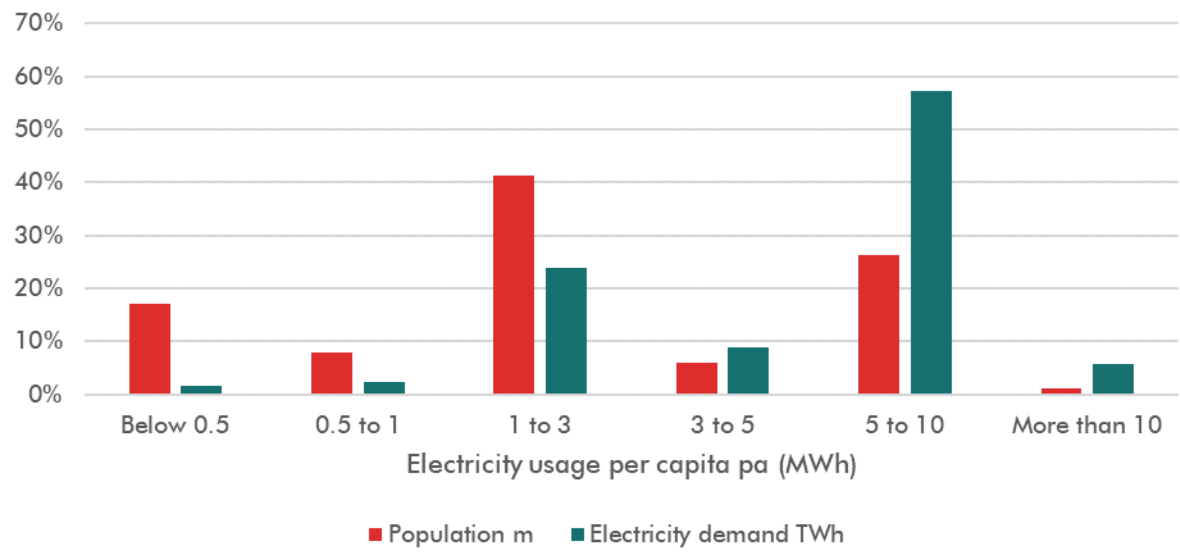
Size

We look at size from the perspective of demand per capita today and the expected growth rate.

Demand today

Ember have data covering 6.1 bn people using 15,400 TWh in the emerging markets as a whole. We show this below, split by usage in MWh per capita in each country.

FIGURE 11: EM – SPLIT OF POPULATION AND ELECTRICITY DEMAND DEPENDENT ON USAGE PP MWH 2019



Source: Ember, BP Statistical Review

There are three key groups within this which are notable:

- Less than 1 MWh per person per day. This is a quarter of the population of the emerging markets (1.5 bn people) but only 4% of the demand. It includes markets like Nigeria.
- More than 5 MWh per day. This is also about a quarter of the population, but just under two-thirds of the demand from the emerging markets. This group includes China (at 5.2 MWh pp) and Saudi Arabia (10.5 MWh pp).

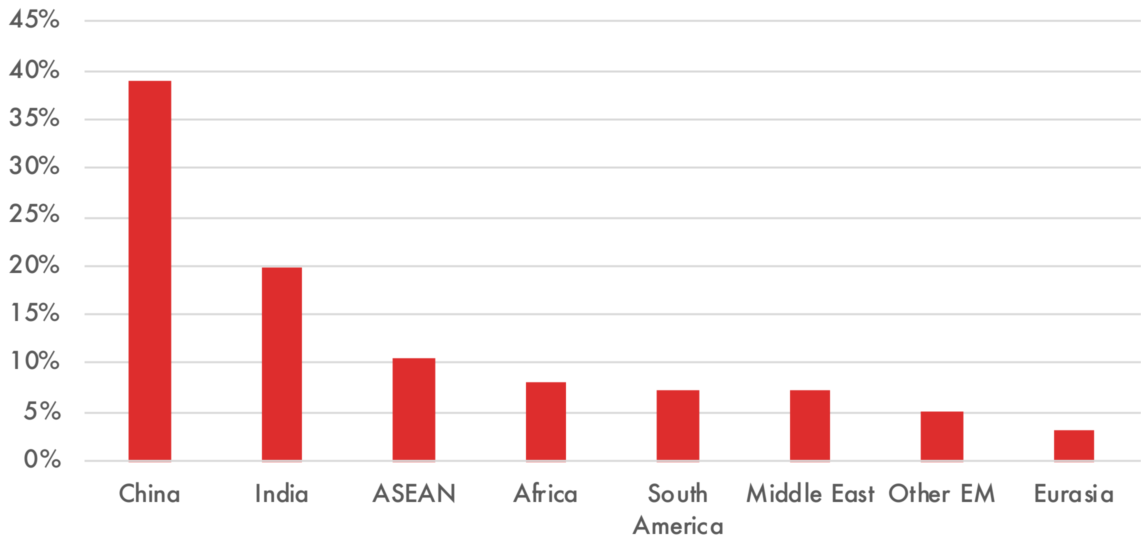
[9] *Source: Financing clean energy transitions in emerging and developing economies, IEA, 2021*

- Between 1 and 3 MWh per day. This is about half the population and a third of the demand. It includes markets like India and Vietnam.

Future demand

There are many scenarios for future electricity demand. They differ widely in the sources of electricity generation but less widely in terms of the size of electricity demand. We take in the first instance the IEA's expected growth in electricity demand between 2019 and 2040 from their primary (STEPS) scenario. 88% of the growth comes from the emerging markets and just 12% from the OECD. And within the emerging markets, 39% is from China and 20% from India. The third largest region is ASEAN at 11%.

FIGURE 12: SPLIT OF GROWTH IN EMERGING MARKET ELECTRICITY DEMAND 2019-40



Source: IEA STEPS scenario from World Energy Outlook 2020

Three observations can be made from this:

- The two key fossil fuel exporting regions of the Middle East and Eurasia are less than 10% of total expected growth in electricity demand. As we will show below, these are the regions most likely to resist an electricity leapfrog, so it is important to realise that they are relatively small as a share of the growth.
- Africa is only 8% of expected demand growth. This is important because the problems facing renewable electricity deployment are especially acute in Africa. But Africa is not a big part of the expected growth at present. By the time Africa begins to account for a larger share of growth in global electricity demand, the case for renewables-based electricity will be even stronger.
- China and India alone are nearly 60% of the expected growth in electricity demand. What happens there will determine the success or failure of the emerging market leapfrog.

The four key groups

As we examine in more detail below, it is possible to split emerging markets according to whether they are importers or exporters of coal and gas, and also specifically to split out the fragile states, which face many systemic issues. It is then possible to allocate all emerging market electricity demand in 2019 according to the four groups below.

The IEA do not provide detailed forecasts for the growth in electricity demand for each country in the world. However, they do produce it for a number of countries (e.g. China and India) and for regions, so the level of uncertainty is not high. If we make the simplifying assumption that the CIS and Middle East are exporters and that half of the expected growth in Africa comes from fragile states, we can allocate the share of growth in electricity demand by these four groups as well.

To summarise these four groups:

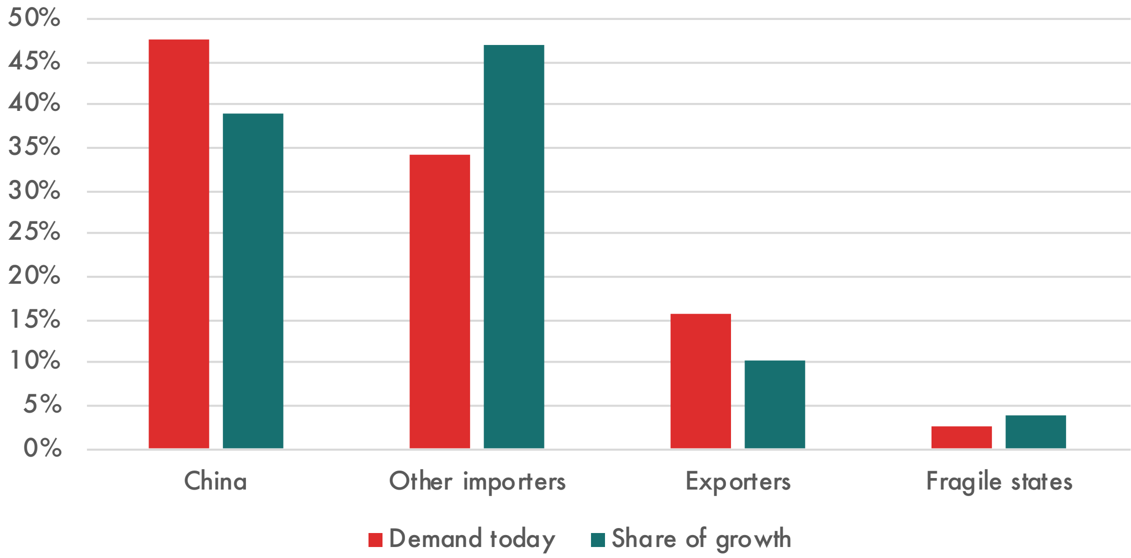
- **China.** Almost half the demand today and 39% of expected growth. Given that China has developed markets levels of demand for electricity per capita, it is a special case.

- **Other importers**. A third of the demand today and just under half the expected growth in demand.

- **Exporters.** 16% of the demand today and around 10% of expected growth.

- **Fragile states**. Just 3% of demand today and around the same share of expected demand growth.

FIGURE 13: SPLIT OF 2019 DEMAND AND EXPECTED DEMAND GROWTH TO 2040



Source: Ember, IEA, Carbon Tracker estimates

3 How advanced is the leapfrog

As we are focussing on marginal change, peak demand for fossil fuels will be seen at the moment when non-fossil sources supply all the growth. We analyse below how close we are to this point both in overall terms and in country terms.

The electricity system can be divided into three parts, which enables us to examine this issue more easily.

- **Solar and wind**. The fastest growing sources of electricity supply, and the drivers of change. Consistently growing every year.
- **Hydro, nuclear and biomass**. They tend to grow slowly over time.
- **Fossil fuels**. The old primary supplier, but now simply the residual in the electricity equation. The solution for when you don't have enough from the other sources of supply. As a result demand fluctuates widely.

Overall

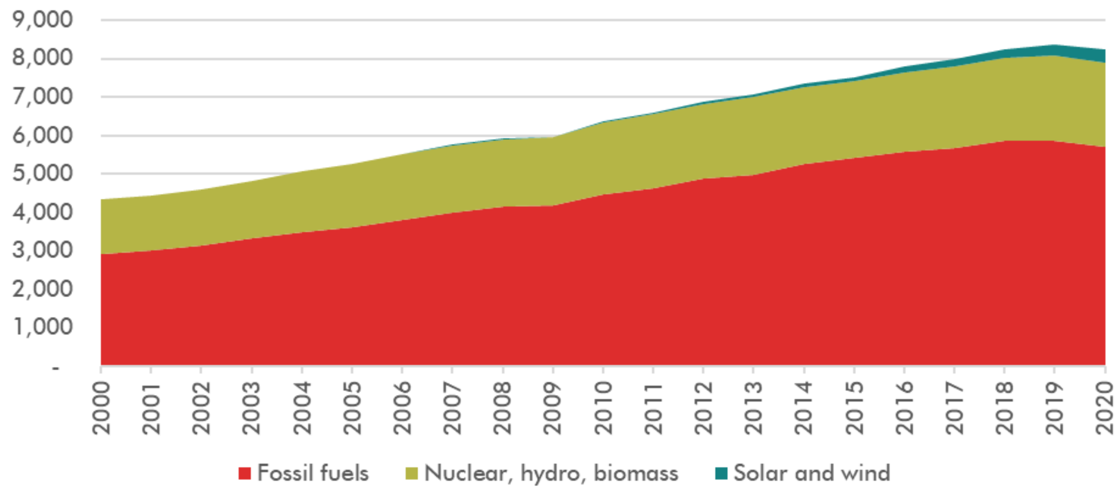
In order to examine the progress made thus far, we split the emerging markets into two roughly equal groups: China; and emerging markets ex-China. Both groups, as we shall see, are already very close to peak fossil fuel demand for electricity generation.

Emerging markets ex-China

Emerging markets ex-China were already very close to peak demand for fossil fuels for electricity generation in 2019. We show below total demand and then split out the growth so as to see better the derivation of marginal change. We focus on 2019 data because 2020 data is so impacted by COVID-19.

Total electricity demand growth has been running at 2.6% a year in the 5 years to 2019, and solar and wind have been rapidly entering the mix at growth rates of 29% a year.

FIGURE 14: ELECTRICITY SUPPLY IN EMERGING MARKETS EX-CHINA TWH

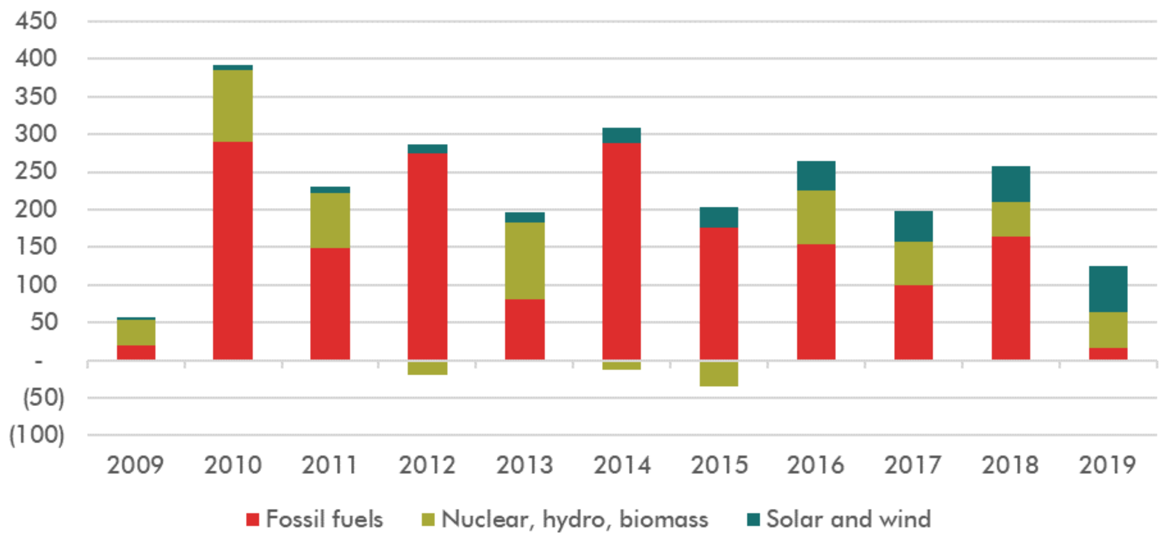


Source: BP Statistical Review, Ember

To summarise the growth in electricity supply in 2019:

- Nearly half of the growth in electricity supply came from solar and wind.
- 38% of the growth came from nuclear, hydro and biomass.
- Only 13% of the growth came from fossil fuels.

Figure 15: Growth in electricity supply TWh. Emerging markets ex-China



Source: BP Statistical Review

China

Total electricity demand in China in 2019 was almost the same size as electricity demand in the whole of the rest of the emerging markets. It follows that as soon as China moves from growth of demand for fossil fuels for electricity generation to slowing demand, the emerging markets as a whole will also move from growth to decline.

We set out below why China is an outlier in the context of the emerging markets, and compare it to Europe before demonstrating that fossil fuel demand for electricity generation has nearly peaked.

China in the context of the emerging markets

Much has been written about Chinese electricity demand,[10] but it is worthwhile to put it in the context of the wider story. In the emerging market context, China is an outlier for four reasons:

- China has high levels of electricity consumption per person (5.4 MWh pp in 2020, almost the same as Europe).
- China has a relatively high level of solar and wind penetration, which were 9.5% of generation in 2020, compared to 4.1% in the rest of emerging markets, but similar to India's levels of 9%.
- China is the manufacturer of much of the solar and wind technology, and already employs more people in these industries than any other country.

[10] *For example: China net zero electricity, RMI, 2021*

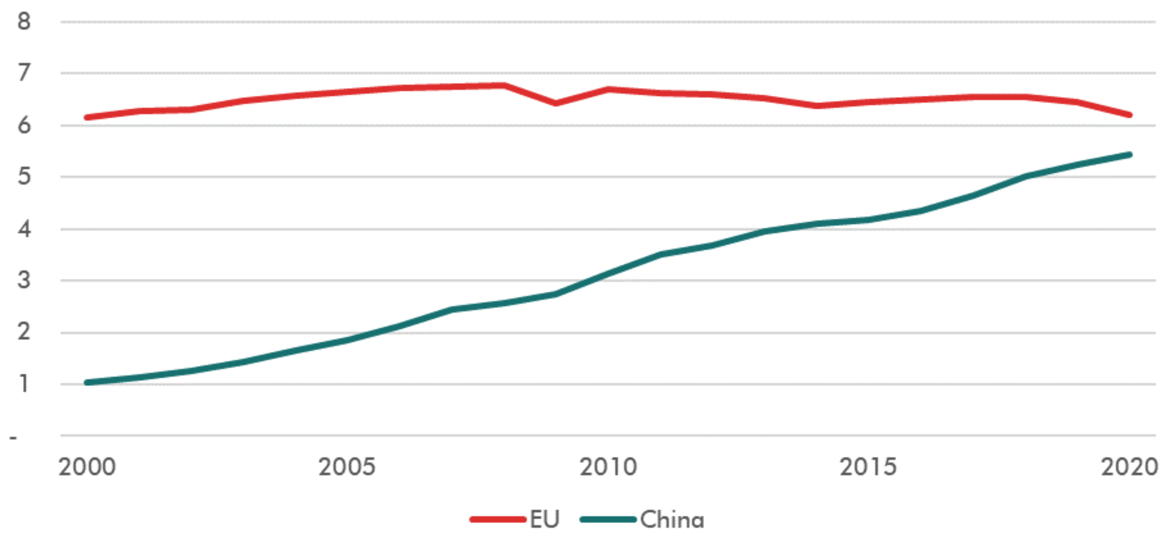
- More people die from fossil fuel pollution in China than in any other country. According to Vohra, China suffered 2.4 million deaths[11] in 2018 from pollution caused by fossil fuels.

Like 80% of emerging markets, China is also an importer of coal and gas. 8% of total energy demand is from imports of coal and gas.

China versus Europe

Electricity demand per person in China is nearly the same as in Europe. And higher than that of the UK for example. The implication is that growth is likely to slow down from the extremely rapid growth rates of the last 20 years.

FIGURE 16: ELECTRICITY DEMAND PER PERSON MWH PP: EU V CHINA

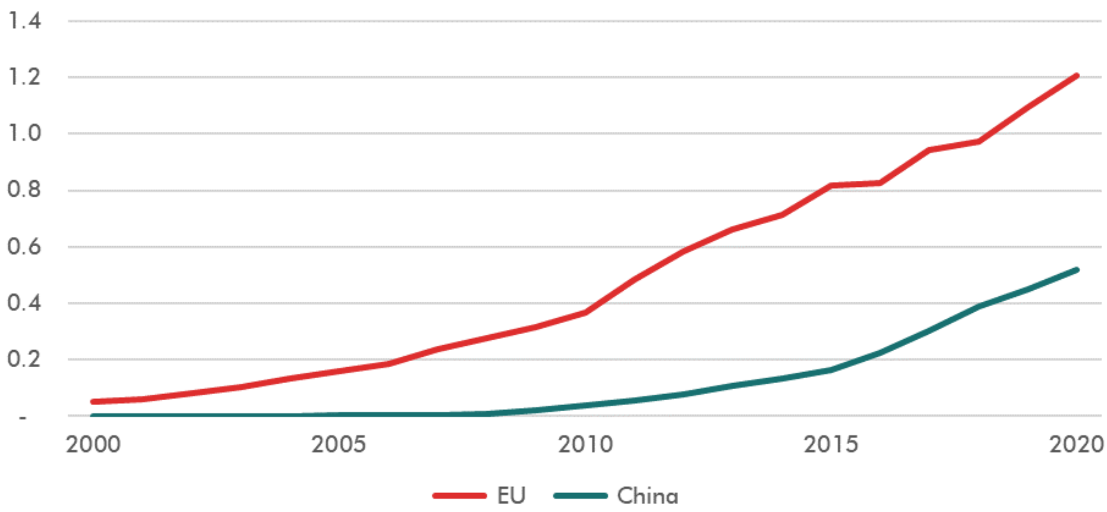


Source: BP Statistical Review, Ember

Chinese supply of wind and solar (impressive though it is) is only at the European per capita level of 2012. The implication is that solar and wind supply are likely to continue to rise on their S curve of growth.

[11] *Source: Environmental Research, Vohra et al., 2021*

FIGURE 17: SOLAR AND WIND ELECTRICITY SUPPLY MWH PP: EU V CHINA

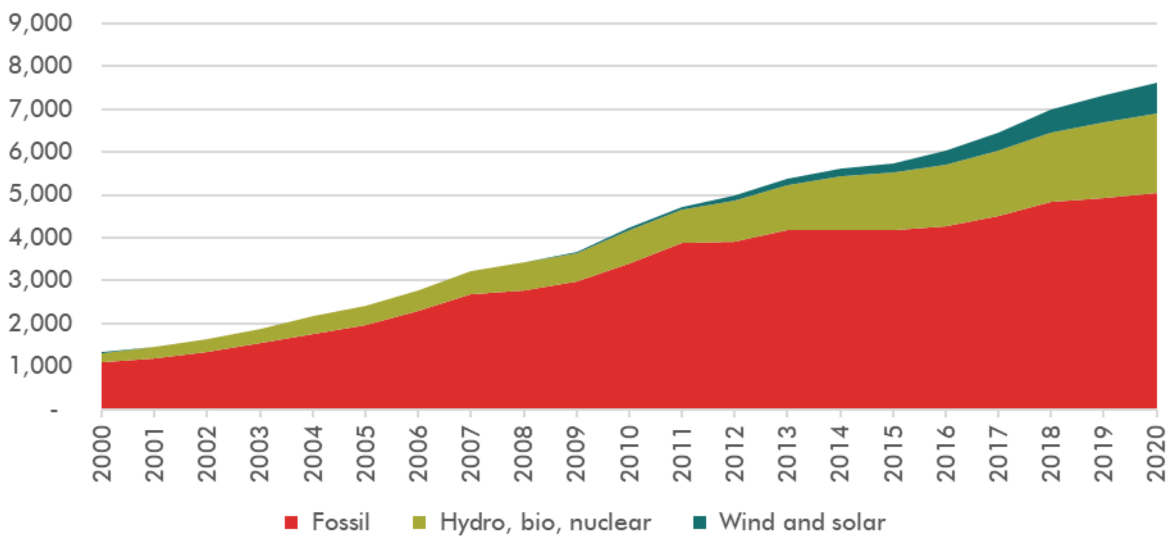


Source: BP Statistical Review, Ember

Change in demand

Chinese demand has been growing inexorably as the chart below shows.

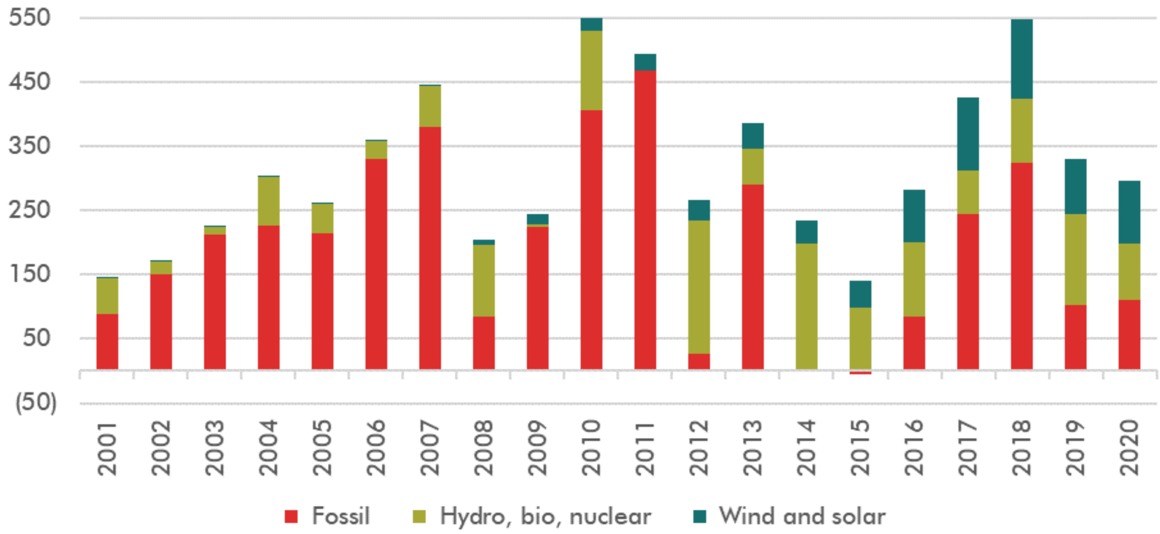
FIGURE 18: SUPPLY OF ELECTRICITY IN CHINA TWH



Source: BP Statistical Review, Ember

However, an increasing share of the growth has come from non-fossil sources. In 2020 for example, the growth in supply was around one-third from each of the three areas of fossil fuels, solar and wind, and other non-fossil sources. The supply growth of fossil fuels for electricity generation has, therefore, slowed to just 2% in the last couple of years.

FIGURE 19: SUPPLY GROWTH OF ELECTRICITY IN CHINA TWH



Source: BP Statistical Review, Ember

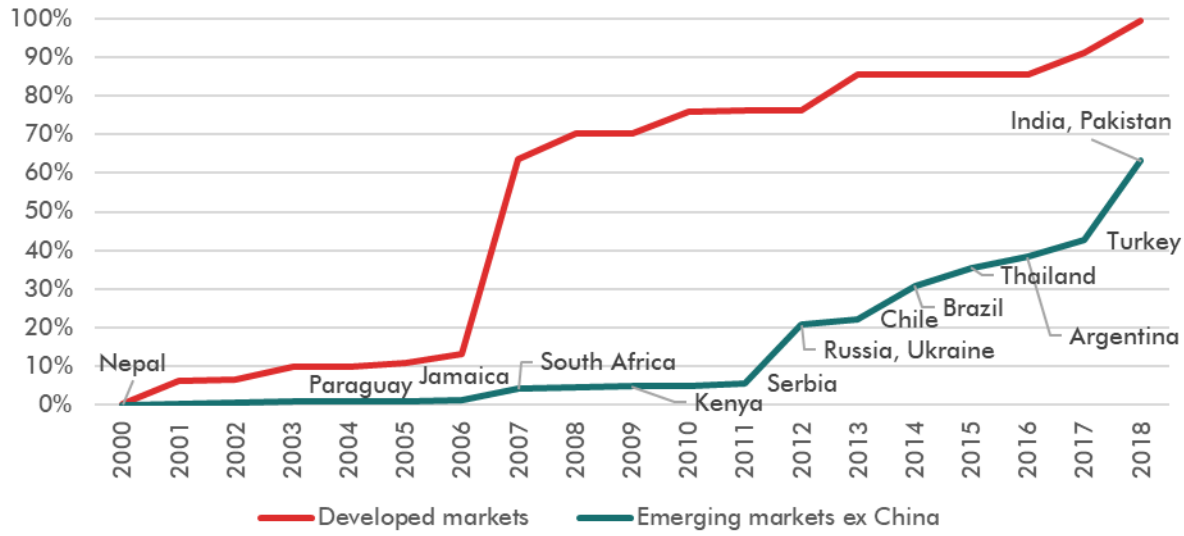
Country

Data from Ember allows us to calculate when fossil fuel demand peaks for each market and the leapfrog thus begins. We deliberately stop the analysis at the end of 2019 because 2020 results will naturally be impacted by COVID-19, and it will likely take until 2022 to get back to a point of fair comparison.

We see below a very similar pattern to what has been observed in developed markets, but with a delay of around a decade. Fossil fuel demand for electricity generation has peaked in 63% of emerging markets ex-China. It peaked in South Africa in 2007, in Russia in 2012, in Brazil in 2014, in Thailand in 2015, in Argentina in 2016, in Cambodia in 2017 and plateaued in India and Pakistan in 2018.

Whilst the key driver of the peak in many markets has been the rise of solar and wind, that is not the case for all markets. For example, Russian fossil fuel demand for electricity generation peaked largely because of small amounts of growth in nuclear and hydro in the context of flat demand.

Figure 20: Share of electricity demand from countries where fossil fuel demand has peaked or plateaued

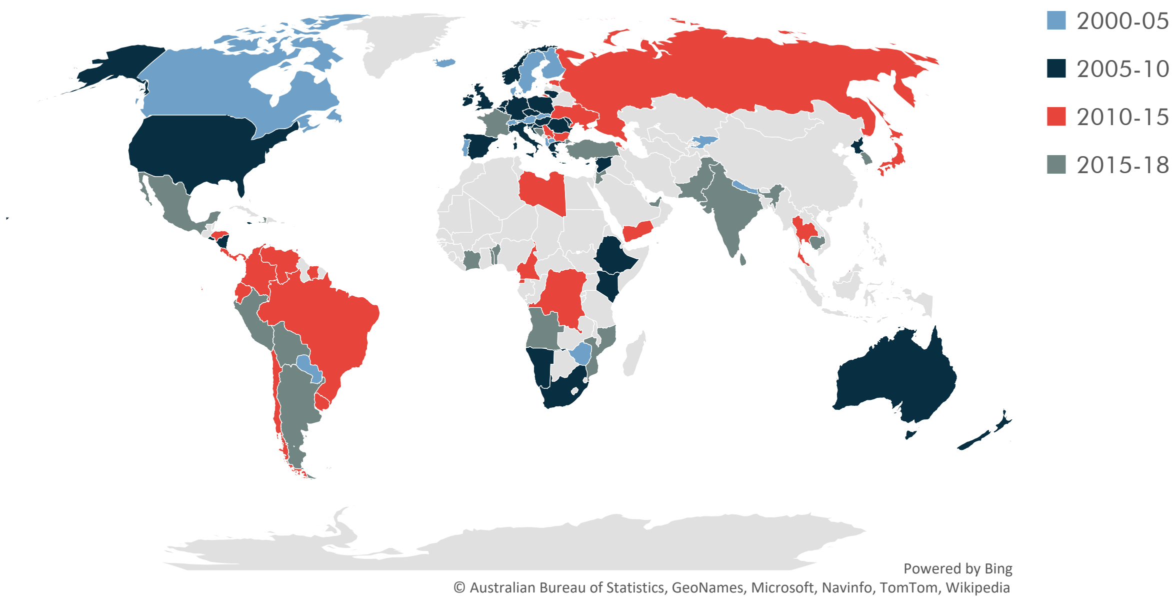


Source: Ember

It is of course possible that the fossil fuel demand peak will be revisited in a number of countries. However, it is unlikely that they would embark upon a huge new growth spurt in fossil fuel demand In light of the drivers we identify below. For such countries it is perhaps more appropriate to say that they have reached a plateau. As with global demand for coal, demand may fluctuate around the peak for a few years before it falls off a cliff.

We group below the countries with peak or plateau fossil fuel demand according to the 5-year period in which they saw a peak.

Figure 21: Peak or plateau demand for fossil fuel for electricity by date of peak



Source: Ember, Carbon Tracker

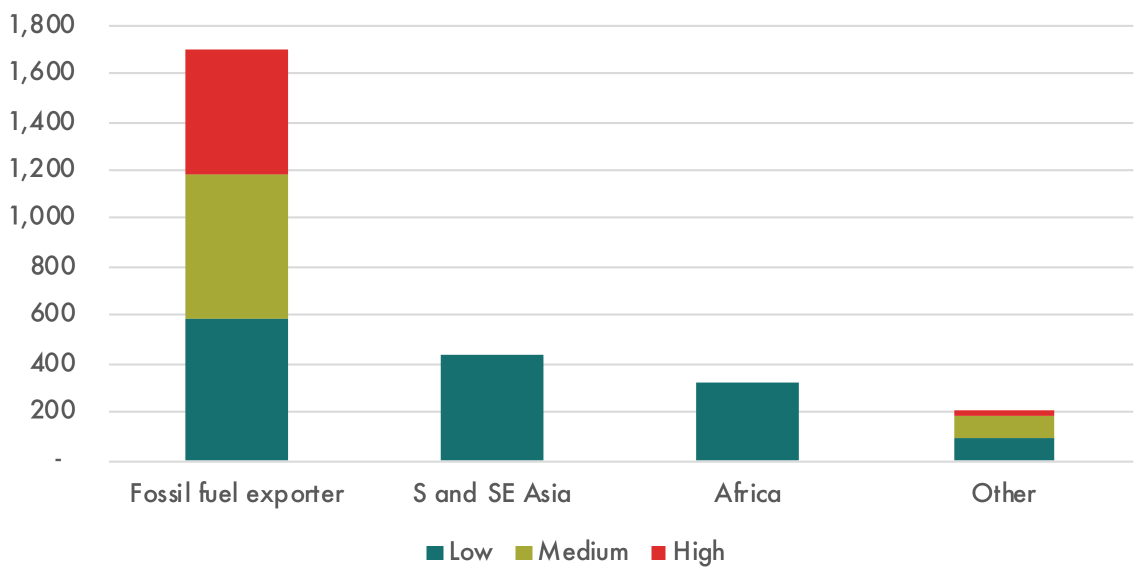
Countries before the peak

Emerging markets ex-China

If we exclude China, total demand from those emerging markets where fossil fuel demand has not peaked was 2,700 TWh in 2019. That is to say, just over a third of the emerging market ex-China group.

We further split these countries into three groups of low demand (below 3 MWh pp); high demand (above 7 MWh pp) ; and medium demand (3-7 MWh pp).

FIGURE 22: TWH OF ELECTRICITY DEMAND IN 2019 WHERE FOSSIL FUEL DEMAND HAS NOT YET PEAKED



Source: Ember, CT estimates.

There are then three notable groups of countries:

African fossil fuel importers

Countries like Egypt, Morocco, Ghana or Tanzania. Amongst African fossil fuel importers, more than two-thirds of the total demand for electricity in 2019 came from Egypt or Morocco, which have plans for very rapid renewable energy growth and where fossil fuel electricity demand is likely therefore to peak soon.

Fossil fuel exporters

These divide in turn into three groups, about one-third each. Those with high demand (over 7 MWh pp) include Saudi Arabia or Qatar. Those with medium demand 3 to 7 MWh pp) include Iran. And those with low demand (under 3 MWh) include Nigeria, Indonesia, or Iraq. For the sake of clarity, there are some countries in this group that are exporters of fossil fuels as a whole but not exporters of coal and gas. Nevertheless, they are best understood in this framing as fossil fuel exporters.

South/ Southeast Asia

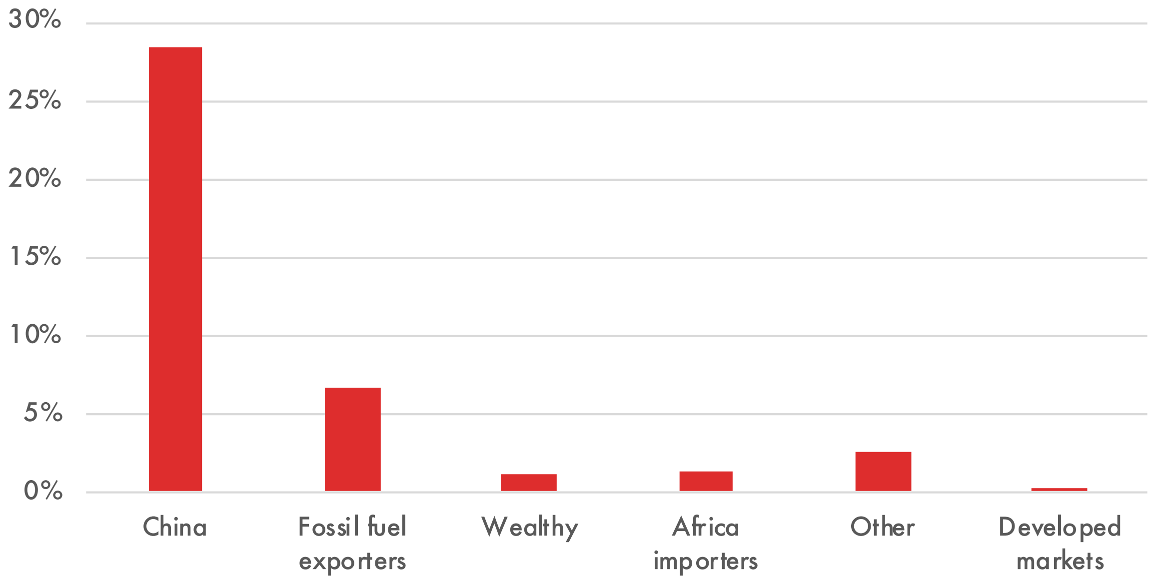
Three countries in particular stand out: Vietnam, Philippines and Bangladesh. Bangladesh and the Philippines have low levels of demand and low renewables penetration. However, Vietnam has higher demand and higher penetration and is likely to see peak fossil fuel demand sooner.

Globally

It is interesting to note the degree to which China is central to the group of countries where fossil fuel demand has not yet peaked.

- All developed markets except Israel and Latvia have seen a peak in fossil fuel demand for electricity.
- 63% of demand in emerging markets comes from countries where fossil fuel demand for electricity has peaked. Most of the rest are fossil fuel exporters.
- China accounts for 71% of electricity demand in all countries where fossil fuel demand has not yet peaked.

Figure 23: Share of global electricity demand in 2019 from areas without a fossil fuel electricity peak



Source: Ember

4 Forces driving the leapfrog

We have examined on many occasions[12] the forces driving the shift from fossil fuels to renewables, and they can be separated into four main groups: economics, technology, domestic politics and global politics.

For emerging markets in particular, renewables are a new development tool. One which relies in the most part on domestic talent and resources rather than importing them from abroad.

Economics

We look at two aspects of the economics of renewables as an electricity source: cost, defined as LCOE; and the threat of stranded assets.

When looking at these issues, the key point is relative advantage versus the fossil fuel alternative. That is to say, it is not relevant to the economic debate to argue that renewables cost money and that, therefore, they cannot be deployed by a country with no money. Fossil fuels also cost money, and the question is simply which is a superior solution.

Costs

The cost of solar and wind has been falling for years and is below the cost of fossil fuels in most locations for new electricity generation, as BNEF and others have shown us[13]. From BNEF calculations, 90% of the world by supply, 66% by population and 76% by GDP have solar or wind as their cheapest new electricity source.

FIGURE 24: CHEAPEST SOURCE OF NEW BULK ELECTRICITY GENERATION BY COUNTRY H2 2020

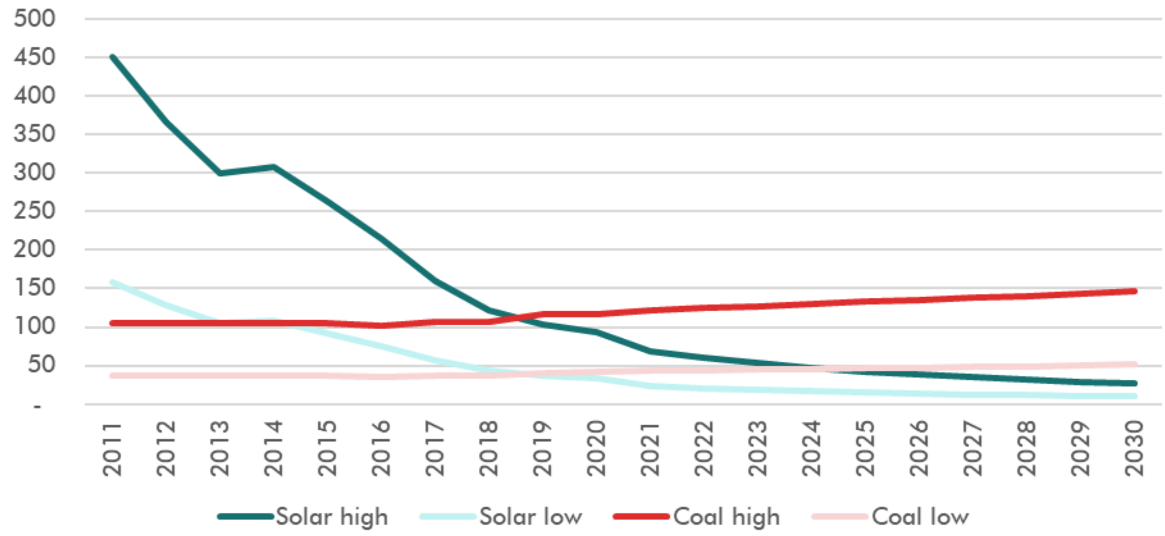
Source: BNEF

[12] *For example: 2020 Vision, Carbon Tracker, 2018*
[13] *Source: LCOE of renewables h2 2020, BNEF, 2020*

Moreover, renewable costs fall every year because the technology is on persistent learning curves, as Doyne Farmer has shown.[14] In the last decade for example the cost of solar has fallen by 18% a year and the cost of wind has fallen by 9% a year. This is why, despite stickiness in legacy energy systems, future growth in energy demand can be met almost entirely from continuously renewables. As more countries copy the successful innovations of the leaders, global average costs continue to fall.

If the economics work today for renewables, then they will be even better within a decade. We illustrate this with a stylised chart of the high and low costs of solar versus coal.[15] Low-cost solar overtakes high-cost coal in this framing in 2013, but as costs continue to fall, high-cost solar falls below low-cost coal in the early 2020s. As we set out below, the key factor to enable renewables to fall below fossil fuel costs is policy.

FIGURE 25: SOLAR AND COAL COSTS $ PER MWH



Source: BNEF, Carbon Tracker assumptions

Threat of stranding

Fossil fuel infrastructure is typically designed to last for 40 years. To build new infrastructure is to bet that renewable costs will not fall over the next 40 years, which in the light of what we know is highly unlikely.

As renewables supply all the growth in supply and at ever lower costs, fossil fuel assets will be stranded because the total cost of renewables falls below even the variable cost of fossil fuels. That means it makes sense to close down existing fossil fuel assets and replace them with new wind or solar ones. We have already seen European electricity write-downs of over $150bn in the period after European fossil fuel demand peaked in 2007, and oil sector write-downs of $200bn in the wake of the COVID-19 shock.

In a recent note on powering down coal, we note that coal asset owners already face considerable stranded asset risk.[16] In China, one exercise modelled what would happen if coal capacity continued to be constructed without any controls. The result would be installed capacity of 1200 GW by 2030 with

[14] *Estimating the costs of energy transition scenarios using probabilistic forecasting methods, Farmer, Oxford Smith School, 2021*
[15] *Source: The sky's the limit, Carbon Tracker, 2021*
[16] *Source: Do not revive coal, Carbon Tracker, 2021*

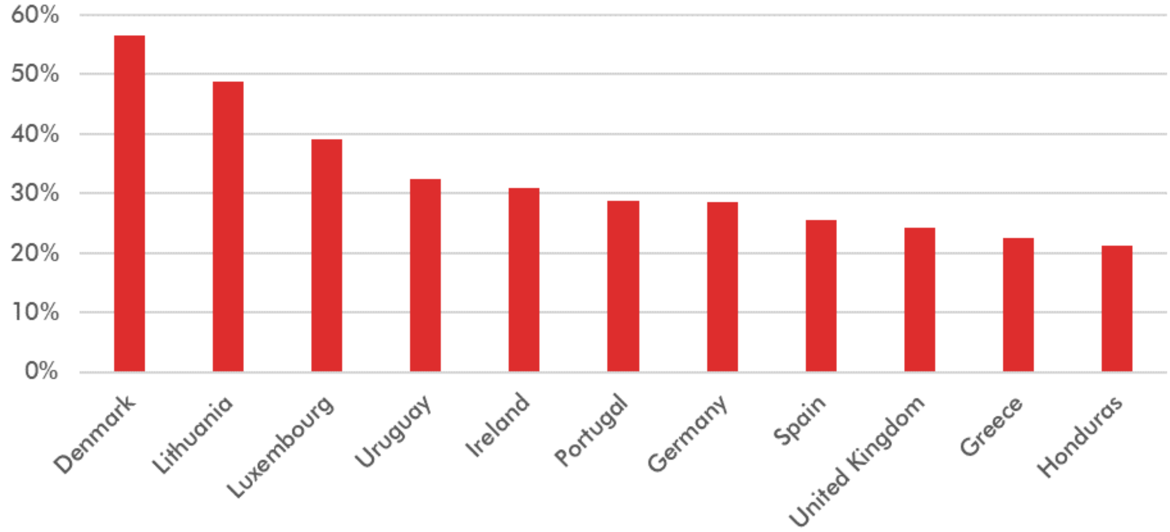
stranded assets valued at more than 103 billion yuan ($15.7 billion) in 2030. If control measures were executed, coal capacity would drop to 1100 GW by 2030 and stranded assets would be far lower at about 40 billion yuan ($6.1 billion)[17].

India gave a boost to its renewable energy sector at a much earlier stage of economic development and when the electricity system was far smaller than what happened in China. Consequently, the risk of stranded assets, while substantial, is still smaller in India. A new analysis finds that nearly 50 GW of thermal capacity could be considered surplus over what the electricity system demands, of which 30 GW of old and least efficient plants can be decommissioned on an accelerated basis and another 16 GW mothballed.[18] Learning from these examples, other emerging markets can also avoid the trap of long-lasting fossil energy assets as well as of foreign currency-linked indebtedness.

Technology

Although technology innovation is, of course, linked to the costs of solar and wind identified above, it is useful to consider it separately with regard to intermittency and policy. Together these have enabled a series of countries and regions to reach high levels of solar and wind deployment.

FIGURE 26: SHARE OF ELECTRICITY FROM SOLAR AND WIND 2019



Source: Ember

Innovation has been able to raise the ceiling of what is possible. Drivers include: digitisation[19] of grids; better handling of intermediate solutions; and falling battery costs. This issue has sparked much analysis already, and we summarise below the key points.

---

[17] *Source: IAEE Energy Forum 2020*

[18] *Ganesan, Karthik, and Danwant Narayanaswamy. 2021. Coal Power's Trilemma: Variable Cost, Efficiency and Financial Solvency. New Delhi: Council on Energy, Environment and Water.*

[19] *For detailed analysis of the impact of digitisation, see for example: Digitisation and the future of energy, DNV, 2019 or The world in 2050, IIASA, 2019.*

The intermittency problem

Fossil fuels are cheap and easy to store, but renewables are not. There are three key aspects of intermittency that need to be solved, as laid out by the Energy Transitions Commission.[20]

- Daily balancing, between day and night. Known as the 'the sun does not shine at night' issue.
- Predictable seasonable month by month cycles. Or 'the sun shines less in the winter' issue.
- Unpredictable week by week variations that are hard to forecast.

The solution

The intermittency issue is complex and there are many solutions as set out by the Energy Transitions Commission (ETC). They are confident that countries can reach variable renewable penetration levels of 75-90% using current technology, and set out a series of solutions to address the problem.

Initially they note that countries can have policy solutions allied to flexible deployment of existing thermal generation in order to allow renewables to supply up to a share of around 30% of the system. That is more than 7 times higher than the emerging market ex-China average of 4.1% in 2020.

The ETC then note that the challenges of higher penetration levels can be met by a combination of:

- **Flexible demand**. For example, EV smart charging, heating loads or industrial loads.
- **Energy storage**. For example, pumped hydro, batteries, power to hydrogen.
- **Wider and more interconnected grids**, to allow for more renewable assets to supply energy.
- Oversized renewable generation.
- **Policy changes,** to make this easier.

Meanwhile, new business models (like aggregators) and system interconnection between for example transport, heat and electricity, is making flexibility easier. And better market design can help to make problems more soluble.

Domestic politics

There are many domestic factors which are likely over time to persuade politicians to overcome the vested interests that are holding up the fossil fuel system. They include: jobs, votes, pollution, energy dependency, energy availability, speed to market, universal electricity access, industrial opportunities and competitive advantage.

Jobs

In broad terms, for the 80% of the world that imports its coal and gas, renewables substitute rents paid to foreigners with construction jobs for local voters. Three points then stand out.

[20] *Source: Making clean electrification possible, Energy Transitions Commission, 2021*

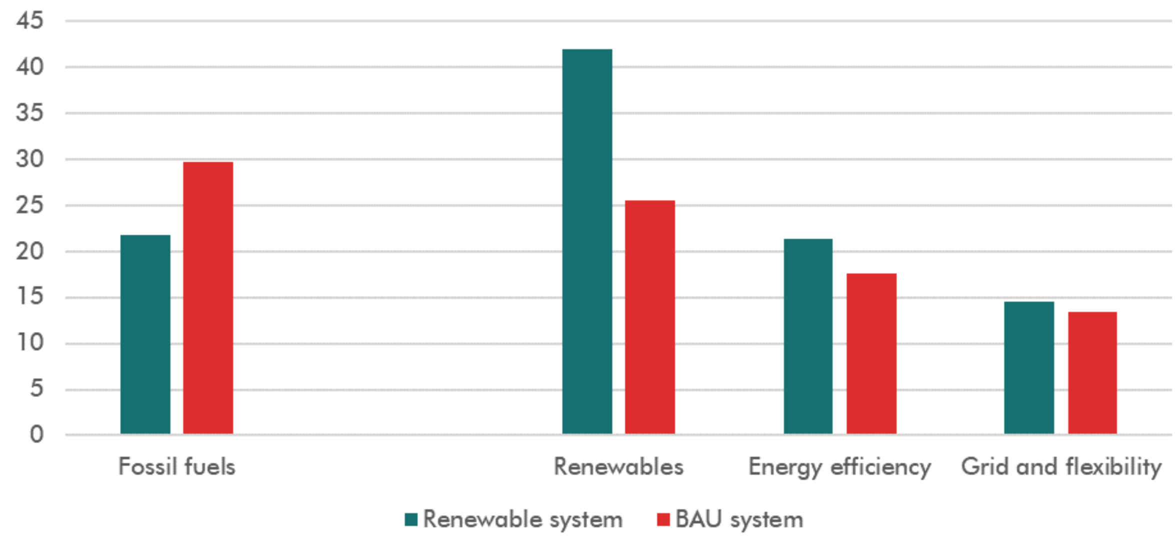
Faster jobs

According to IRENA, renewables create three times as many jobs per dollar of investment as fossil fuel investments.[21] Not all renewable energy is the same. Distributed energy is far more labour intensive than utility-scale renewables. In India, for instance, rooftop solar creates 24.7 jobs per MW installed against 3.45 jobs per MW in large solar plants and 1.27 per MW in large-scale wind.[22] Therefore, if countries are land-constrained, distributed renewables would not only help to generate more power but also significantly add to the employment potential.

More jobs in total

A renewable system will employ more people than a fossil fuel system. IRENA[23] calculates that a renewables-based system in 2050 would have 10 million more jobs than a BAU system. There are fewer jobs in fossil fuel extraction, but many more in renewable generation.

FIGURE 27: ENERGY SYSTEM JOBS IN 2050 (M)



Source: IRENA

Mark Jacobson has a similar calculation in his more radical version of a renewables-powered system.[24]

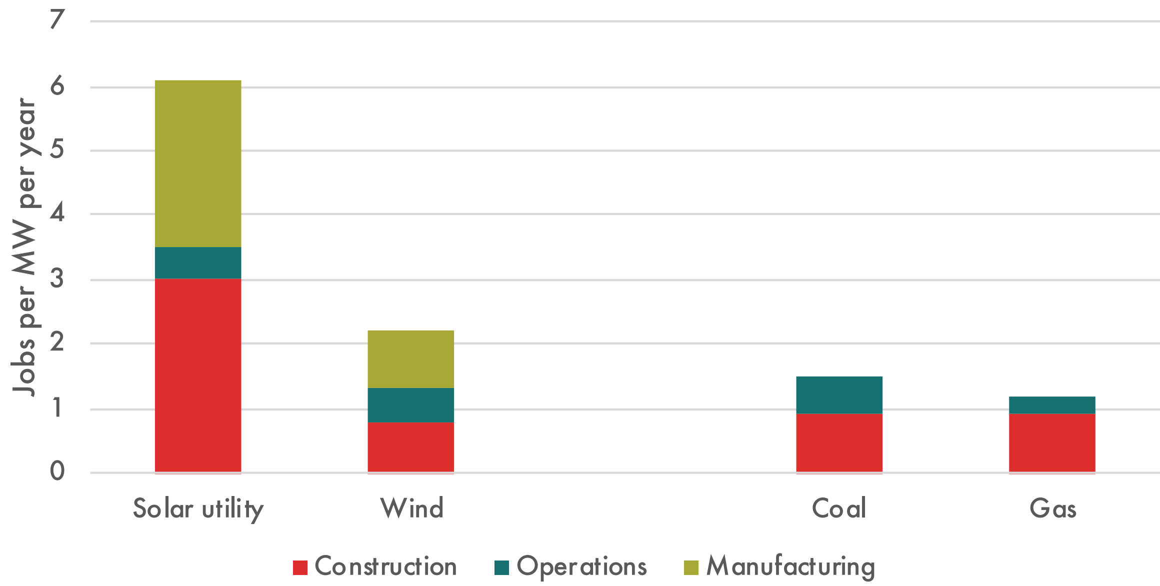
Local jobs

About 80% of people live in countries that import fossil fuels. Renewables are, by definition, local. It follows that governments (including local governments) can substitute local jobs in construction (for people who do vote) for foreign jobs in fossil fuel extraction (from people who do not vote in your elections).

[21] *Source: Renewed call for action, IRENA, 2020. Based on Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model, University of Massachusetts, 2017*
[22] *Kuldeep, Neeraj, and Arunabha Ghosh (2019) 'Building the workforce for India's emerging clean energy sector' in Reviving Jobs: An Agenda for Growth, edited by Santosh Mehrotra. Penguin*
[23] *Source: Focus on jobs, IRENA, 2020*
[24] *Source: 100% clean renewable energy and storage for everything, Jacobson, 2021*

Furthermore, if countries build up a domestic renewables production industry, then there are additional jobs here as well. We illustrate this below with CEEW data for India.

FIGURE 28: JOBS PER MW PER YEAR IN INDIA



Source: CEEW

Pollution

Fossil fuels create a cocktail of pollution which kills millions, especially in the densely populated cities of Asia. The standard analysis of this issue is the Global Burden of Disease study, which calculated in 2018[25] that 4.5 million people a year die of outdoor air pollution caused mainly by fossil fuels.

However, since then the analysis has been refined in order to incorporate the impact of fossil fuel pollution on a wider range of diseases and to incorporate a more detailed understanding of country dynamics, especially in Asia. In 2020 CREA[26] calculated that deaths from fossil fuel pollution alone were 4.5 million. In 2021 Vohra et al.[27] released a paper in which they calculated that the deaths from fossil fuel pollution alone were 8 million in 2018. Of these 4.8 million were in China and India, and 7 million were in the emerging markets.

Water usage is another area of risk for emerging markets facing increased water stress, as has been pointed out by the World Resources Institute (WRI).[28] Renewables require far less water than fossil fuels to generate electricity, and so help also to address this issue.

Energy resources

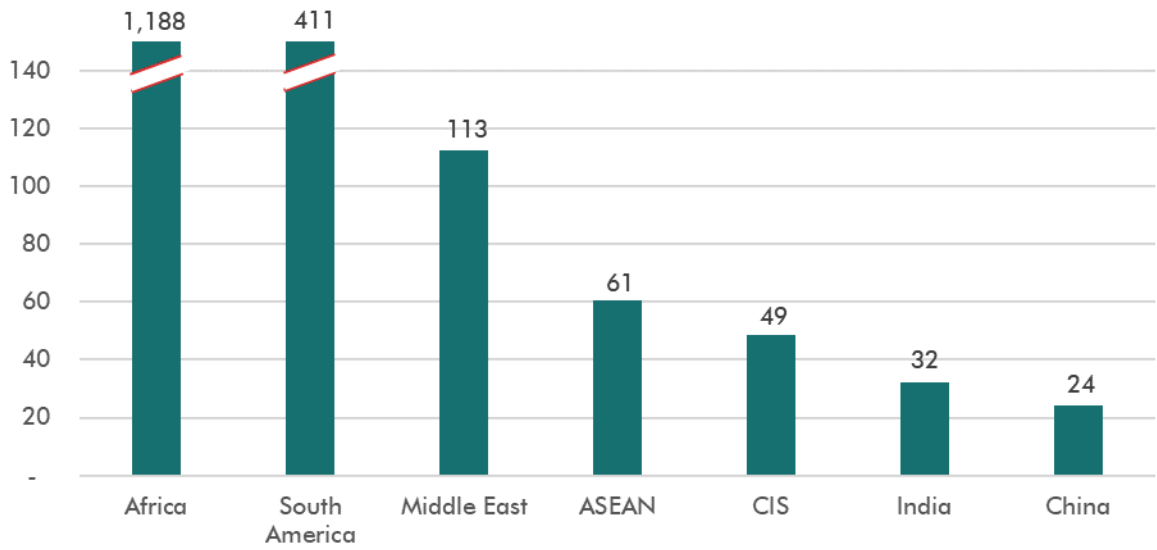
It is often argued that emerging markets should exploit their fossil fuel reserves in order to enjoy the energy that they contain. However, emerging markets have far more renewables than fossil fuels. In The Sky's the Limit[29] we demonstrated that emerging markets as a whole have 140 times as much

[25] *Source: Global Burden of disease study, GBD, 2018*
[26] *Source: Quantifying the Economic Costs of Air Pollution from Fossil Fuels, CREA, 2020*
[27] *Source: Global mortality from outdoor fine particle pollution generated by fossil fuel combustion, Vohra et al, 2021*
[28] *Source: These 20 water-stressed countries have the most solar and wind potential, WRI, 2018*
[29] *Source: The Sky's the Limit, Carbon Tracker, 2021*

renewable technical potential as fossil fuel production. And also 140 times as much renewable technical potential as their entire energy demand.

The same logic suggests that finance ministers should be falling over themselves to exploit their own home-grown renewable energy resources.

FIGURE 29: RENEWABLE TECHNICAL POTENTIAL AS MULTIPLE OF ENERGY DEMAND



Source: Solargis, NREL, BP

Why importing solar panels is not the same as importing fossil fuels

It is occasionally argued that the import of solar panels creates the same type of dependency as imported fossil fuels. However, they are different in size, cost and nature.

Size. A 400 Watt solar panel weighing 20kg will produce around 16 MWh over the course of its 30 year life. To generate that amount of electricity from coal would require over 5 tonnes of coal. So more than 270 times as much by weight.

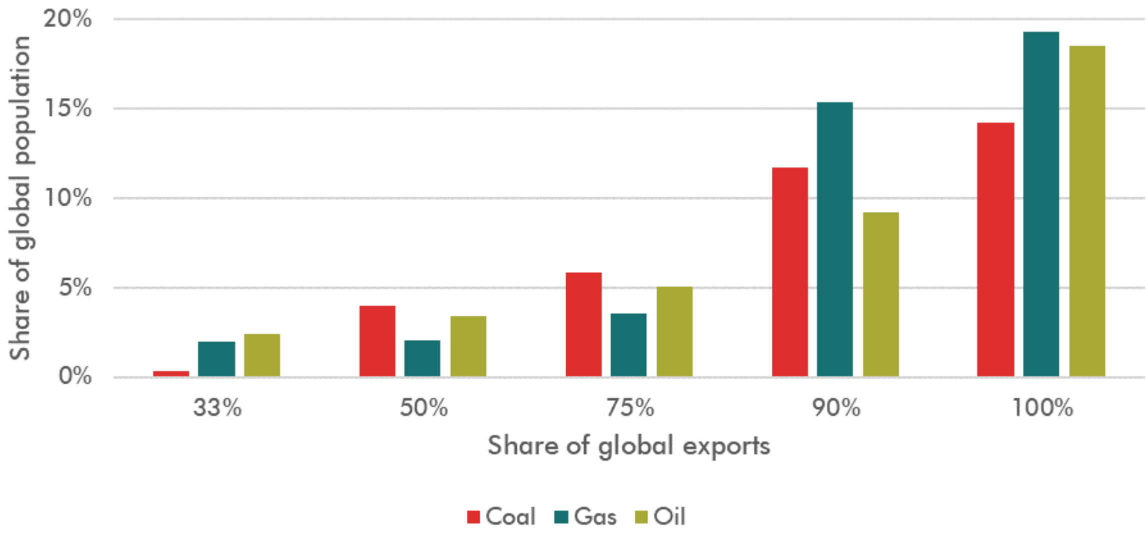
Cost. At 20 cents per Watt, a 400 Watt solar panel will cost $80. At today's thermal coal price of around $100 per tonne, the cost of 5 tonnes of coal is $500. So 6 times as much.

Stock or flow. There is a systemic difference between a solar panel which is a stock and fossil fuels which are a flow. So if you buy a good-quality solar panel it should last for 25-30 years. If suppliers stop supplying, then you can find a new supplier. In contrast you need coal every day, and if your supplier stops supplying you then you have an immediate problem.

Energy dependency

The export of coal and gas is extremely concentrated in the hands of a small number of countries. Countries with a population of just 14% of the total are responsible for all coal exports, and countries with a population of 20% of the total are responsible for all gas exports. Even within this, exporters are highly concentrated, with 75% of exports coming from countries with less than 5% of the global population.

FIGURE 30: SHARE OF THE POPULATION LIVING IN COUNTRIES RESPONSIBLE FOR A STATED SHARE OF 2019 FOSSIL FUEL EXPORTS



Source: IEA

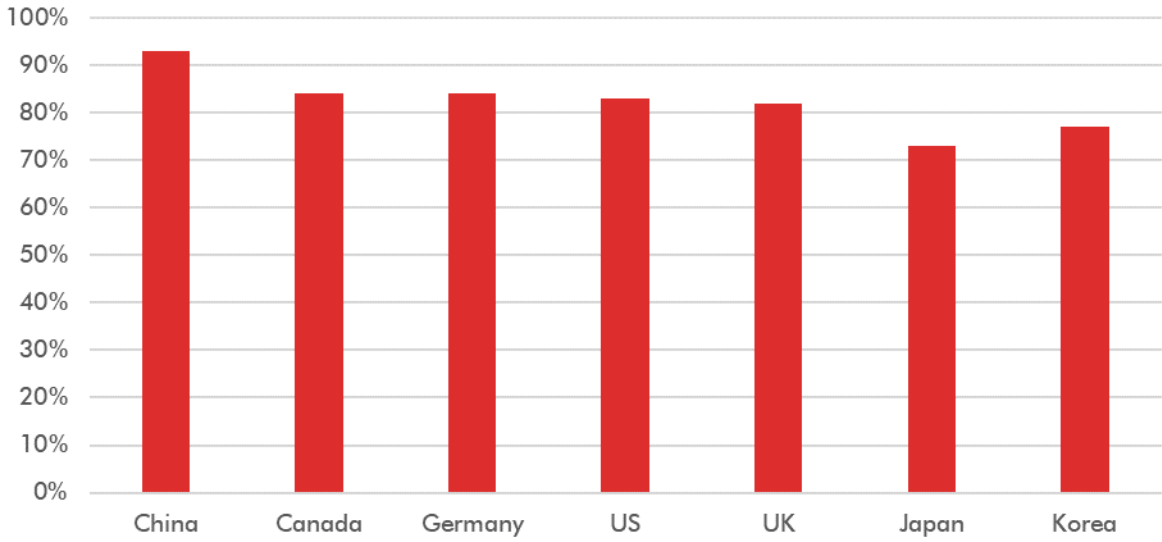
As a result, 80% of people live in countries that import coal and gas, much of which is used for electricity generation as we examine later in more detail.[30] It follows that for these countries, it would likely be beneficial to reduce fossil fuel consumption in electricity generation.

Votes

Renewables are increasingly popular across the world, even in fossil fuel exporting countries. Ørsted, the Danish energy company with a large wind portfolio, did a survey of views on green energy and found that 82% of their 26,000 surveyed people thought it was important to create a world powered by renewable energy. This included large majorities not just in energy importers like China and Germany but even in exporters such as Canada and the US.

[30] *According to the IEA, 64% of coal and 40% of gas were used for power generation in 2019.*

FIGURE 31: IS IT IMPORTANT TO CREATE A WORLD POWERED BY RENEWABLE ENERGY?



Source: Ørsted, Green Energy Barometer

Moreover, there is a well-documented link between fossil fuels and corruption.[31] Countries that are able to move on from fossil fuels may find it easier to tackle corruption.

Meanwhile, politicians are answering to the local pressure. Over the course of the last year, the share of global emissions in countries where politicians have set out a net zero target has risen to 73%.

Speed

It is much faster to deploy renewables than fossil fuels. Coal plants can take five years to build. Solar plants can be up in months. Meanwhile, importers of fossil fuels also have to set up a huge associated infrastructure of ports and pipelines in order to be able to use the fossil fuels. The sun provides its own distribution mechanism right across the world.

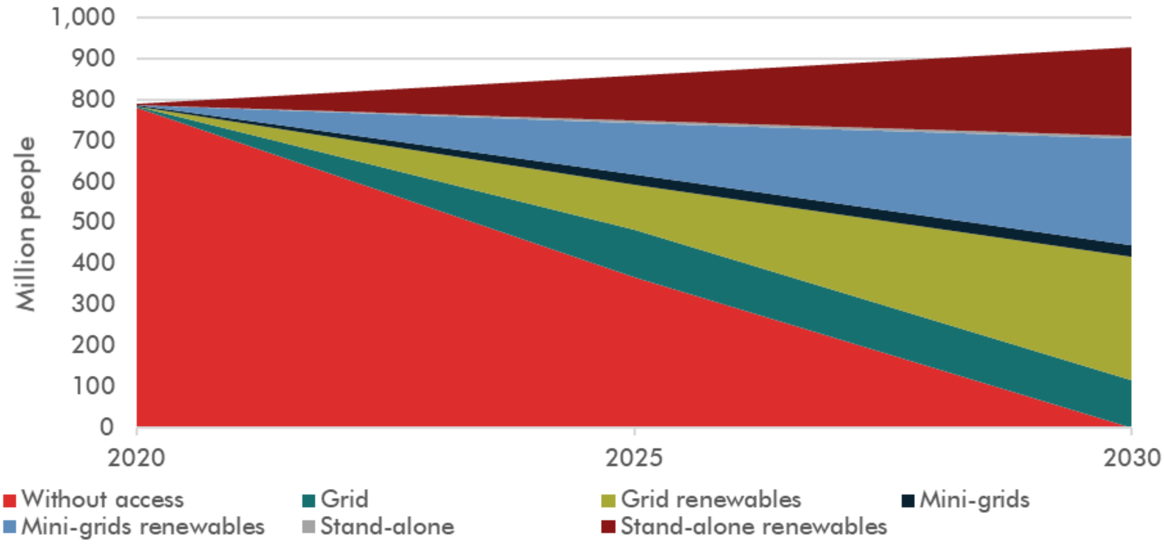
The standard counter is to note that renewables need connections to the grid and a bigger grid. But new fossil generation also needs connections to a grid and a bigger grid. Moreover, renewables can be located at any size in a very wide range of locations, from rooftops to fields, deserts to offshore wind.

Energy access

After over a century of development, fossil fuels have failed to bring electricity to 770 million people[32]. Renewables are local, widely distributed and in the last decade alone have helped bring energy to 400 million people.[33] They are widely seen as a key way to enable us to reach the goal of universal energy access for everyone. For example, in the IEA's recent 1.5 degree report, renewables could provide 84% of the electricity to the 770 million lacking it.

[31] *See for example The oil curse, Ross, 2013 or Oil, corruption and the resource curse, Shaxson, 2007*
[32] *Source: Implementing SDG7, IRENA, 2020*
[33] *Source: Off-grid solar market trends report, World Bank, 2021.*

FIGURE 32: HOW TO GAIN ACCESS TO ELECTRICITY IN EMERGING MARKETS UNDER NET ZERO EMISSIONS



Source: IEA NZE 2050

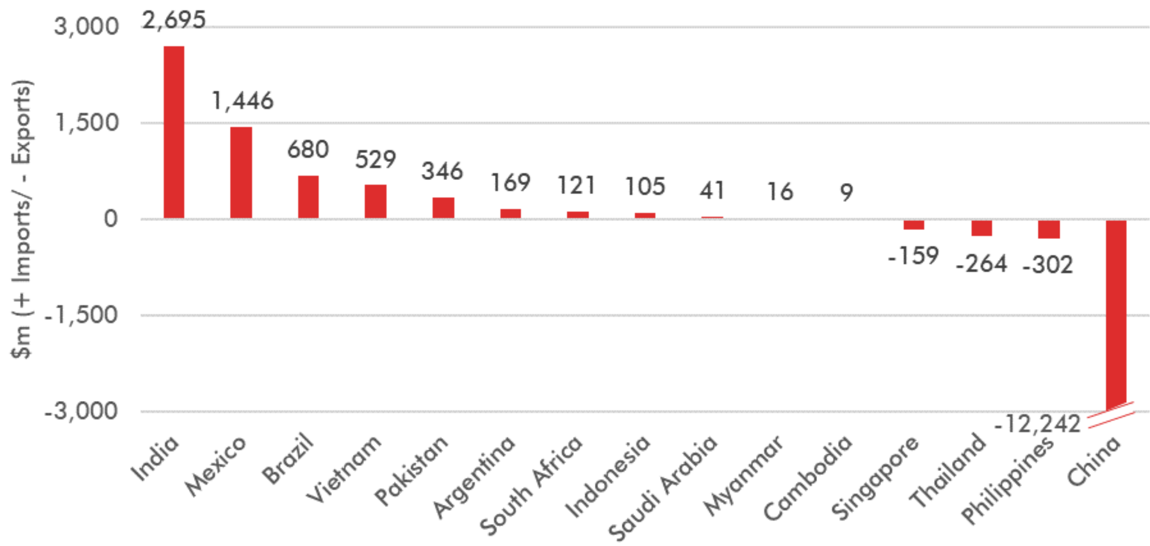
Industrial advantage

As the world shifts to a new paradigm, countries want to be at the cutting edge of change. This has been a key part of China's industrial strategy for many years, and the US has just woken up to the threat posed by its loss of dominance in energy technologies. Meanwhile, India also sees renewable energy as a key source of domestic strength and plans to produce solar panels and increase indigenisation of electric vehicle powertrains and batteries. A production-linked incentive (PLI) scheme, introduced in November 2020, is targeting 10 sectors including high-efficiency solar PV modules (an additional 10,000 MW of integrated solar PV manufacturing capacity with USD 2.36 billion in investment), along with related materials such as solar glass, back-sheets, and junction boxes.

We should, however, recognise that developing local clean energy manufacturing capacity will not be easy. The figure below shows the net import dependency of emerging markets for solar photovoltaic cells, modules, panels as well as batteries and cells. Only China, Philippines, Thailand and Singapore turn out to be net exporters. As the energy transition unfolds, emerging markets will also look for opportunities to develop domestic manufacturing capacity and diversified supply chains in order to reduce their dependency on only a few countries. Moreover, countries might also look to broaden their sources of import of renewable energy equipment for energy security, human rights,[34] and concerns about governance of critical minerals extraction. In order to avoid a suboptimal geopolitical battle over the control of renewable energy technology markets, it would be critical to deepen integrated supply chains across emerging markets to give more economies a stake in an emerging green industry.

[34] *Note for example the recent US ban on the import of polysilicon from the Hoshine Silicon Industry Company and others in Xinjiang*

FIGURE 33: NET IMPORTS (EXPORTS) OF RENEWABLE ENERGY EQUIPMENT 2018 $M



Source: Harvard Dataverse

Global drivers

We focus on three global drivers above all: carbon; geopolitics and capital markets.

Carbon

It is fair to say that carbon has been more of an issue for the wealthier developed markets than for many of the emerging markets which lack resources. Nevertheless, the carbon imperative is driving leaders in the US, Europe, Japan and China to at least claim to push for a radical shift in energy systems. However, there remains some inconsistency in these general claims. There has been continued funding of coal power stations overseas by China. And between 2017 and 2019, developing countries received $16 billion per year for natural gas projects (48% of this financing was from China, Japan and the US).[35] Meanwhile, India is the only G-20 country with policies and performance that are compatible with a target of 2-degree-Celsius warming.[36] Now with its enhanced ambition of 450 GW of renewables by 2030, India's emission intensity of GDP could drop by 54% by 2030 (above 2005 levels), against the stated commitment of 33-35% reduction.[37] As they implement policies at home, these renewable energy leaders are leaning on the emerging markets to do the same. Moreover, as they find technology and policy solutions to replace fossil fuels, they are, at least in principle, prepared to roll out those solutions to the emerging markets. India and France have together promoted the International Solar Alliance with 95 countries as signatories of the ISA Framework Agreement.

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[35] *Muttitt, Greg, Shruti Sharma, Mostafa Mostafa, Kjell Kühne, Alex Doukas, Ivetta Gerasimchuk, and Joachim Roth. 2021. Step Off the Gas: International public finance, natural gas, and clean alternatives in the Global South. Winnipeg: IISD*

[36] *Climate Transparency. 2020. The Climate Transparency Report 2020. https://www.climate-transparency.org/g20-climate-performance/the-climate-transparency-report-2020#1531904263713-04b62b8d-e708 . Accessed 10 June 2021.*

[37] *Ghosh, Arunabha. 2021. "Imagining a climate-resilient economy", Hindustan Times, 15 April. Available here: https://www.hindustantimes.com/environment/imagining-a-climate-resilient-economy-101618391865267.html. Accessed 10 June 2021.*

Geopolitics

In the new geostrategic competition emerging between China and the US, each side is encouraged to champion its own energy technology.[38] It is surely likely then that both China and the US will promote their renewable energy technologies as solutions for the emerging markets, in the same way as the US and the USSR promoted competing economic systems during the Cold War. So energy ministers are likely to have a choice of options.

This framing has come to the fore in the last few weeks as the G7 has explicitly stated its desire to provide alternatives to China's Belt and Road Initiative (BRI).[39] The scene is set for a green G7 infrastructure programme (named B3W) versus a Chinese fossil-heavy BRI.

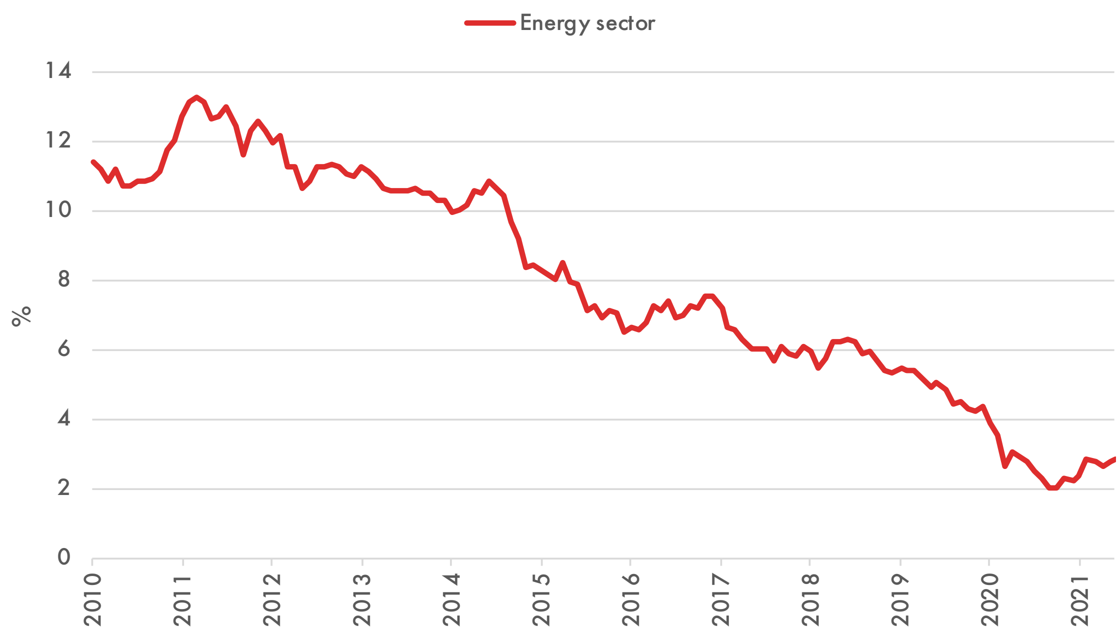
Moreover, in light of growing local preferences for renewables technologies and in the face of this challenge, we are likely to see the Chinese BRI pivot rapidly to a green one.[40]

Capital markets

Capital markets are turning their backs on fossil fuels[41] and reallocating into renewables, a shift that became especially clear in 2020 as renewable stocks doubled and fossil fuel stocks halved.

That reduces the cost of capital for renewables and increases it for fossil fuels. That then drives more renewable deployment and less fossil deployment, in the process known as reflexivity, popularised by George Soros. This means that there is a large pool of capital available to invest in renewable energy opportunities. The wider shift can be seen in the long derating of the size of the energy sector in the S&P500. The share of the energy sector has fallen from 13% a decade ago to around 3% today.

FIGURE 34: SHARE OF THE ENERGY SECTOR IN THE S&P INDEX



Source: Bloomberg

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[38] *Source: Sino-US competition is good for climate change, Foreign Policy, 2021.*
[39] *Source: B3W partnership, White House, 2021*
[40] *The Green BRI Centre for example notes that of the 52 coal-fired power projects with Chinese financing announced between mid-2014 and the end of 2020, 25 have been shelved and eight have been cancelled. Only one has gone into operation.*
[41] *See for example: A tale of two share issues, Carbon Tracker, 2021*

5 Barriers to change

As with all technology shifts, the forces resisting the transition are formidable and the solutions are complex. A number of excellent reports address these issues in much more detail, most notably the recent report by the IEA on financing clean energy transition in emerging and developing economies,[42] the Climatescope emerging markets outlook 2020,[43] the Climate Finance Leadership Initiative (CFLI) report[44] on unlocking private climate finance in emerging markets, the Energy Transitions Commission report on making clean electrification possible,[45] the RMI report on net zero electricity in China,[46] the IRENA report on Tracking SDG7,[47] and the IRENA report on the renewable energy transition in Africa.[48]

Moreover, there is a very wide literature on carbon lock-in,[49] describing how hard it is to change a carbon-based system. However, our focus in this report is not on winding down the existing system but on the growth of the new, where the forces of lock-in are smaller. Existing electricity systems in the emerging markets can be maintained (for the time being) even as all the growth is derived from renewable sources.

The story in broad terms is pretty clear: the technology, cost and capital barriers now all have solutions; and these solutions get better every year. Policy solutions are understood and can be implemented by governments with the will to do so. Systemic barriers to change are hard to solve, but the key question is whether they are harder for renewables to solve than for fossil fuels. The real barrier to change is vested interests. And there are some countries where these vested interests will be very hard to dislodge; they are the laggards of the energy transition.

Intermittency

As noted above, plenty of countries have high levels of penetration of renewables, so intermittency is clearly a soluble problem.

There is then a further argument that the solution of intermittency problems is only a luxury that can be solved by developed markets. However, as we noted, markets at a wide range of levels of electricity consumption per capita have been able to leapfrog and thus to solve the intermittency problem. Solutions have materialised in many countries, from Denmark and Germany to Chile and Uruguay, to Thailand and India.

There is then a further argument that perhaps it is necessary to expand fossil fuel supply as demand grows from a lower level. Again, this argument does not really hold up to scrutiny. Even for countries at a relatively low starting point, it has proven possible to move to relatively higher levels of electricity consumption whilst getting almost all the growth from renewables.

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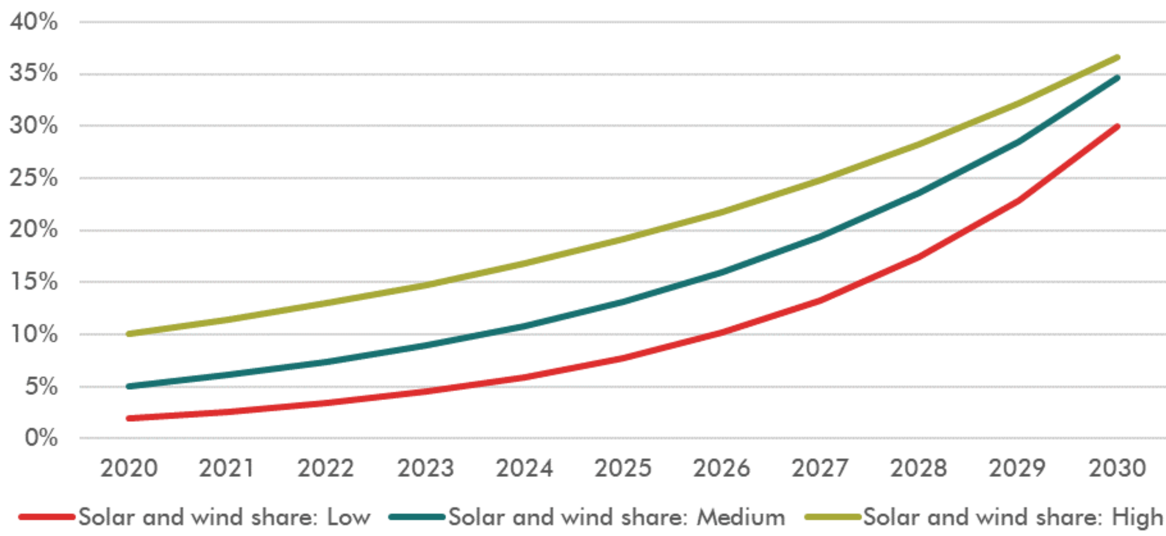
[42] *Financing clean energy transition in emerging and developing economies, IEA, 2021*
[43] *Climatescope emerging markets outlook 2020, BNEF, 2020*
[44] *Unlocking private climate finance in emerging markets, CFLI, 2020*
[45] *Making clean electrification possible, ETC, 2020*
[46] *China net zero electricity RMI, 2020*
[47] *Tracking SDG7, IRENA, 2021*
[48] *Renewable energy transition in Africa, IRENA, 2021*
[49] *See for example Making climate policy work, Victor, 2020*

For example, we show below the share of solar and wind in total electricity supply in three systems, characterised as high, medium and low.

- **High**. Demand pp of 7 MWh. Renewables starting share 10%. Demand growth of 1%. Renewables growth of 15%.
- **Medium**. Demand pp of 3 MWh. Renewables starting share 5%. Demand growth of 3%. Renewables growth of 25%.
- **Low**. Demand pp of 0.5 MWh. Renewables starting share 2%. Demand growth of 3%. Renewables growth of 35%.

FIGURE 35: SHARE OF SOLAR AND WIND IN THREE SYSTEMS: CONCEPT CHART

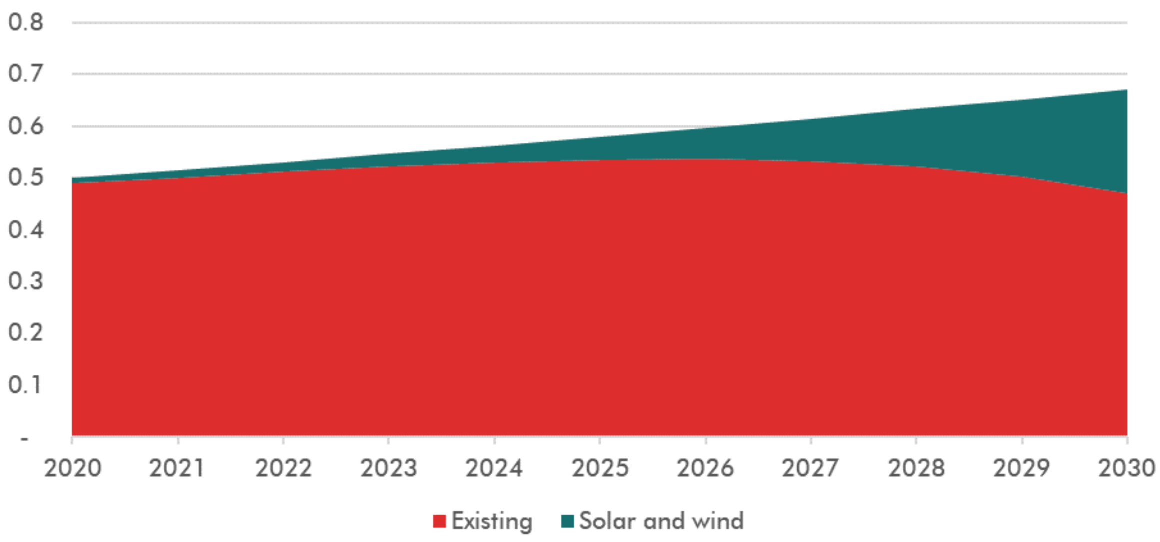


Source: Carbon Tracker

The share of solar and wind does not reach the level of 30% of the system characterised by the ETC as a 2020 threshold level until nearly the end of the decade. Moreover, the share of the system supplied by solar and wind in low demand markets remains lower than in the higher demand markets. This illustrates a broader truth — emerging markets embarking on a renewable leapfrog can simply copy the actions taken by other emerging markets, which started down the same path in the last few years. There is no need to reinvent the wheel.

Specifically it is worth highlighting how solar and wind come into the low demand system. The system is able to sustain very significant renewables growth (35% pa in this example) without reaching the initial implementation ceiling of 30% identified by the ETC. And fossil fuel demand per capita remains basically flat before starting to decline at the end of the decade.

FIGURE 36: ELECTRICITY DEMAND MWH PP IN A LOW DEMAND COUNTRY WITH HIGH RENEWABLE GROWTH



Source: Carbon Tracker

System costs

Fossil fuel advocates argue that the LCOE of renewables is indeed cheaper than fossil fuels, but that system costs will be higher for renewables-based systems. After all, renewables are an intermittency technology and need some backup as well as bigger grids and so on. There are two answers to this, which we take directly from the Energy Transitions Commission.[50]

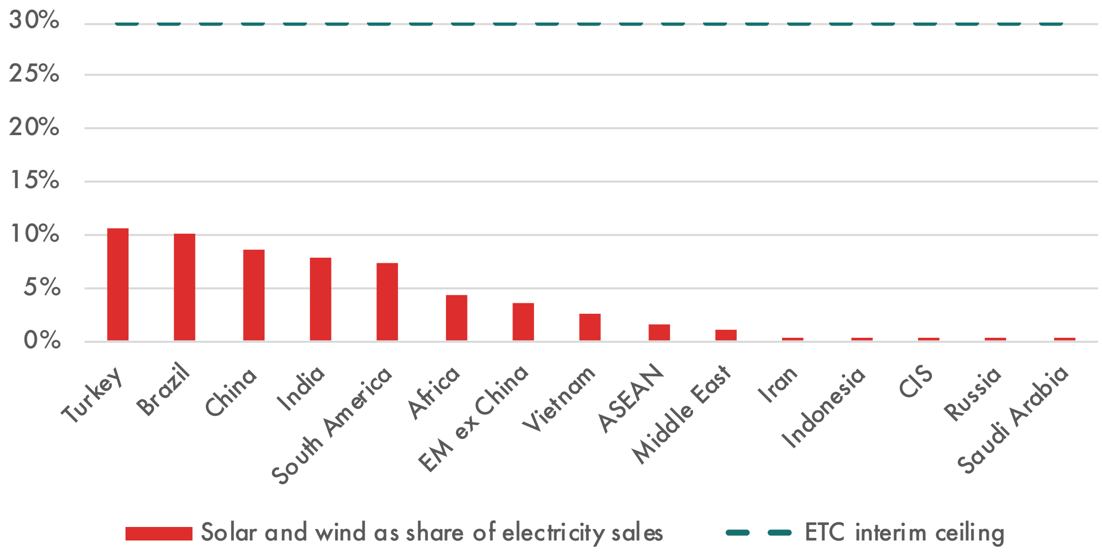
The first part is not expensive

According to the ETC, renewables do not add greatly to system costs until they have a market share of around 30%. The lower cost of the renewables outweighs the higher costs of the various intermittency solutions. New technologies make it possible to incorporate an ever rising share of variable renewables into an electricity system without expensive capital costs.

It is notable then that at present, this is an entirely theoretical debate for almost all emerging markets. For the emerging markets ex-China, variable renewables are 4% of electricity provision and will certainly not get to 30% before the end of the decade. Meanwhile, the threshold of 30% identified by the ETC is of course rising over time as new solutions are found.

[50] *Making clean electrification possible, Energy Transitions Commission, 2021*

FIGURE 37: SOLAR AND WIND SHARE OF ELECTRICITY GENERATION 2019



Source: BP Statistical Review, ETC

The second part is still cheaper than the alternative

By the time the share of solar and wind does get to 30%, the system costs will be lower, thanks to the work put in by the industry leaders such as Denmark, California, Germany or South Australia, which are already seeking to get to 80-100% variable renewables. Tools being used include flexible demand, flexible supply, more batteries, bigger grids better forecasting and system coupling. And all of this needs much better regulation and policy.

The implication of this for emerging markets is not that they can rest on their laurels, but that it will be necessary to plan ahead for a renewables-based system. All the analysis suggests that the earlier countries plan, the lower the costs will be. India has already begun auctions for solar-plus-storage and round-the-clock renewables generation. These bids are designed to increase competition while driving down the prices of renewable electricity without intermittency challenges.

Capital

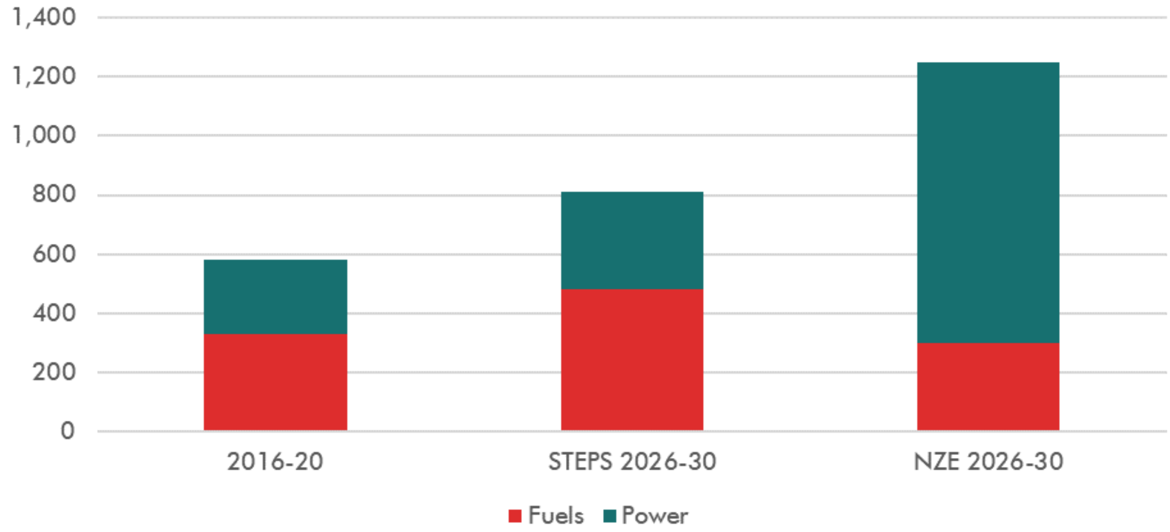
Conventional wisdom argues that the issue holding back change in the emerging markets is a lack of capital; the solution therefore is to increase the flow of capital through various government measures. We argue below that the picture is more complex than this. The total capital requirement of a renewable electricity system is unlikely to be greater than that required by a fossil fuel system, and the amount of capital required is not challenging by the standards of global capital markets. Moreover, the cost of capital for renewables is usually lower than for fossil fuels. The solution to this issue is domestic policy to unlock the capital flows allied to international action to reduce the cost of capital. The combination of the two is likely to drive the flows of capital required. The importance of combining local and global action was analysed at length by CEEW in 2019 in *Greening New Pastures for Green Investments.*[51]

[51] *Chawla, Kanika, and Arunabha Ghosh. 2019. Greening new pastures for green investments. New Delhi: Council on Energy, Environment and Water. Available at:* https://www.ceew.in/publications/greening-new-pastures-green-investments

Incremental capital needed

The IEA calculate that the annual cost of an emerging market shift to net zero would be a little over $1,200bn a year, versus the cost of maintaining the current fossil fuel system of $800bn a year. So there is a gap of around $400bn per annum.

FIGURE 38: ANNUAL ENERGY CAPEX IN THE EMERGING MARKETS EX-CHINA $BN PA



Source: IEA NZE

However, this this gap can be questioned from a number of angles:

- The capital requirement refers to an entire energy system change. Not the electricity sector specifically.
- The IEA notes that when operating savings are taken into account (the cost of the fuel), the total cost is similar.
- Implicit within this number is the assumption that the cost of solar will fall by only 5% this decade and 2% next decade. In light of the fact that the cost of solar has been falling at 18% a year for a decade, that is very conservative.
- Capital costs of renewable technologies have been falling rapidly at the same time as utilisation rates have been rising and the utilisation rates of fossil fuels have been falling. The gap between the initial cost of the two technologies is already close in leading markets. Given that renewables can be deployed much more rapidly, the gap narrows still further.[52]
- Although we not aware of detailed analysis for the emerging markets as a whole, well designed renewable based distribution grids are likely to cost less than systems that rely on imported fossil fuels to generate electricity that then needs to be transported around. Fossil fuels also need specialist infrastructure in order to import the extremely heavy fossil fuels that are burnt. That is to say, railways and ports and pipelines for the coal and gas. Meanwhile, solar and wind is provided for free by the sun and, if used optimally through distributed generation, the costs of distribution can come down significantly. We believe it is a reasonable

[52] *A more detailed analysis of this issue will be the subject of a separate report.*

working assumption that the transport costs for the molecules of the fossil fuel system will be higher than those for the electrons of the renewable system.

If capital costs of a new renewables and fossil based electricity system are indeed similar, the implications are profound. It is not necessary to do complex calculations to demonstrate the superiority of renewables as a new energy source for the emerging markets. One simply has to examine the relative costs of capital of fossil fuels and renewables.

Are global capital markets large enough to finance this

Even if the total additional sums required were as high as $400bn per annum, this is not a challenging sum in the context of global financial markets. Global financial wealth is in the region of $400tn, and $18tn is in bonds with negative interest rates. Meanwhile, developers are able to raise capital for deployment into good quality projects, and the universal mantra is that they lack projects not capital. And developers are key. Climatescope calculates the share of capital coming into the emerging markets ex-China as FDI to be $32bn out of $57bn in total. Of this, 31% came from project developers, 19% from utilities and 11% from development banks.

Cost of capital

The argument is often made that the cost of capital of emerging markets is too high to allow for the installation of renewable energy technologies. However, if the capital required is about the same for renewables as for fossil fuels, then the key issue is not the total cost of capital but the relative cost of capital. Relative between the fossil fuel option and the renewable option.

If the fossil fuel capital requirement to generate electricity is $1bn and the cost of capital is 15%, then a renewable option with a capital requirement of $1bn and a cost of capital of 14% will be superior.

The implication of this is that developed market policymakers do not need to drive down the cost of capital for the emerging markets to the same level as Germany. They need rather to ensure that the cost of capital of renewables is lower than that of fossil fuels. And this is a much easier barrier to cross.

The flow of capital

However, in spite of all this, some emerging economies struggle to tap international capital markets at the scale they need. In 2018, lower-middle and low-income countries (with more than 40% of global population) received less than 15% of energy investment. But 15% of the world's population in advanced economies got more than 40% of energy investment[53]. Excluding large hydropower, of the total global investment in renewables of $2.6 trillion during 2010-19, only China, India, Brazil, Mexico and South Africa (along with developed countries) managed to secure investments exceeding $20 billion[54]. This inequity in access to finance stands in sharp contrast to the large renewable energy resources available in the developing and emerging countries. In other words, money does not flow yet to where the sun shines the most or the wind blows the hardest.

The reason is that international investors expect high returns to cover for the risks they perceive. CEEW and IEA analysis on India shows that solar PV equity IRR expectations stood at around 15% on a weighted average basis over the course of 2019 and the first half of 2020. These edged up from 14% in the first half of 2019, to 16-17% over the second half of the year through mid-2020[55]. On the debt

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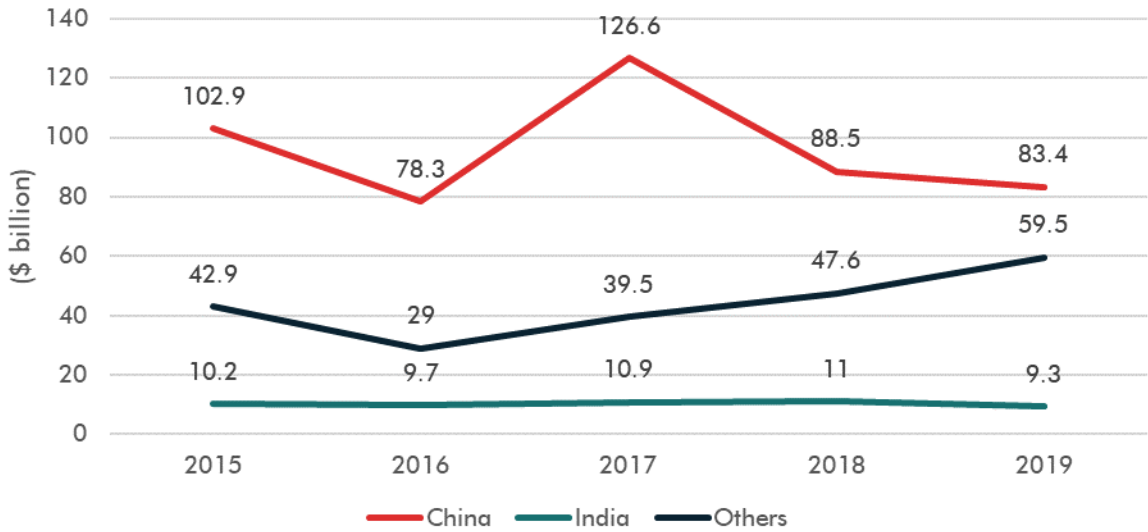
[53] *Chawla, Kanika, and Arunabha Ghosh. 2019. Greening New Pastures for Green Investments. New Delhi: Council on Energy, Environment and Water.* https://www.ceew.in/publications/greening-new-pastures-green-investments
[54] *UN Environment, Frankfurt School, and BNEF. 2019. "2019 Global Trends Report." 2019. https://wedocs.unep.org/bitstream/handle/20.500.11822/29752/GTR2019.pdf?sequence=1&isAllowed=y*
[55] *Dutt, Arjun, Lucila Arboleya, Pablo Gonzalez, Kanika Chawla, Michael Waldron. 2020. Clean Energy Investment Trends 2020: Mapping Project-level Financial Performance Expectations in India. New Delhi and Paris: Council on*

side, emerging markets suffer from underdeveloped domestic bond markets; hence refinancing is challenging. International debt markets are deeper, but they provide more expensive capital after hedging for various non-project risks, such as currency fluctuations, policy and political, offtaker risk, and transmission and power evacuation risk[56].

The other soluble but persistent challenge is the low volume of investment (compared to the need) accompanied by high costs of finance. So far, a rising trend in investments in renewables can be observed across emerging economies (see figure). However, the scale of investment needed is far higher.

FIGURE 39: INVESTMENT IN RENEWABLE ENERGY IN EMERGING MARKETS 2015-19 $BN



Source: UNEP-BNEF Global Investment Trends Reports

The real issue then is not the quantum of capital but why it does not flow into all emerging markets. Climatescope note that the majority of capital is flowing into a relatively small number of countries. Those countries which have set in place the right policies as we set out below. So the answer is clear – what is required is policy, and capital will flow. Moreover, if backed up by global support to lower the cost of capital, money will flow still faster.

Policy

The primary barrier to change is thus policy as we set out below. Most countries have electricity systems which are set up for fossil fuels. And in many countries where the state runs the electricity system, it creates a very sclerotic system, resistant to change. We set out below the policy issues and solutions below, with the proviso that the primary issue standing behind a lack of policy action is often vested interests.

Energy, Environment and Water, and International Energy Agency. https://cef.ceew.in/solutions-factory/clean-energy-investment-trends-2020.india

[56] *Aggarwal, Manu, and Kanika Chawla. 2019. Deepening Renewable Energy Markets in South Africa: Lessons for and from the Indian renewable energy market. New Delhi: Council on Energy, Environment and Water.* https://www.ceew.in/publications/deepening-renewable-energy-markets-south-africa-0

The issue

As noted earlier, many others have looked at the policy factors holding back change, and it is not our intention to repeat these in detail. The issues include the formidable list below:

- Historic fossil fuel contracts
- High grid connection costs
- Lack of local expertise
- State-controlled electricity system in many markets
- Regulations frequently change
- Underdeveloped energy markets
- Electricity tariffs below cost price, with the median electricity subsidisation rate in emerging markets at an extraordinary 20%, according to the IEA
- Lack of system flexibility
- Regulatory system designed for fossil fuels
- High local content requirements
- Bankrupt offtakers
- Unclear land ownership
- Electricity markets are artificially skewed in favour of fossil fuels. The fossil-based power infrastructure is often financed via state-owned utilities, such as NTPC in India, PLN in Indonesia and EVN in Viet Nam. These quasi-sovereign entities are able to tap into bond markets and enjoy lower costs of debt financing compared to renewables-based independent power producers. Nevertheless, recognising the changing market conditions, in June 2021 NTPC submitted an energy compact to the UN High-Level Dialogue on Energy committing to install 60 GW of renewables capacity by 2032, among several other pledges to reduce energy intensity of its operations and investing in clean energy R&D via international collaborations.

The World Bank examined these barriers to change in detail in its excellent piece on how to deploy solar.[57] When developers were asked what are the key risks, two risks stand out – offtaker risk and currency risk.

The solution

CFLI and BNEF also detail the technical solutions to all of these issues. In a nutshell, countries that want to escape the fossil fuel trap need to set goals for a shift, create targets and then write policy to hit those targets.

Policies that are likely to work vary by country, but are highly likely to include the following:

- Reduce the influence of the state in electricity markets
- Unbundle markets
- Stop subsidies to fossil fuel companies and charge them for their externality costs
- Cost reflective tariffs
- Transparent payment arrangements

[57] *A sure path to sustainable solar, World Bank, 2019*

- Good market design
- Recapitalise offtakers
- Solve land availability issues
- Put in place an auction system for renewables
- Change grid codes
- Build more grid infrastructure
- Put in place legislation to allow and honour power purchase agreements
- Reduce currency risks with superior financial structures involving development banks
- Build up robust local currency financial markets to finance the necessary infrastructure.

Amongst these policies, the key local drivers are to allow competition into the electricity system, to make sure that the offtakers are financially robust and introduce auction systems. And the key global support that can be given apart from expertise is to use the development banks to help reduce currency risks and drive down the cost of capital.

BNEF analyses this issue every year in their Climatescope report,[58] and notes that there is a very strong correlation between countries that put enabling policies in place and those that obtain capital. They note that on average the 60 markets at the bottom of their policy ranking received on average only $55m per annum. Whilst the top 47 markets attracted on average $907m a year. That is to say, countries that put in place the superior policies received 16.5 times as much capital.

BNEF note that only 41% of emerging markets had put into place the detailed policy changes required. That is to say nearly 60% of countries have not even put the necessary policy changes into place to obtain the capital to drive an energy transition.

There are even specific statistics by Climatescope on the most successful policies such as auctions. In 2019, for example, the 53 countries with no auctions in place received $10bn in new-build clean energy asset finance. Whilst the 48 countries with auctions in place received $42bn.

Competitive auctions and international finance are two important levers for accelerating the shift to renewables. Competitive auctions are increasingly being used to bring down renewable energy tariffs. Whereas only 20 countries were using tenders in 2009, the number rose steadily to more than 100 countries, catching up with countries using feed-in tariffs. Thanks to auctions, India now has amongst the cheapest cost of solar in the world. Similarly, Sri Lanka halved solar and wind tariffs between 2012 and 2016[59]. International finance has been critical to lowering the cost of renewables in Indonesia, where projects with international financing have been discounted at more than 20% compared to those relying on domestic finance[60].

The financing challenges underscore that it is not enough to recognise the market opportunity for a shift to renewables, at scale and with speed. It is also critical that international institutional capital is

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[58] *Source: Climatescope, BNEF, 2020*

[59] *Dutt, Arjun. 2020. Accelerating Investments in Renewable Energy in Sri Lanka - Drivers, Risks, and Opportunities. CEEW Centre for Energy Finance Report. New Delhi: Council on Energy, Environment and Water. https://cef.ceew.in/solutions-factory/publications/accelerating-investments-in-renewable-energy-in-sri-lanka-drivers-risks-and-opportunities*

[60] *Dutt, Arjun, and Kanika Chawla. 2020. Cheaper Finance is Key to Lowering RE Tariffs in Indonesia. Policy Brief, July. New Delhi: Council on Energy, Environment and Water.* https://cef.ceew.in/solutions-factory/publications/cheaper-finance-is-key-to-lowering-re-tariffs-in-indonesia

reoriented in a way that its investments in emerging markets face lower risks and higher returns — and at larger volumes.

Who can help?

There are many organisations which focus on providing policy expertise to the emerging markets. Notable amongst these are the World Bank's scaling solar programme, IRENA, which is currently working with over 60 countries to help them integrate more renewables into their systems, and the International Solar Alliance which provides a platform for solar-rich countries to increase their deployment of solar.

There are also bilateral organisations such as the German bilateral energy partnership programmes or the Africa EU energy partnership. In 2021, the IEA and the European Union reiterated their commitment under the Green Energy Initiative to put energy access at the centre of co-operation between Europe and Africa.

Meanwhile developers and consultants stand ready to provide expertise and detailed plans. So it is fair to say that with the right political will, policy solutions can be found.

A key role of development banks is to help de-risk initial projects, reduce the cost of capital, bring in successful policies, and thereby attract private capital. In South America for example, this has been a successful strategy, meaning that most FDI now comes from private sources. In order to do so, development finance institutions have to also change how they operate. Their approach to country-by-country financing creates suboptimal outcomes when de-risking can be better delivered through portfolios of projects across countries. We address this at the end of this paper.

Systemic barriers

Even if all of these policy issues are solved, some countries also face systemic issues which are beyond the power of even benign policymakers to solve without external support. We detail some of these below, but it rapidly becomes clear that there is simply a group of countries for whom the implementation at scale of renewable energy technologies will prove extremely difficult because they have such profound problems that they will struggle to implement major systemic change. Issues include:

- Weak grid
- Highly inefficient system
- Weak legal system
- Political risk
- Currency risk
- High cost of capital
- Weak local banking markets

And surrounding all of this this is the systemic problem of endemic corruption. The types of changes that are required are deep and complex and easily frustrated by powerful incumbents. So countries facing deep corruption will struggle to change.

Solutions to this type of problem are outside the scope of this paper. Although it is worth noting that some of them can be addressed with sufficient international support. For example, development banks can help to reduce political and currency risk in order to attract private capital into markets.

Vested interests

We set out below the nature of the vested interest problem, and at first glance it seems intractable. Nevertheless as we noted above, 99% of developed markets and 63% of emerging markets ex-China have already seen peak fossil fuel demand for electricity generation. Clearly, vested interests can be accommodated.

What are they?

Vested interests result from the fact that there are jobs and capital which are dependent on the fossil fuel system. It is fair to say that financial markets are in fact more exposed than labour to the impact of change. To summarise the key aspects that we can quantify:

- **Jobs**. According to the IEA, there are around 20 million people working in the fossil fuel extraction sector out of a global workforce of 3300 million,[61] so less than 1% of the total. And because the fossil fuel system will only gradually run down, most of these people can continue for years in current jobs. On the other hand, there are certain regions and cities which are highly exposed and clearly it is the role of central government to solve this issue.

- **Fixed assets**. The total amount of fossil fuel fixed assets is in the region of $40tn.[62]

- **Financial markets**. We calculate that financial markets have a quarter of equity and half of bonds in sectors linked to the fossil fuel industry.

In addition, there are further links between the fossil fuel system and society. For example, some people get subsidised fossil fuel, and value that subsidy. This issue has been analysed in detail for example by David Victor.[63] The IEA calculates that fossil fuel sector subsidies cost emerging markets 1.5% of GDP.[64]

Why growth and low costs matter

The existence of growth and low costs goes a very long way to resolve the barriers imposed by vested interests.

Growth matters because vested interests are typically more anxious to defend existing assets and jobs than to fight for new ones.

Lower costs matter because they enable politicians to focus on sharing the gain not sharing the pain. That is to say, as lower cost renewables became available, so this frees up money to spend on enabling governments to support fossil fuel workers.

Where are vested interests strongest?

There are many factors that drive the balance of power in a country, and we defer to individual country analysts to establish in detail where vested interests are most powerful. However, in this report we are looking for a broad framework in order to determine how the battle will play out in most countries. We suggest below that the key factor is likely to be the size of coal and gas exports. Countries like Russia with very high levels of exports will tend favour the status quo whilst counties like India with high levels of imports will tend to favour change.

[61] *Source: International Labour Organisation*
[62] *Source: Decline and Fall, Carbon Tracker, 2020*
[63] *Source: Political economy of energy subsidy reform, David Victor, 2017*
[64] *Source: Financing clean energy transitions in emerging markets, IEA, 2021*

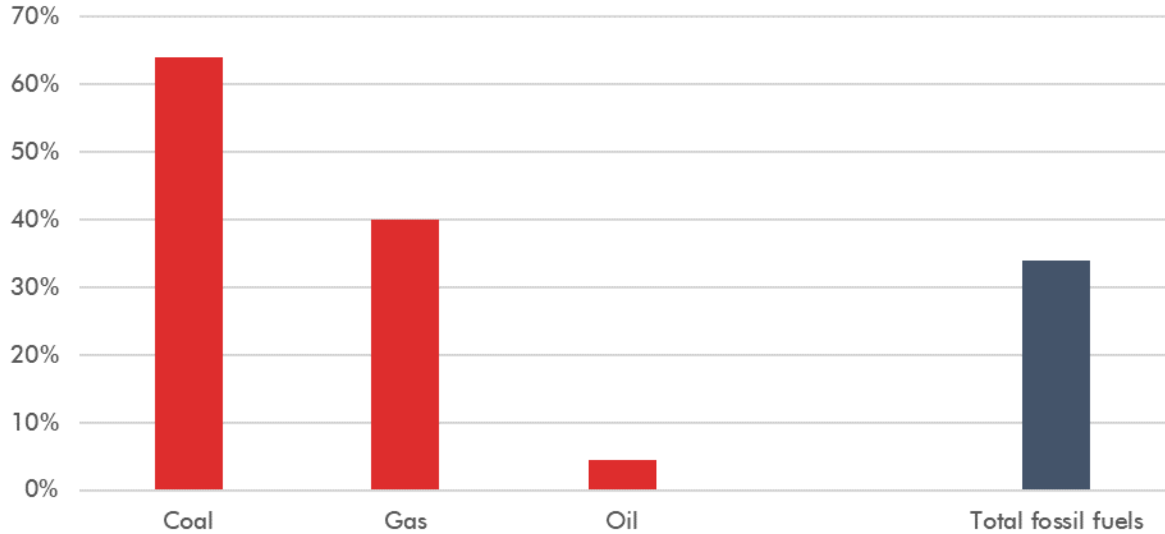
There will, of course, be individual countries where there vested interests are more powerful in spite of the country being an importer; Mexico is one famous recent example. And there will be other countries, which are major exporters but which have nonetheless embraced change; Norway being the classic example.

We set out below our analysis of where lie the most powerful vested interests, looking at products, sectors and counties.

By product

It is possible to consider the generation of electricity from two perspectives to understand how much fossil fuels matter to electricity and how much electricity matters to each fuel. According to the IEA, in 2019 electricity used 64% of coal and 40% of gas but only 4% of oil.

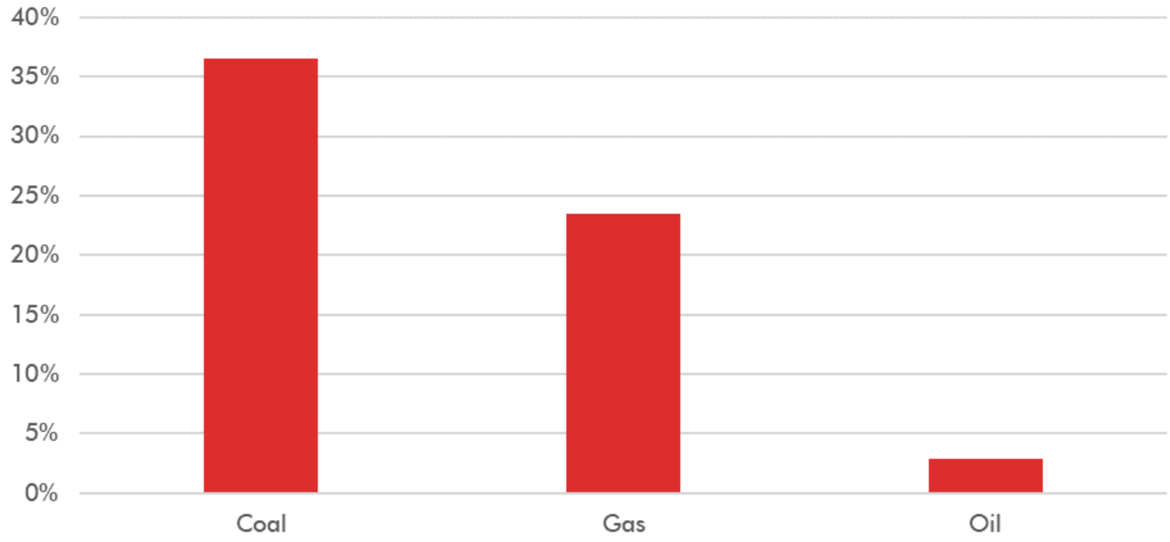
FIGURE 40: SHARE OF FOSSIL FUEL USED IN ELECTRICITY GENERATION 2019



Source: IEA WEO 2020

Meanwhile, in 2019, 36% of electricity generation came from coal, 23% from gas and 3% from oil.

FIGURE 41: SHARE OF TOTAL ELECTRICITY GENERATION BY FOSSIL FUEL 2019



Source: IEA WEO 2020

The conclusion is that oil plays a minimal role in the electricity system, and in theory we should not expect the oil sector to deploy its considerable strength to fight for continued fossil fuel usage in the electricity sector. However, in practice, oil and gas interests are often aligned, both at a company and at a country level. In certain instances the gas sector may, of course, be able to leverage the strength of oil interests.

Over the last decade, the World Bank has quantified the share of oil, gas and coal rents as a share of global GDP. Since 2000, rents to oil have averaged 1.8% of GDP, while coal and gas have each been just 0.3% of global GDP. So oil rents are three times higher than coal and gas combined.

By sector

There are three main sources of fossil fuel vested interest in an economy: the extraction sector (e.g. Exxon); the electricity sector (e.g. Enel); and the machinery sector (e.g. GE). The electricity and machinery sectors can be retooled, so the nexus of opposition to change is often in the extraction sector.

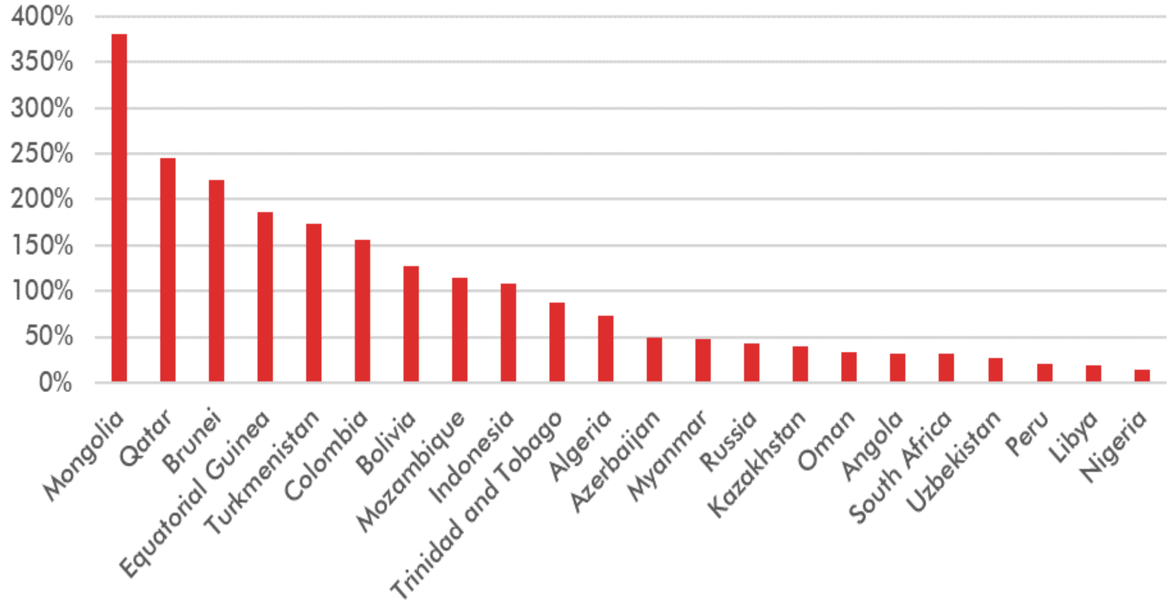
So our working assumption is that resistance to change will be most powerful in those countries which have large coal and gas extraction sectors.

It is again a moot point just how large a sector needs to be in order to have major political power, but we think it is good starting point to examine the size of total coal and gas exports as a share of total energy demand.

By country: relative

We set out below the world's top emerging markets ranked by coal and gas exports as a share of total demand. For nine countries it is over 100%, and amongst these the only one with a population of over 100 million is Indonesia.

FIGURE 42: EXPORTS OF COAL AND GAS AS A PERCENTAGE OF TOTAL ENERGY DEMAND

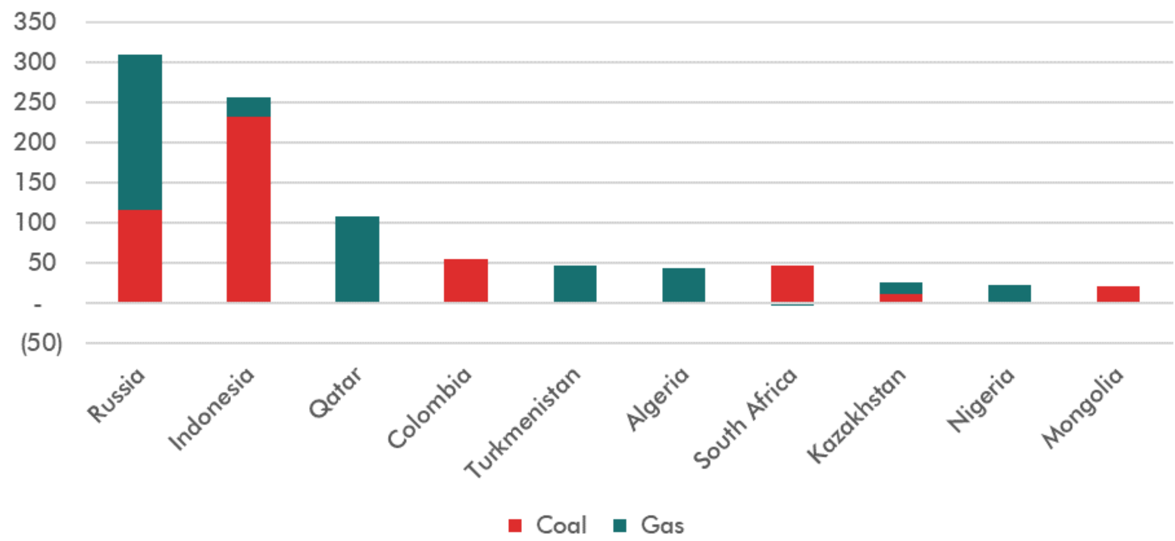


Source: IEA

By country: total

We show below the largest emerging market largest exporters of coal and gas to illustrate this.

FIGURE 43: EM: MAJOR COAL AND GAS EXPORTERS 2019 (MTOE)



Source: IEA

How do vested interests frustrate change

As Mancur Olson pointed out[65] as long ago as 1971, small groups of concentrated losers from change are able to resist that change even when it would benefit the vast majority, whose interests are diffused. For example, Leah Stokes[66] sets out how even in a relatively transparent market like the United States, incumbent fossil fuel interests have been able to slow down and reverse change in certain states. Tactics include scare stories about the negative impact of change and using the complexity of electricity systems to tip the playing field against renewables.

What is the solution to vested interests?

It is again beyond the scope of this paper to solve the problem of the vested interests that seek to prop up the fossil fuel system. The solution in broad terms, as David Victor noted,[67] is to assemble a more powerful coalition of interests behind change. This can involve many policies depending on the country. They are likely to include:

- Carbon dividends. Using the taxation from the carbon system to build support amongst a wide group of people
- Support to workers in the fossil fuel system
- Bad banks to buy out fossil fuel owners, bearing in mind the huge issue of moral hazard
- Education about the damage done by the fossil fuel system and the attraction of having clean air and local jobs
- Transparency about who is causing the emissions
- The build-up of new renewable industries with new jobs
- Open markets to allow renewables to grow. It is notable that in spite of the attempts by US and Australian incumbents for example, fossil fuel demand for electricity generation peaked in both counties over a decade ago.

One option (at an international/regional level) could be to create a "bad bank" to offload the legacy fossil fuel assets, which have become completely unviable. Ringfencing these assets would improve the balance sheets of state-run utilities, reduce national debt, improve sovereign credit ratings and lower the cost of finance for investing in new renewable energy capacity. Since this approach would be to trigger a wholesale switch in the choice of electricity sources, it would not necessarily create a moral hazard for the new investments in clean energy. Those projects would still have to prove their viability at a project economics level.

Can renewable energy jobs solve the problem?

Can renewable energy jobs counteract these pressures? Not all regions and countries will benefit from this shift. Regions that are highly dependent on fossil fuel jobs will face job losses unless they reinvent themselves as renewable energy hubs. It is important not to overstate the size of this issue however. The fossil fuel extraction industry employs around 20 million people, of whom 11 million work in the oil and gas sector. According to the ILO there are 3,300 million jobs globally, meaning that the entire fossil fuel workforce is less than 1% of the total.

At the same time, the concentrated power of the incumbent workforce does complicate the smoothness of the energy transition. The net gains in jobs from the transition must be measured against the

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[65] *The logic of collective action, Olson, 1971*
[66] *Short circuiting policy, Stokes, 2021*
[67] *Source: Accelerating the low carbon transition, Victor, 2020 or The political economy of energy subsidy reform, World Bank, 2017*

distribution of jobs even within countries, the mobility and dynamism in the labour market, provisions for retraining and upskilling the fossil fuel labour force, and the insurance cushion for those who are left stranded.

There are broadly two solutions to this challenge. The first is to train and upskill coal workers for renewable energy jobs. In India, albeit not a fossil fuel exporter, a primary survey of 40 renewable energy companies found that 83 per cent of industry representatives believed there was a shortage of skilled manpower in the sector to keep pace with the pace at which renewables installations were being carried out[68]. The demand for new clean energy workers certainly exists and will keep rising. But the highly regulated nature of the power sector in many countries means that the workforce might not be easily transferable from thermal projects to renewable ones. This is why special programmes would be needed for courses to train and deploy these workers to new projects. The potential in expanding distributed energy infrastructure also promises to create more jobs closer to where the workers live.

The second is to create a voluntary retirement scheme for those whose jobs are threatened, rather than leave them to the vagaries of the market alone. In both cases, it would signal governments' commitment to create safety nets for existing workers. This could, potentially, reduce the resistance from coal power trade unions. But we must recognise that this will require continued and empathetic political engagement, dialogue, consultation and a genuine effort to support. Public policy interventions are necessary to avoid a populist backlash against the energy access and local employment opportunities offered by an energy leapfrog in emerging markets.

[68] *Arunabha Ghosh, Kanika Chawla, Neeraj Kuldeep, Anjali Jaiswal, Meredith Connolly, Nehmat Kaur, Bhaskar Deol and Sameer Kwatra, 'Filling the Skill Gap in India's Clean Energy Market-Solar Energy Focus', CEEW-NRDC Policy Brief, February 2016,* https://www.ceew.in/publications/filling-skill-gap-india%E2%80%99s-clean-energy-market.

6 How the balance of forces plays out

In broad terms the picture is clear. The forces driving change are powerful and inexorable, and will be adopted by most countries whose rulers are driven by concerns about the welfare of their citizens. In a small and shrinking band of states held captive by fossil fuel elites, an attempt will be made to hold back the forces of change.

That is not to say that the process of change will be either easy or smooth. It will continue to be resisted by incumbent interests. And this once more emphasizes the importance of joining local policy action with international financial support.[69] Systemic change is likely to occur and be politically sustainable when the interests of a new green elite converge with the interests of the climate vulnerable, and this is likely to become more and more evident in renewable energy, sustainable mobility and industrial decarbonisation.[70] It is important, then, to create the conditions under which these new sources of investment, jobs and economic and environmental resilience gain prominence.

We distinguish between the various barriers to change, and then split markets into two key groups – those likely to embrace change and those likely to resist it.

How to distinguish the barriers

As we set out below, in order to block change completely, a barrier to the energy transition needs to be specific to renewables, it needs to be permanent and it needs to be insoluble. When looked at in these terms, the formidable list of barriers looks less concerning.

General or specific

Our analysis focuses on new energy assets. It follows that if a country has so many problems that it cannot deploy any energy assets, then it is not relevant to this analysis. Whilst renewables can solve many problems, they are not a universal panacea. The point is that for countries mired in conflict and with very weak governments or a weak record for the rule of law, it is regrettably hard to deploy large amounts of energy infrastructure, renewables or fossil fuels. However, even in such jurisdictions, renewables-based distributed energy offers more opportunity for innovative business models that can bypass or substitute for (often absent or poorly run) state-owned utilities. This would still be a better way to increase access to electricity than wait for the entire governance system to be overhauled before large-scale fossil fuel infrastructure can be deployed.

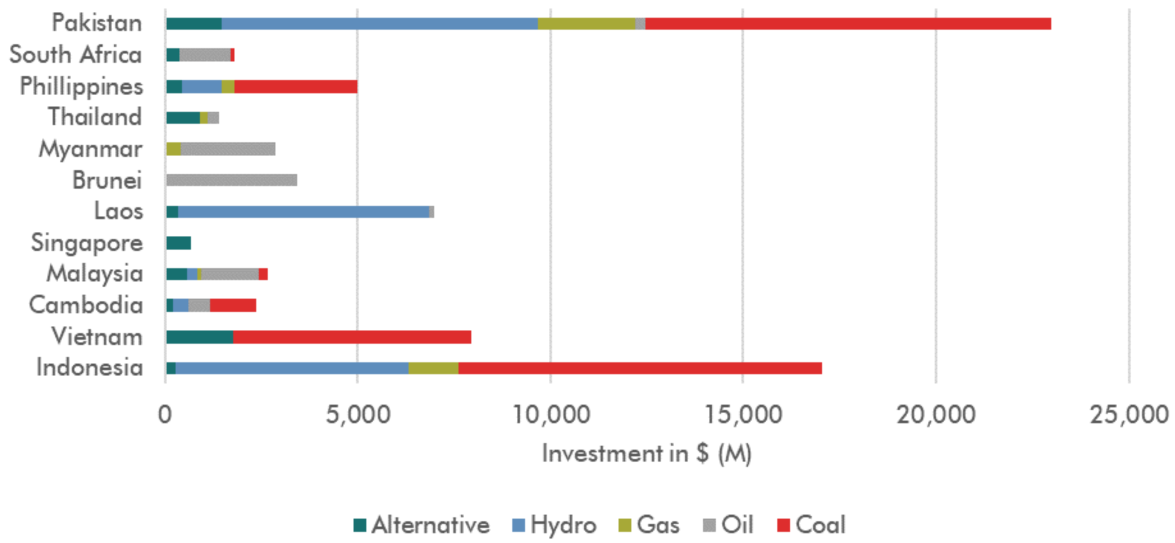
Temporary or permanent

At the peak of the fossil fuel era, there are of course many aspects of inertia. Coal-fired power generation stations are still being built, import contracts are signed, fossil fuel burning capacity is high. As the graph below shows, Chinese energy investment via the Belt Road Initiative has been substantially in fossil fuel assets. For Southeast Asian countries, coal, oil and gas have dominated, although some countries have received large investments in hydropower. As long as easy financing continues, the temptation to keep investing in fossil-based energy infrastructure will continue to be high in regions with growing energy demand. Of course, this creates the risk of stranded assets in future (as discussed above).

[69] *Greening new pastures for green investments, CEEW, 2019*

[70] *Ghosh, Arunabha, 'Aligning growth, politics and climate', Hindustan Times, 16 February 2021,* https://www.hindustantimes.com/opinion/aligning-growth-politics-and-climate-101613394230556.html

FIGURE 44: FOSSIL FUELS DOMINATE CHINESE ENERGY INVESTMENT IN BRI COUNTRIES (2013-19) $M



Source: Green BRI Centre

However, the question that needs to be asked is whether these are temporary or permanent impediments to the growth of renewables.[71] In most instances it is clear that they are temporary. The question that emerging markets should consider is whether they can shorten the lifespan of fossil fuel assets or renegotiate fossil fuel import or power purchase agreements, and at what cost? If the economy-wide costs are lower than the additional investment that could flow into renewables-based infrastructure, then the equation tilts from what seems "permanent" in terms of long-term lock-in towards temporary assets. There is, no doubt, the challenge of managing the political economy of the asset-specific losses even when there are net gains to the economy as a whole.

Soluble or insoluble

The third issue is whether or not the barrier is soluble. For example, many countries suffer from a lack of experienced regulators who can put into place the necessary regulatory regime to encourage the rapid growth of renewables. However, this is not an insoluble problem. There are a number of international organisations, like the World Bank and regional development banks, as well as civil organisations, which can transfer regulatory know-how. Again, as argued earlier, the role of the regulator must be to ringfence the legacy fossil fuel infrastructure so that it does not preclude investment in renewables to meet the growth in electricity demand.

Countries likely to leapfrog

With the various provisos set out above, we believe that the importers of coal and gas are more likely to leapfrog to renewables because the political economy will favour change. Most importers of coal and gas are quite clear, but about 5% of emerging market electricity demand comes from countries such as Saudi Arabia or UAE which are of course major oil exporters but not major coal and gas exporters. For the sake of argument and in light of the stated plans of some of these countries (most notably of course Saudi Arabia) to shift to renewable-based electricity, we include them in our 'importer' grouping.

[71] *Of course very few issues are in fact permanent for a sovereign state.*

The importers made up 82% of total emerging market electricity demand in 2019. We split them in turn into three groups: those which have already seen fossil fuel demand peak (22% of total demand); those which have not seen peak demand (12% of demand); and China, (48% of demand) which is a special case of an importer which has not yet seen peak demand.

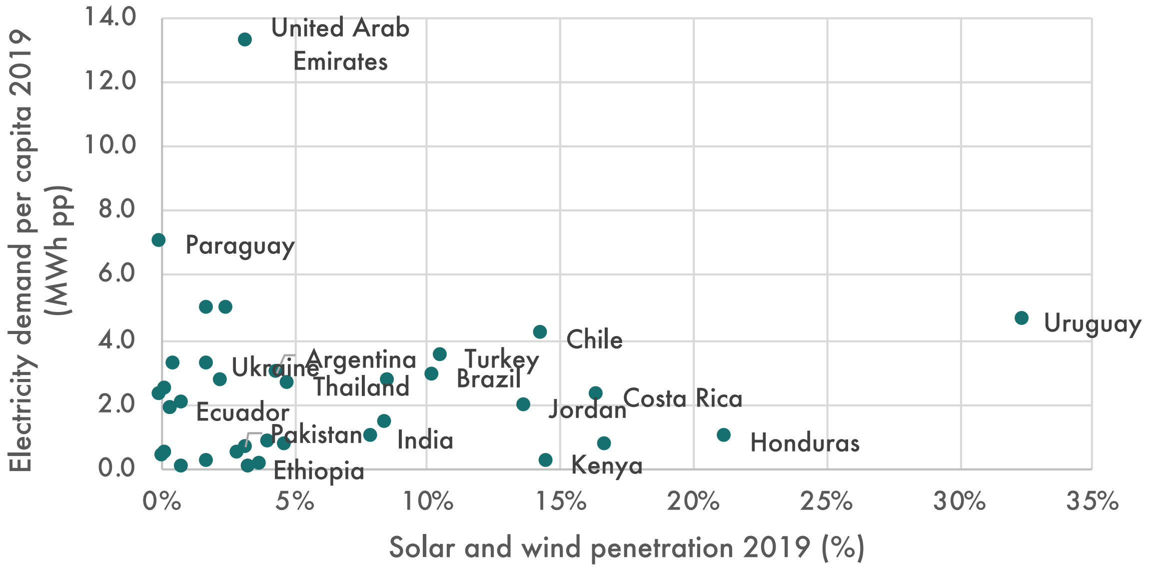
Past or at the peak

We set out below those countries which are both importers and where fossil fuel demand has peaked or at least reached a plateau before 2019. They have a total population of 2,500m and total electricity demand of 3,500 TWh.

Most of them are comfortably past peak fossil fuel demand, although there will be some which may fluctuate around the peak for a while because total demand for electricity is low and growth is likely to be high. In these countries, such as India, the peak may be crossed again dependent on many variables.

We separate them by percentage penetration of solar and wind and electricity demand per capita.

FIGURE 45: COAL AND GAS IMPORTERS CURRENTLY PLATEAUING OR PAST THE PEAK OF FOSSIL FUEL ELECTRICITY DEMAND



Source: Ember, Carbon Tracker. Note these are countries where fossil fuel electricity demand was lower in 2019 than in a previous year. Countries where fossil fuel demand has plateaued could witness a surge if electricity demand jumps rapidly or cost differentials between renewables-plus-storage and coal do not fall quickly.

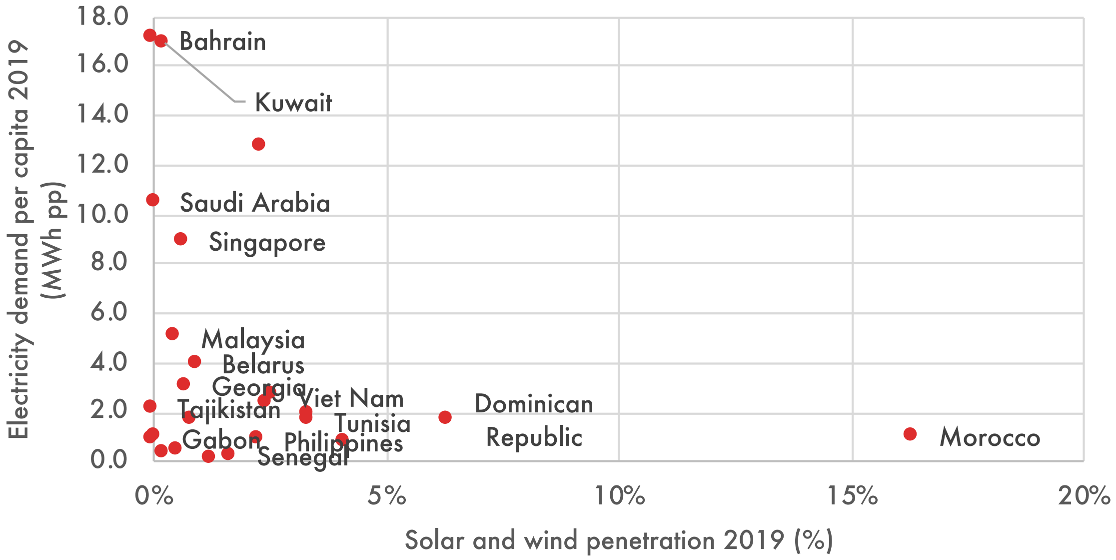
Likely to peak

The second group is coal and gas importers where demand for fossil fuels for electricity generation has not yet peaked. They have a population of 800m and electricity demand of 1,800 TWh.

Notable in this group are markets like Vietnam where peak demand for fossil fuels is simply a matter of time. Electricity demand is already 2.7 MWh per person and solar and wind is 3% of the system and growing fast. Or Morocco where demand per person is 1.1 MWh but solar and wind are already 16% of demand. High demand markets like Saudi Arabia and Kuwait, which are major oil exporters but not net coal and gas exporters have not (as of 2019) embraced solar and wind; but as soon as they do they are likely to see peak demand for fossil fuels in electricity generation.

We split these markets by the share of solar and wind penetration versus electricity demand per capita. Those with higher demand per capita and higher penetration are likely to leapfrog first.[72] Indeed for some of them, the COVID-19 shock in 2019 will prove to be the catalyst of peak demand.

FIGURE 46: COAL AND GAS IMPORTERS BEFORE THE PEAK OF FOSSIL FUEL ELECTRICITY DEMAND



Source: Ember, Carbon Tracker. Note these are countries where fossil fuel electricity demand in 2019 was higher than in any previous year. Moreover, this list includes countries that, on a net basis, are neither importers not exporters of coal and gas.[73]

China

China is a unique case as we noted earlier. With nearly 10% solar and wind penetration and electricity demand per capita of over 5 MWh, it would fit comfortably into the top right corner of those counties most likely to see a leapfrog in the near future.

Where change will be hard

We believe there are two key groups where change will be hard: the coal and gas exporters and the fragile states.

Fragile states

As noted below, 'fragile' is a term taken from the World Bank definitions. Countries that have a fragile political system are likely to find it especially hard to implement the detailed policy measures which are required in order to allow the growth of wind and solar technologies.

[72] *We set out the basic maths behind this observation in the Appendix.*
[73] *And for the sake of clarity it is also, of course, possible that India could return to this group if coal demand surges at a time when renewables are not growing fast enough or if the gap between renewables-plus-storage versus coal does not close rapidly.*

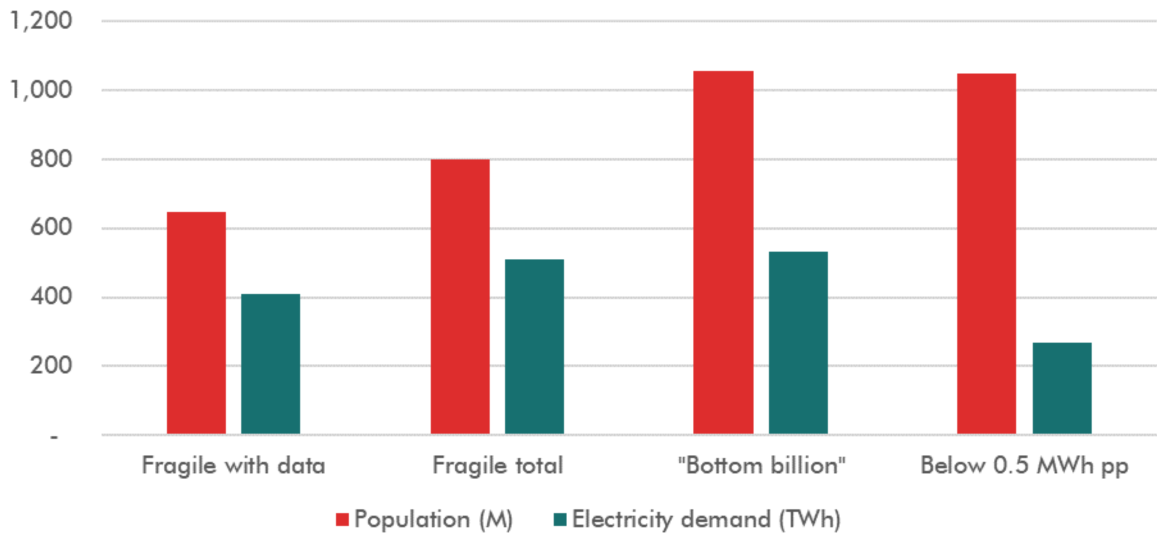
There are various ways to identify this group of countries:

- The World Bank every year provides a list of 'fragile and conflict situations'.[74] Where we have electricity data, the population of these countries is 650 million people with 400 TWh of demand. However, electricity data is not available for some states totalling ~150 million people. By assuming that per capita demand is equal to the fragile states where we do have data, then we can estimate fragile states have a population of around 800 million people with around 500 TWh of demand.

- Paul Collier identified a group of countries in which live what he called the Bottom Billion.[75] These are countries where the institutional framework is so weak and prone to corruption it is hard to get any growth at all, let alone change an electricity system. These add up to little over 1bn people with demand of 500 TWh.

- We can also calculate from the Ember data the number of people living in states with electricity demand of less than 0.5 MWh per person in 2019. They are similar to the fragile states, with many overlapping countries. The population of these countries is 1,046m people with total demand of 270 TWh.

FIGURE 47: POPULATION AND ELECTRICITY DEMAND OF FRAGILE COUNTRIES 2019



Source: Ember, World Bank, Paul Collier

In summary, this group of countries is around one billion people with demand of under 500 TWh. That is to say 13% of the global population with electricity demand of 2% of global demand and 3% of emerging market demand.

How solar and wind can help get energy to people in fragile states

Fragile states have weak governments which even after over a century of fossil fuel-based electricity systems have been unable to get much electricity to their people. As SDG7 notes, there are still 770 million people lacking in electricity.

[74] *Source: World Bank, Classification of fragile and conflict afflicted situations, 2020*
[75] *Source: The Bottom Billion, Collier, 2007*

Into the mix now comes a new solution — distributed renewables. They are of course not a panacea, but they can and do provide the ability for people to get access to their own electricity that they can control. As a result, we have seen in Sub-Saharan Africa the growth of many companies which specifically provide off-grid solar to people without the intervention of the state.

Access to electricity means that these countries then have a platform for rural development. Moreover, renewables enhance rather than impeding development for these countries.

Fragile states are not large enough to drive global demand

There is an impassioned debate between proponents of fossil fuels and renewables about whether fossil fuels or renewables are the way forward for fragile states. As noted above, we believe that solar and wind are indeed the solution. However, we also recognise that there will, of course, be states which need fossil fuels to get their electricity systems off the ground. But the wider point for the debate about global fossil fuel demand is that the route chosen by these states will have little impact on the global demand for electricity either from fossil fuels or from renewable sources.

Even at 5% growth (which they are not currently enjoying), fragile states would only grow demand by 25 TWh, which is less than 5% of total emerging market electricity demand growth in 2019.

How the world will look when these countries have a material impact on global demand

Over time, the international community clearly needs to step in to support fragile states increase their provision of electricity. Programmes such as the Africa EU energy partnership and the new fund set up by Rockefeller Foundation and IKEA Foundation are certainly part of this solution. There is a greater chance of these initiatives succeeding if the focus is on using the potential of distributed energy to power livelihood applications, which can increase incomes for poor households. This is a multi-billion opportunity across emerging markets and needs a dedicated multilateral and multi-stakeholder platform.[76]

By the time this group of countries are likely to be of a material size they will face a very different world. For example, even at 5% annual growth rates it would take 15 years to double demand. So, in 2035, demand from the fragile states might be 1,000 TWh growing at 50 TWh a year. And by that stage, renewables will be dramatically cheaper than they are today. So the opportunity to deploy renewables will simply improve over time.

Coal and gas exporters

Coal and gas exporters were 16% of emerging market electricity demand in 2019, with demand of 2,400 TWh and a population of just over 800 million.

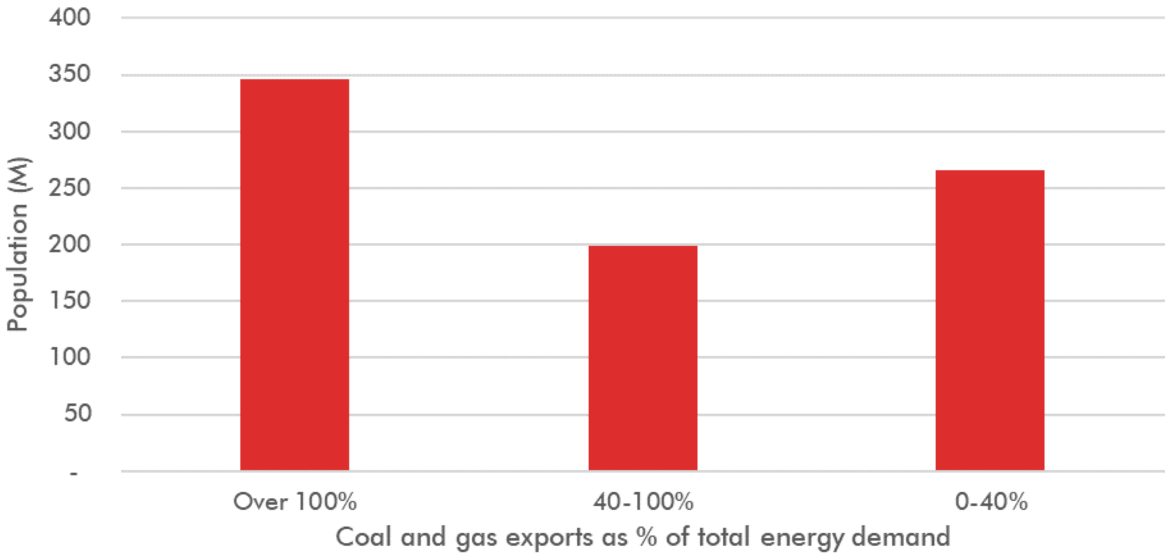
There are a few countries which are both exporters and fit into the 'fragile' state framing of the World Bank. They include Nigeria, Mozambique, Myanmar, and Libya. To avoid double counting, we have included them in the fragile state group.

Some are more exposed than others

As we have seen, the fossil fuel exporters are not a homogenous group. In the chart below we split them out according to coal and gas exports as a share of energy demand.

[76] *Jain, Abhishek, Arunabha Ghosh, and Sanjana Chhabra, Powering Livelihoods Globally through Clean Energy, Global Challenges Foundation, July 2021 (Forthcoming)*

FIGURE 48: POPULATION (M) OF EXPORTERS GROUPED BY COAL AND GAS EXPORTS AS SHARE OF ENERGY DEMAND.



Source: IEA, Carbon Tracker estimates

They break down into three roughly equal groups:

- **More than 100%**. Such as Qatar. Countries unlikely to embrace an energy transition.
- **40-100%**. Countries such as Russia or Algeria.
- **Less than 40%**. Countries such as South Africa or Iran.

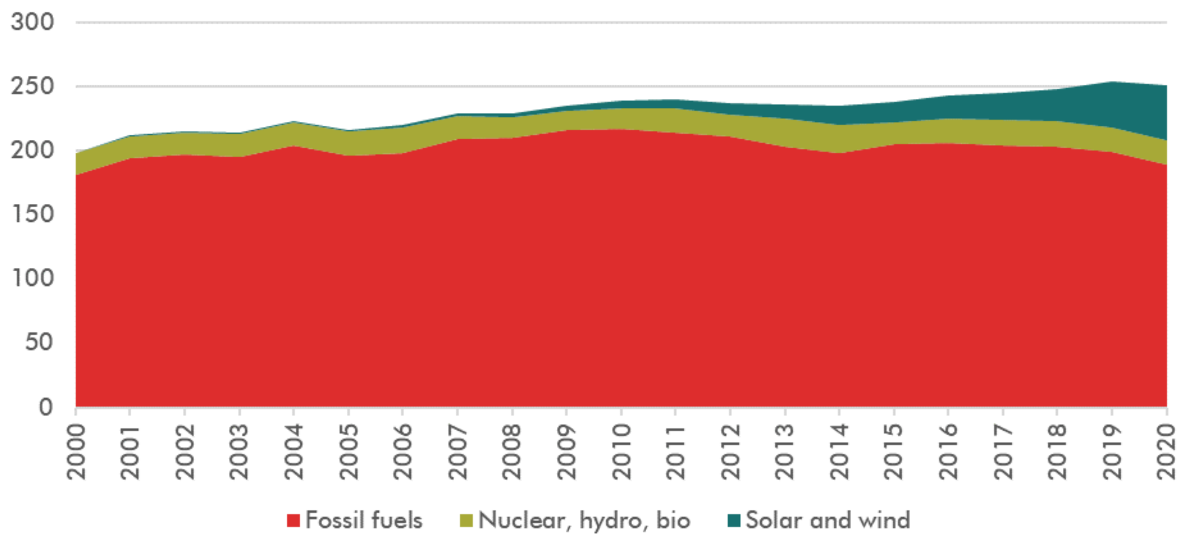
But the key point is that some are changing. This is not a united block seeking to hold back change. For example, fossil fuel demand for electricity generation peaked in South Africa in 2007 (mainly because of renewable growth in a flat market) and the government plans to obtain supply growth from renewable sources.[77]

Developed market exporters are already changing

The big developed market coal and gas exporters such as Australia or Canada have already seen peak demand for fossil fuels for electricity generation, and are rapidly adopting solar and wind technologies. In spite of current uncertainty around policy, Australia for example saw peak fossil fuel demand for electricity generation in 2010. Since that time fossil fuel demand has fallen by 13%.

[77] *See for example: South Africa energy perspective, McKinsey, 2020*

FIGURE 49: ELECTRICITY SUPPLY IN AUSTRALIA (TWH)



Source: Ember

Does it make sense for coal and gas exporters to resist change

Although we note that resistance to the energy transition will be most entrenched within coal and gas exporters such as Russia or Nigeria, it is worth noting that this makes little sense for the people living in the exporter countries. We set out the arguments, fully cognisant that most exporters would likely ignore them. The balance of political forces is likely still tilted in favour of fossil fuels but the trends in technology, markets and investment are pointed in a different direction.

- Risk. Exporters of coal and gas already have a large degree of exposure to the fossil fuel system. Therefore, they should be looking to reduce their risk.
- Cost. Domestic transitions amongst the fossil fuel exporters will not impact the global supply demand balance. So countries will benefit from using the cheapest domestic energy source when it is renewables in order to get cheaper electricity for their people.
- Freedom. The links between fossil fuels and corruption are well-documented.[78] In many countries the rent from the fossil fuel system goes to the elite and rarely benefits the poor. And indeed it engenders and entrenches corruption. Renewable energy therefore provides a way for emerging markets to escape the curse of oil.

How long till the peak

We set out a framework for the peaking of fossil fuel demand for electricity in China, in the rest of emerging markets and in the world as a whole. Our conclusion is that global demand for fossil fuel for electricity most likely peaked in 2018, that demand in emerging markets ex-China reached a plateau in 2019 and that Chinese demand will peak in the early 2020s. And as soon as Chinese demand peaks, emerging market demand as a whole will peak.

[78] *For example see The oil curse, Ross, 2013*

Emerging markets ex-China

As we are focussing on marginal change, we simply need enough deployment of renewables in total to supply the growth in electricity demand. As we set out below, for emerging markets ex-China it is reasonable to argue that a plateau was reached in 2019 for fossil fuels. This will last until around the middle of the decade before decline sets in.

The framing

As we have noted, fossil fuels were only 13% of the growth in electricity supply in 2019. To summarise the growth rate of the three components of supply in recent years.

- **Solar and wind**. The fastest growing sources of electricity supply, and the drivers of change. The average growth rate in the last five years has been 25%.
- **Hydro, nuclear and biomass**. Consistently growing and generally preferred by policymakers as they avoid fossil fuel type pollution. The average growth rate in the five years to 2019 has been 2%.
- **Fossil fuels**. The old primary supplier, but now simply the residual in the electricity equation. The solution for when you don't have enough from the other sources of supply. The average growth rate in the five years to 2019 has been 1%.

The maths

If we make the simplifying assumption that hydro, nuclear and biomass supply grow at the same rate as the total growth in demand then we can work out the date of peak fossil fuel demand in the emerging markets based on only two variables: total demand growth; and the growth rate of solar and wind.

So for example, if the growth rate of demand is 2.5% and the growth rate of solar and wind remains at 25%, the year of peak demand will be 2023. If solar and wind growth rates drop to 20% per annum, the peak will be 2025.

FIGURE 50: DATE OF PEAK FOSSIL DEMAND FOR ELECTRICITY IN THE EMERGING MARKETS EX-CHINA

	Demand growth				
Solar and wind growth	1.5%	2.0%	2.5%	3.0%	3.5%
15%	2025	2028	2030	2032	2034
20%	2022	2024	2025	2026	2028
25%	2020	2022	2023	2024	2025
30%	2019	2020	2021	2022	2023

Source: Carbon Tracker estimates based on annual growth rates of total demand and solar and wind supply

We start our analysis deliberately in 2019 in order to strip out the impact of COVID-19. As noted by Carbon Tracker in 2020,[79] COVID-19 is likely to advance the year of the peak.

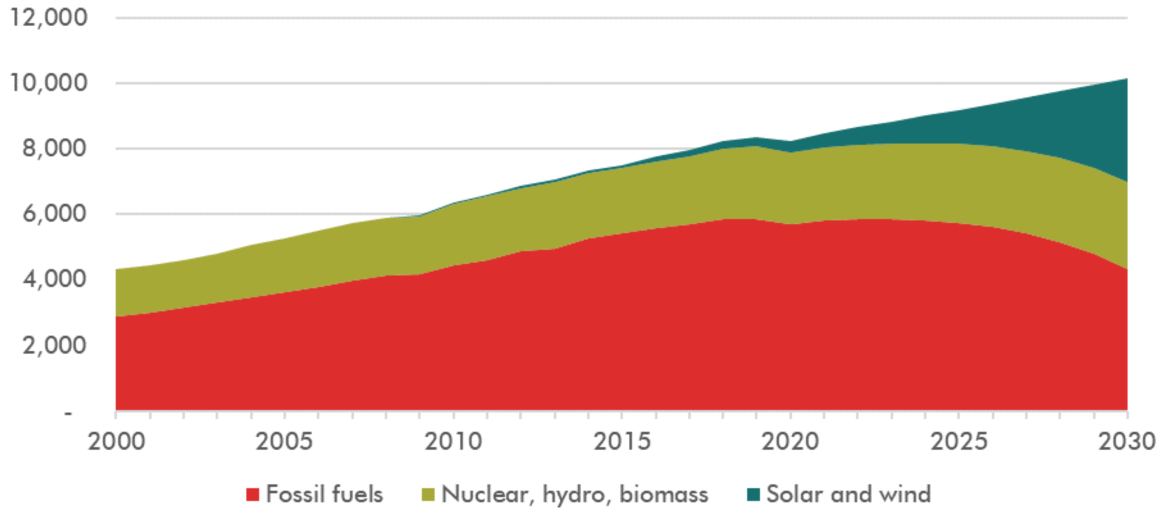
[79] *COVID-19 as midwife to the energy transition, Carbon Tracker, 2020*

The projection

If we assume growth continuity in the next few years, then fossil fuel demand for electricity generation in the emerging markets ex-China is at a plateau. We illustrate this in the chart below, assuming 2% demand growth after the 2021 bounce back and 25% solar and wind growth.

The plateau thus begins in 2019, and will last until around 2025. After which the size of solar and wind will be large enough to mean that fossil fuel demand falls rapidly.

FIGURE 51: EMERGING MARKETS EX-CHINA ELECTRICITY SUPPLY ILLUSTRATION (TWH)



Source: BP, Ember, Carbon Tracker estimates

China

There are many forecasts available for the date of peak fossil fuel supply for electricity generation in China. They range from Tsinghua University (2025 for a 2-degree world) to the forecasts of the state grid (State Grid Energy Research Institute) of a 2027-29 peak.

We will not attempt to second-guess the China experts, but it can be noted that the speed of the energy transition has caught out many seasoned incumbent forecasters before. We set out some basic parameters below.

The framing

As we have seen, non-fossil sources made up nearly two-thirds of the growth in demand in China even in 2020, and solar and wind were 10% of total electricity supply, whilst other non-fossil sources were 24% of supply. To summarise the growth rates for the last 5 years to 2020:

Over the last 5 years solar and wind have been growing at 26% a year.

- Hydro, biomass and nuclear have been growing at 7%.
- Fossil fuels have been growing at 6%.
- Total electricity demand growth has been 6% a year. Indeed, the only reason why wind and solar have not already driven a peak in fossil fuel demand in China is that total demand growth has been so high.

The maths

If we make the simplifying assumption that the other non-fossil sectors of nuclear, hydro and biomass grow at the same rate as total demand, then it is possible to calculate the date of peak demand for fossil fuels for electricity generation in China simply by reference to two variables – total electricity demand growth and solar and wind growth rates. We show below the year that fossil fuel demand will peak, with reference to these two variables only. We start our analysis in 2020.

FIGURE 52: YEAR OF PEAK FOSSIL FUEL DEMAND FOR ELECTRICITY IN CHINA DEPENDENT ON KEY VARIABLES

	Demand growth			
Solar and wind growth	3.0%	4.0%	5.0%	6.0%
15%	2024	2027	2031	2034
20%	2021	2023	2025	2027
25%	2020	2021	2023	2024
30%	2020	2020	2021	2022

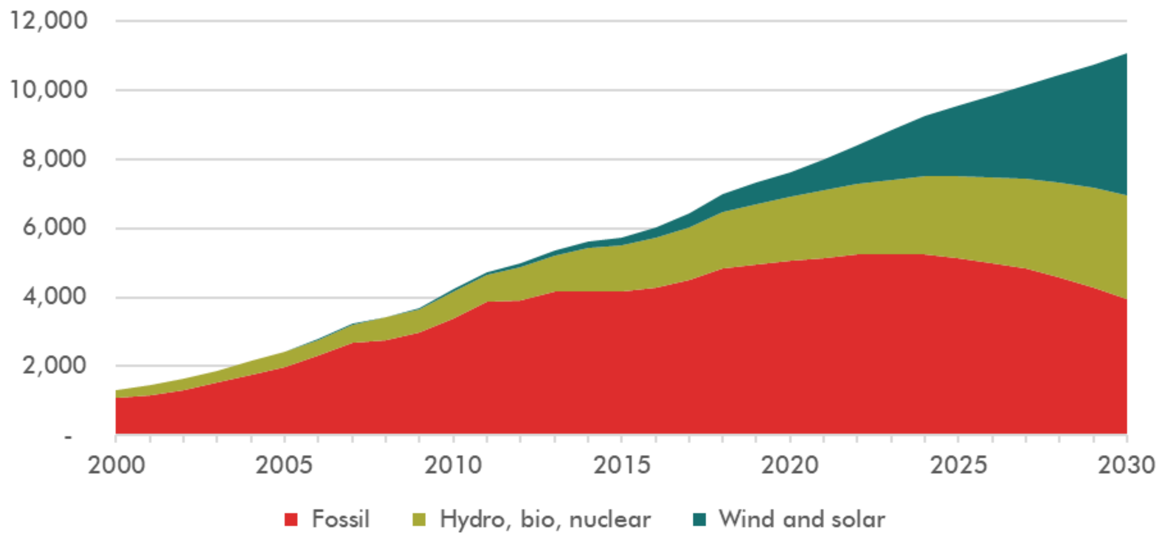
Source: Carbon Tracker estimates based on annual growth rates of total demand and solar and wind supply

Assuming 4-5% annual electricity demand growth and 20-25% solar and wind growth, peak fossil fuel demand will be in the period 2021-2025. That is to say, a little earlier than the experts are predicting.

Projected electricity supply in China

By way of illustration we show below how supply for electricity would look in China with 5% growth of total demand and 25% growth in solar and wind supply. Peak fossil fuel demand is 2023.

FIGURE 53: CHINA ELECTRICITY SUPPLY ILLUSTRATION TWH



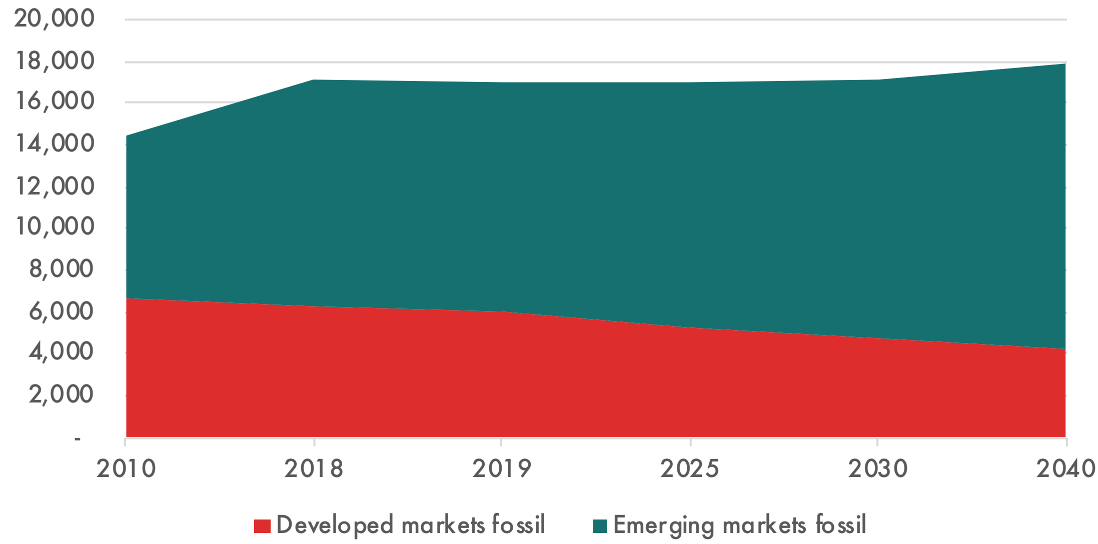
Source: Ember, CT assumptions

Global

If we take the framing set out above, then it is highly likely that 2018 was when we reached the global demand plateau for fossil fuel for electricity generation. This is not, in fact, a very bold statement to make. Even in the IEA STEPS scenario below, fossil fuel demand for electricity generation only edges up marginally.

In the STEPS scenario, all of the expected growth in electricity demand and in fossil fuel demand for electricity comes from the emerging markets. If they do not embrace fossil fuels, there will be no demand growth for fossil fuels for electricity.

FIGURE 54: FOSSIL FUEL SUPPLY FOR ELECTRICITY GENERATION – STEPS FRAMING TWH

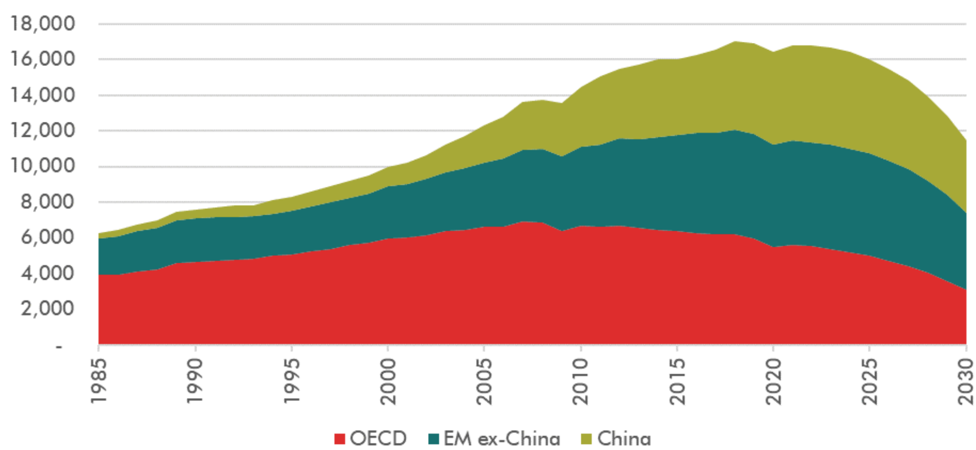


Source: IEA STEPS scenario WEO 2020

Whether or not 2018 turns out to be the global peak is a slightly moot point; demand may scrape a little higher for a couple of years in 2022 and 2023. But the key issue is that the plateau has been reached. As with coal, we will bump along the plateau for a few years, and then demand will fall rapidly.

We set out below expected demand for fossil fuel for electricity over time, using the framework we set out above.

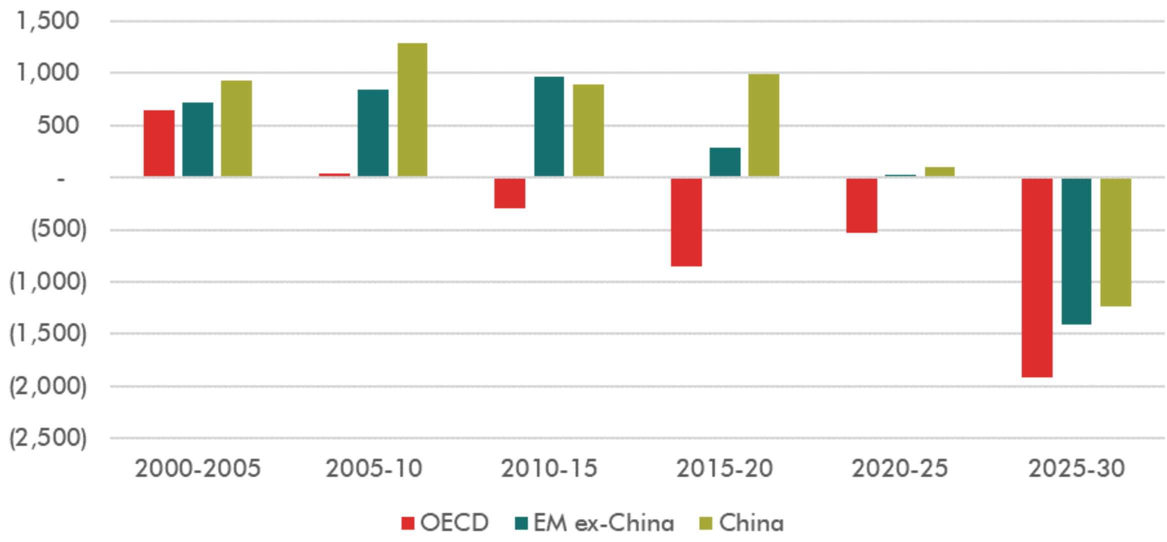
FIGURE 55: GLOBAL DEMAND FOR FOSSIL FUELS FOR ELECTRICITY GENERATION (TWH)



Source: Ember, Carbon Tracker estimates

If we split the growth of demand for fossil fuels for electricity generation for every 5-year period, we see how the split has changed. In 2000-2005, there were three growth drivers — OECD, China and emerging markets ex-China. By 2010-15, that had dropped to just two drivers. In 2015-20, China took over as the main driver. And in the 5-year period to come, there will likely be no drivers of growth.

FIGURE 56: CHANGE IN FOSSIL FUEL ELECTRICITY SUPPLY FOR FOSSIL FUELS IN EACH 5-YEAR PERIOD (TWH)



Source: BP Statistical Review, Ember, Carbon Tracker estimates

The framing of the decline in global fossil fuel demand is, in fact, very intuitive. Fossil fuel demand for electricity generation splits into three roughly equal groups – OECD, China and emerging markets ex-China.

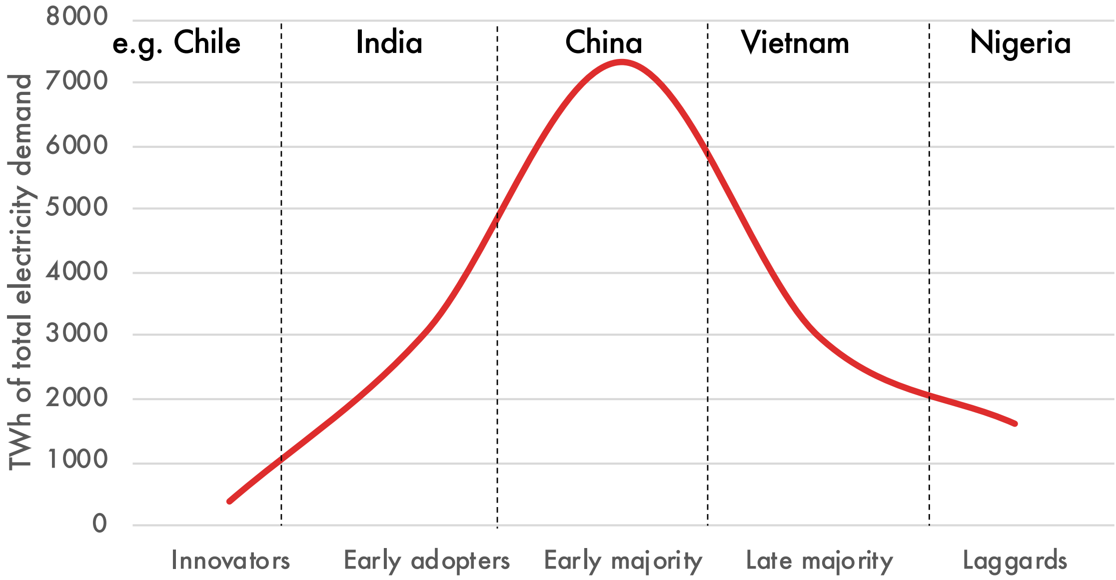
There is little dispute that OECD demand will continue to fall. If emerging markets ex-China have demand that is flat and then falling, then the only driver of growth is China. As we have seen we can expect a few more years of growth before Chinese demand for fossil fuels also falls. So the balance is simply decline in the OECD versus growth in China. If OECD decline is faster than Chinese growth, then total demand will fall.

The phasing of change

It is possible to set out the phasing of the emerging market shift in the electricity sector in the typical Rogers framing of the diffusion of innovations into his categories of innovators, early adopters, early majority, late majority and laggards.

- **The innovators**, such as Chile.
- **The early adopters**, such as India. It is important to note that India has leapfrogged China in the electricity sector by driving a surge in renewables at a much lower level of electricity access.
- **The early majority** – China. As we have seen, it is likely to see peak demand in the early 2020s.
- **The late majority**. Other fossil fuel importers such as Vietnam or Morocco. As well as those oil exporters such as Saudi Arabia who can see the way the energy system is moving.
- **The laggards**. This is where we would place the coal and gas exporters more resistant to change and the fragile states without international support. And, being laggards, they can lag behind but not influence the overall transition.

FIGURE 57: DIFFUSION OF INNOVATIONS: APPLIED TO THE EMERGING MARKET ELECTRICITY LEAPFROG



Source: Carbon Tracker, Ember

7 How to speed up the leapfrog

From our framing of the nature of the emerging market leapfrog, it follows that there are local and international solutions. The local ones are the key, because without local support, global polices are unlikely to succeed. It follows that international policymakers should focus their attention on the coal and gas importing countries with governments likely to embrace policy solutions. As this is where change will be most likely.

As noted above, there are many reports and organisations which set out the local actions that are needed to speed up change. We focus below on the international action.

Identify the right targets

From our analysis there are broadly three types of countries:

- **Fragile states**. The electricity transition needs to be part of a wider package of measures related to technology, finance and business models to expand access.
- **Coal and gas importers**. This is where attention will yield early wins and case studies for replication in other emerging markets.
- **Coal and gas exporters**. Some may wish to change, and some may simply wish to pay lip service.

Developed markets policymakers should take different approaches to the different groups.

For the fragile states, the motive for interventions would have less to do with spurring a shift to renewables and more to do with building a robust electricity sector that can support economic development. Energy access is a key driver of the other sustainable development goals. Although these countries will not impact the direction or pace of the leapfrog, finding solutions for their energy transition could be a 'deal for development', drawing them into the emerging global green economy.[80] There is a moral obligation of the international community to support universal access to electricity as the basis of achieving many other sustainable development goals. No doubt, for reasons outlined above, the task would be harder in these countries. But their marginal share in global electricity demand growth should not be a reason to leave hundreds of millions of people in the dark.

Focusing on those countries in the second group that can act as lighthouses to their neighbours and encourage them to follow suit will yield early wins. Lighthouses include India for those countries still lacking in electricity access[81], Chile in South America, Vietnam in SE Asia or Morocco in Africa. These countries can demonstrate how lower levels of development need not be a hindrance to a leapfrog to a cleaner energy future. But as argued earlier, this will not happen automatically at a pace commensurate with the global carbon constraint. The policy choices in these lighthouse economies must be supported with international financial assistance to drive down storage prices rapidly or cover for the RE-plus-storage price gap that still exists with coal.

Coal and gas exporters can in turn be split into those with large export sectors and those with smaller export sectors. The first group are more likely to embrace change.

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[80] *Ghosh, Arunabha. 'On climate, our hubris is the problem.' Hindustan Times, 15 June 2021. Available at:* https://www.hindustantimes.com/opinion/on-climate-our-hubris-is-the-problem-101623665204047.html

[81] *India's policy lessons and experience have been showcased in Government of India, "Accelerating Citizen-centric Energy Transition: The India Story, Council on Energy, Environment and Water, June 2021.* https://www.energytransition.in/

Stop financing fossils

As we have seen, cost of capital is one key way in which renewables can overcome fossil fuels. This is, of course, an area where much pioneering work has been done by ESG and impact investors to curtail the flow of capital to fossil fuel projects. Meanwhile, it makes sense thus for developed markets policymakers to curtail the finance flowing to fossil fuel generation. This has been a feature of policy over the last couple of years. It would be equally important, via the G-20 deliberations, to impress upon China the risk of exporting cheap finance for fossil fuel infrastructure in emerging markets. If many of these markets, as shown above, are at or near their peak, any further investment in such infrastructure would burden them with debts they will struggle to repay and assets they will find impossible to refinance.

Technology and policy transfer

There is no need for emerging market policy makers to reinvent the wheel. Technologies and successful policies can be transferred from the leaders to those aspiring countries in the emerging markets. It will be necessary, for example, to help build up robust local currency financial markets to help to channel domestic savings into renewable projects.

The reality, however, is that technology transfer seldom happens despite promises. A review of more than 30 climate technology platforms found that few were designed to go beyond organising workshops and very few had provisions of genuinely collaborative R&D, deployment or commercialisation at scale.[82] For the leapfrog to renewables to be realised, there must be a fundamental rethink about how technology diffusion occurs and the alternative institutional designs needed for the same.[83]

More so, the policy lessons can come from other emerging markets, which are crafted for the *sui generis* conditions in which many of these economies operate. Countries like India or Vietnam have been able to build substantial renewable energy capacity even under policy and market conditions might not match the standards of advanced economies. It is this experience of leapfrogging under imperfect market conditions that holds the greatest attraction for other emerging markets to follow suit.

It should be noted here that it is at least as important to transfer policy innovation as technology. Project developers operate globally and can bring new technologies to bear. It is the policy innovation that governments can bring.

Reduce cost of capital

Capital needs to be made available to those who can deploy it. Development finance institutions need to de-risk projects in order to bring the cost of capital down to acceptable levels for countries that are serious about embracing renewables.

One option is to create a Common Risk Mitigation Mechanism (CRMM) as a multi-risk and multi-country approach to lower the exposure for individual emerging markets, investors or project developers. The CRMM was first designed by CEEW, the Currency Exchange Fund (TCX) and the Terrawatt Initiative (TWI), with a mandate from 17 member countries of the International Solar Alliance. Its proposition is to use pooled public resources to crowd in more, newer and cheaper private

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[82] *Ghosh, Arunabha, Anupama Vijayakumar, and Sudatta Ray (2015) 'Climate Technology Partnerships: Form, Function and Impact' CIGI Fixing Climate Governance Series – Paper No. 2, October, Waterloo, ON: Centre for International Governance Innovation. Available at* https://www.cigionline.org/publications/climate-technology-partnerships-form-function-and-impact.

[83] *Ghosh, Arunabha, Vaibhav Chaturvedi, and Shikha Bhasin (2019) 'Climate Ambition Needs Targeted Technology Collaboration' in 20 Years of G20: From Global Cooperation to Building Consensus, edited by Rajat Kathuria and Prateek Kukreja, 157-179. Singapore: Springer.* https://link.springer.com/chapter/10.1007/978-981-13-8106-5_9

investment into grid-connected solar assets around the world. The idea is to use small quantum of public funds to de-risk renewable energy projects as a portfolio across countries and, thereby, crowd in billions of dollars of institutional investment. In addition to underwriting risks, Additionally, the CRMM cover for projects could deepen markets by underwriting risks, it could lower transaction costs (with homogenous credit rating of aggregated assets) and, in turn, improve the liquidity of assets.[84]

The above interventions — in policy, finance, technology and cost of capital — could be modified for countries based on their local situations. Together, they could form the bedrock of a more determined push towards a leapfrog for *all* emerging economies to a cleaner energy future.

[84] Council on Energy, Environment and Water, Confederation of Indian Industry, The Currency Exchange Fund, and Terrawatt Initiative. 2017. *Common Risk Mitigation Mechanism Feasibility Report.* New Delhi: Council on Energy, Environment and Water. Available at: ceew.in/publications/common-risk-mitigation-mechanism.

8 Appendix

The maths of the leapfrog

What market share of solar and wind is needed for a leapfrog

We can work out what market share of solar and wind is needed to drive a peak in incumbent demand, based on only two variables:

- The growth rate of solar and wind
- The growth rate of the entire system

FIGURE 58: WHAT MARKET SHARE OF SOLAR AND WIND IS NEEDED TO CAPTURE ALL THE SYSTEM GROWTH?

	Energy demand growth				
Solar and wind growth	1%	2%	3%	4%	5%
15%	7%	13%	20%	27%	33%
20%	5%	10%	15%	20%	25%
25%	4%	8%	12%	16%	20%
30%	3%	7%	10%	13%	17%

Source: Carbon Tracker estimates based on annual growth rates of total demand and solar and wind supply

So, for example, markets with 3% total demand growth and with solar and wind growing at 20%, solar and wind need to be 15% of the market before they capture all the growth.

By contrast, in low growth markets where total demand growth is just 1%, solar and wind growing at 15% a year capture all the growth at a market share of only 7%. That is why we are already seeing falling demand for fossil fuel electricity in developed markets.

As an aside, this framing of the issue is in fact somewhat generous to the fossil fuel system. We have examined growth only from the perspective of solar and wind. In reality, growth is also coming from other non-fossil technologies such as hydro, biomass and nuclear. Which mean that peak demand for fossils will typically come a few years earlier than the incumbent peaks we have been looking at.

How long until leapfrog

If we assume 3% annual total demand growth, we can also work out how many years it will take before you get to a peak in incumbent demand based upon:

- The starting share of solar and wind
- The growth rate of solar and wind.

Figure 59: How many years for solar and wind to capture all the growth in demand

Solar and wind growth rate	Starting market share 2%	4%	6%	8%	10%
15%	21	15	11	8	6
20%	13	9	6	4	3
25%	9	6	4	2	1
30%	7	4	2	1	-

Source: Carbon Tracker estimates based on annual growth rates of total demand and solar and wind supply

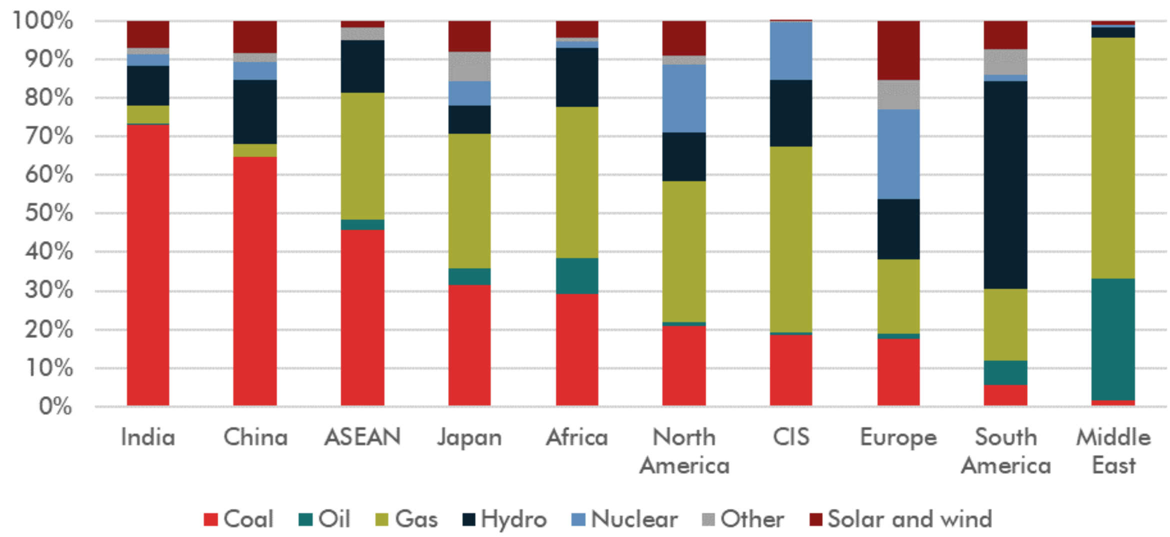
So for example, if your starting market share for solar and wind is 6% and solar and wind are growing at 25% a year, it will take 4 years to reach peak incumbent demand.

Again, this is to be slightly generous to the fossil fuel sector. Thanks to the existence of non-fossil technologies in addition to solar and wind , peak demand for fossils will come a little earlier.

Electricity supply by region and source

Regional demand and source of demand varies considerably. Coal is the largest source in China, India and ASEAN. Gas is the largest source in Africa, the Middle East and the CIS. Hydropower dominates in South America.

Figure 60: Share of electricity generation 2019



Source: BP Statistical Review

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