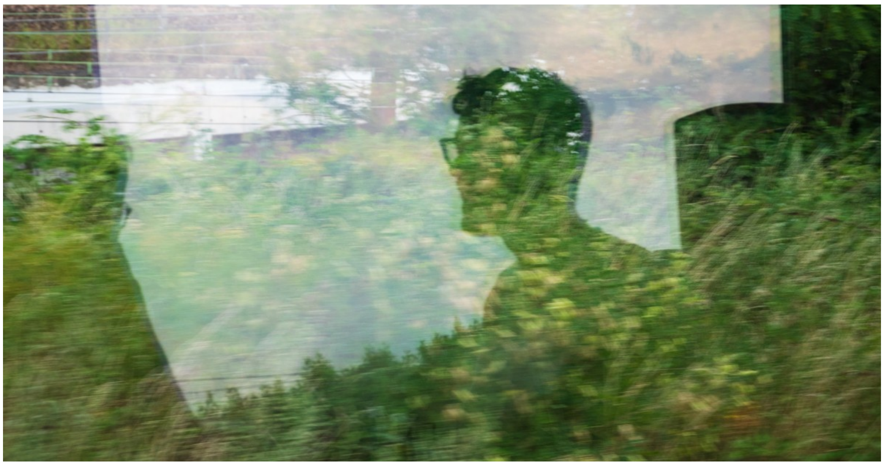
$12.4tr: The cost of greening Asia's transport and generation capacity

Asia emits half the world's carbon dioxide, but China, Japan and South Korea are now embarking on net-zero carbon plans. How much is this going to cost in terms of new electricity generation capacity? We estimate $12.4tr for just the transport sector alone. Here are the main points of our major new report, which you can download here



$12.4tr

Costs of energy generating transition for transport

China, Japan and South Korea

$12.4tr is just the beginning

In our major new report, "Asia's race to net-zero carbon: $12.4 trillion and counting", we have taken the three Asian economies which have made firm commitments to achieving a net-zero carbon future, China, Japan and South Korea, and estimated a portion of the costs that achieving that will involve.

Our note zooms in on the costs of supplying a new generation of net-zero carbon transport with the clean and green electricity it will need if these targets are to be met.

We estimate that even this small part of the transition process will cost these economies $12.4tr to achieve. It's a huge amount but the sums look more manageable if things were started right now and spread over the next thirty to forty years.

Why this matters

Fifty-nine countries have so far made net-zero carbon pledges, including from Asia, China, Japan and South Korea. These three economies account for about two-thirds of total Asian emissions. More pledges of net-zero carbon will doubtless follow, perhaps in the run-up to the COP 26 meetings in the UK in November. This may even include some more from Asia.

> *Making pledges and actually doing what is necessary are not the same things*

But making pledges and actually doing what is necessary to achieve net-zero carbon are not the same things. By looking at transport - typically only a small part of the required transition process - we can begin to capture a sense of the daunting scale of what lies ahead.

$12.4tr will cover the electricity generating capacity that will be needed to supply new fleets of battery electric vehicles, electrified rail, hydrogen-powered trucks, sustainable aviation fuelled planes, and ammonia-burning ships that such pledges imply. It is already a huge amount. For reference, global GDP in 2019 was a shade over $87tr.

But if the transition process starts today, then spread over the next 30 years (40 for China) the annual costs drop to more manageable figures - 0.6% of current GDP per year for Japan and Korea, and 1.8% for China.

In case that sounds too comfortable, remember, this is just one part of the transition process for just one sector. We don't consider the costs of upgrading or replacing existing vehicle fleets, provision of charging points, or storage of new fuels within the transport sector or any of the other likely transport-related costs. And we don't include the bigger and more complicated industrial and household sectors either. Reaching whole-economy net-zero carbon over the pledged timescales will very likely cost multiples of the $12.4tr we have highlighted.

Sector differences

The different forms of transport that will play a part in a net-zero carbon future offer very different opportunities and costs.

Road transport offers one of the easiest and cheapest areas for the transition to net-zero. Battery electric vehicle (BEV) technology is already well advanced. Battery storage capacity and vehicle range are being continuously extended, while costs are steadily falling. Compared to internal combustion engine vehicles (ICE) or hybrids, battery electric vehicles are considerably more efficient, so total fleet replacement implies a relatively small adjustment in terms of the additional electricity generating capacity that will be required.

Hydrogen fuel cell electric vehicles (FCEVs) offer some of the same advantages as BEV's, but as generating hydrogen will likely require the generation of green electricity, the additional and energy-consuming steps to then create, liquefy and transport hydrogen seem a bit pointless. We think there may be some role for FCEVs in longer haul vehicles. And hydrogen seems to have a stronger role to play elsewhere, such as shipping, and off-grid storage and supply. But perhaps governments are overhyping its role?

Rail: There isn't much to be done here. Most rail is already electrified in the region. We would caution against assuming that widescale adoption of bullet-train formats will provide much additional benefit unless it can draw demand from other less carbon-friendly modes of transport such as aviation. This is already one of the most energy-efficient forms of transport per kilometre. There may be fewer efficiency gains to be found from future rail innovations than elsewhere as it is already a thoroughly mature technology.

Aviation: Though perhaps not as tricky as marine, aviation offers few obvious answers. We are sceptical of the future for battery-powered or hydrogen-fuelled planes. Though there may be some marginal adoption of these technologies. Sustainable aviation fuel (SAF) seems to offer more promise, though would require some offsetting carbon capture or mitigation efforts to be truly carbon neutral.

Marine: This is the transport sector which seems to create the most controversy. Part of the industry sees the future in LNG, though this is still a fossil fuel and there is growing concern over "methane slippage" which we believe may grow. A truly net-zero carbon alternative is difficult to envisage. Batteries and hydrogen sound impractical. Consequently, ammonia or ammonia/hydrogen hybrid engines may offer one plausible version of the future that doesn't require huge scale carbon capture and storage. But ammonia creation is energy-intensive, its combustion even in hydrogen hybrid engines is not very efficient, and as a result, it tends to have some of the largest implications for electricity generation cost of all the sectors we consider.

Key findings for China

The headline figure for China from our analysis is $11tr, or 1.8% of GDP per year through to 2060.

China is the world's largest emitter of carbon dioxide, and its emissions are not expected to peak until 2030. In part, this reflects China's economy, which we expect will continue to grow rapidly, resulting in greater future demand for transport and consequently greater adjustment costs than either Japan or South Korea.

China is aiming for a net-zero carbon economy by 2060, unlike 2050 for Japan and South Korea; still a challenging goal.

Within the transport sector, China has already made a lot of progress, with the world's largest fleet of electric vehicles. But the economy as a whole is still heavily reliant on fossil fuels.

Passenger road transport: Passenger car transport in China will more than double from 220 million vehicles to 450 million by 2050 according to official estimates. Thanks to the greater energy efficiency of battery electric vehicles (BEVs) compared to internal combustion engines (ICEs), this will only require an electrical energy supply of about 79,500 GWh.

Rail: China's rail usage is likely to increase to around 4 trillion passenger-km in 2060 from 1.415

trillion in 2018. We find that an additional 344GW of capacity will be needed to supply a fully electrified rail system at a cost of US$2.9tr, equivalent to 0.49% of GDP in 2020 terms each year over 40 years.

Aviation: Most of the recent growth in aviation in China comes from passenger travel, which official sources expect to grow 5.4% p.a. for 20 years from 2018, China expects that most jet fuel will still be fossil fuel by 2050. Even if China adopts large-scale use of sustainable aviation fuel, net-zero carbon will likely require a carbon capture offset or other mitigation efforts.

Marine: Official sources predict demand for sea freight in China will be around 120% that of today's levels by 2060. This could be reduced by China's own standardised technical specifications for green designs for ships, but that won't achieve net-zero without carbon capture or other mitigation, both of which may have electricity generating capacity implications. Achieving net-zero carbon points to a much bigger role for hydrogen technology, perhaps most plausibly in the form of ammonia or ammonia-hydrogen hybrids.

Key findings for Japan

We estimate the electricity-generating transformation costs for Japan's transport sector are around $1tr, or about 0.6pp of GDP per year.

Japan aims to be net-zero carbon by 2050. Japan has made little progress in terms of decarbonising its economy and fossil fuels make up more than two-thirds of its primary energy supply. Yet this unflattering starting point also means that Japan has a lot of low-hanging fruit to exploit in the transition process offering the prospect of rapid progress.

Passenger transport: 98% of the Japanese road passenger vehicle fleet is conventional or hybrid. So a net zero-carbon economy will require the replacement of almost the entire fleet. Japan's ageing population and slow GDP growth suggest that by 2050, there will be lower road passenger traffic. Together with efficiency gains from full conversion to BEVs, even accounting for energy losses at charging and distribution to the grid and substations, total energy demand from passenger vehicles in 2050 could be as low as 70-75,000GWh.

Rail: Japan's rail accounts for 29% of their current passenger transport energy consumption, which is very high for an advanced economy. And 85% of Japan's rail network is already electrified. Full electrification of the remaining network will not lead to much additional electricity generating cost compared to other sectors.

Aviation: To manufacture a "sustainable" alternative to the 10.4 billion litres of aviation fuel Japan used in 2019 would require an additional 62GW of capacity at $168bn, assuming that demand eventually crept back to 2019 levels and allowing for some further efficiency gains. Though to make this truly carbon neutral will likely result in additional mitigation or carbon capture costs.

Marine: Assuming an ammonia-based future for Japan's marine industry, we calculate that the additional electricity generating capacity costs required to create green ammonia even if used in the most efficient hybrid hydrogen-enhanced engines would require an additional 216GW of capacity at the cost of about $588bn. Efficiency gains to this new technology may reduce these costs over time.

Key findings for South Korea

We estimate that transforming Korea's transport sector would imply additional sustainable electricity generating costs of around $400bn, or 0.6pp GDP per year.

South Korea's primary energy demand is heavily reliant on fossil fuels, with petroleum and other liquids accounting for 43% of all energy consumption, and coal 28%. Nuclear fuel accounts for around 10%, and renewables only 3%.

Passenger transport: Our projections show a substantial rise in Korean road transport over time, though this begins to top out around 2040. Most of the increase is due to private road-passenger traffic.

Rail: President Moon has already pledged to replace all existing diesel passenger trains with electric bullet trains by 2030. The Korean government claims that this will reduce carbon emissions from rail transport by around 30%. At present, 85% of Korea's rail network is electrified. So a claim of a 30% reduction of carbon emissions already looks ambitious. To meet net-zero targets for this sector without relying on carbon capture or mitigation efforts, it would really need to reduce carbon emissions by 100%.

Aviation: Air transport accounts for about 12% of total Korean transport energy consumption and compared to China and Japan is much more evenly split between cargo and passenger traffic (60% passenger-km and 40% freight tonnage). 95% of Korea's aviation passenger-transport and 99% of its aviation freight transport is international. Our aviation cost calculations are based on domestic aviation moving entirely to rail and road transport, which will require future policy changes.

Marine: To generate Korea's current maritime energy usage entirely using green energy, assuming as elsewhere a hybrid ammonia combustion/hydrogen gas engine, would need about 28bn litres of ammonia. Making this amount of ammonia and hydrogen would take about 166,000 GWh of energy, assuming the process becomes more efficient by 2050. This would require an additional electricity generating capacity of about 44GW at a total cost of about $109b or $3.6bn per year.

Lessons and thoughts for the future

Undertaking this analysis has helped to highlight the gulf between the net-zero carbon goals and the paths set out to achieve those goals, as outlined by official plans in the three countries we have examined.

However, the government blueprints we have used to guide our calculations should only be considered as "work in progress". Considerable further effort will likely be needed in areas such as the interlinkages between hydrogen, nuclear, renewables, carbon capture and storage and the different and overlapping roles that each will play.

For such a massive endeavour, it is totally understandable that these official publications are not the last word on this subject. But we hope that our research will, in some small way, help to shape discussions on the next steps that will be needed in more consistent and internally coherent plans for the future.

There are many conclusions one can draw from this work. But perhaps the three broadest and most obvious are:

1. **The scale of the whole-economy transition is going to be absolutely huge - no numbers are required**
2. **Most governments have barely got going**
3. **If time is not wasted now (the clock is ticking), this is still a manageable prospect**

The prospects for growth in sustainable finance to achieve net-zero carbon goals know almost no bounds. And this part of the financial industry is likely to grow not just in scale, but will likely evolve new and ever more innovative ways in helping these goals to be achieved.

Finally, in terms of the macroeconomy, some will see our cost figures as immensely depressing. But it's worth remembering that all of this spending is going to show up as GDP. There will of course be considerable disruption to existing industries, and large cost increases and job losses for many.

But there is also the possibility that this process can help reinvigorate stagnating economies. Today, as well as climate change, we also worry about global excess savings, secular stagnation and productivity declines. These concerns are unlikely to prosper in a world where such huge sums are being invested in a net-zero carbon future.

You can download the full report here.

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