Article

Pragmatism Versus Idealism in Building Sustainable Decarbonization

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Abstract

In late 2021, the global community appeared committed to accelerating net-zero decarbonization, primarily through solar power, wind farms and electric vehicles. The dominant idealistic narrative held that these power generation and storage technologies offered cheaper and cleaner electricity and mobility, and that only political will stood in the way. Yet less than half a year later, the idealistic narrative has foundered in the face of hard evidence that raw-material costs are rising, energy security is imperative, and broader decarbonization portfolios are necessary. This paper investigates the shift from idealistic to pragmatic narratives and practice, and situates the Japan and ASEAN transition-finance approach within the latter.

Introduction

"If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them."

Henry David Thoreau[1)]

In 2020-21, ambitious commitments to net-zero decarbonization by 2050 increased to over 120 countries,[2)] as green idealism captured the commanding heights of geopolitical discourse. Many countries even started to compete on aggressive mid-term targets, such as achieving net-zero in electricity by 2030 or 2035. High-level academic and other initiatives

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1) Henry David Thoreau, *Walden and On the Duty of Civil Disobedience,* 1854 (first publication) : https://www.gutenberg.org/files/205/205-h/205-h.htm

2) Cited in "Net-Zero Emissions by 2050," Government of Canada, May 19, 2022: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

insisted that the fossil-fuel age was ending, and that further investment would become "stranded assets."[3)]

But from the fall of 2021, hard questions emerged about how to implement the net-zero ambitions, particularly in the context of rising inflation, critical mineral constraints, geopolitical tensions, and other issues. Idealists had depicted shifting to solar and wind plus batteries as almost wholly a matter of political will.[4)] But closer inspection showed that decarbonization is actually an unprecedented material challenge stretching over decades, across all global regions, and encompassing all economic sectors.[5)]

Then in February of 2022, Russia invaded Ukraine. Europe's high dependence on Russian natural gas and other fossil fuels imperiled its strategy of decarbonizing the power sector and had severe knock-on effects on global energy markets.[6)] The war quickly added energy security to the already complicated task of coping with climate change while keeping the lights on. And it turned out that the idealistic narrative had overlooked the challenge of energy security.

Craig Golinowski, managing partner at Carbon Infrastructure Partners, summed up the shock thus:

> "The anti-fossil fuel movement (broadly embraced by governments, pension funds, and banks) have subscribed to a deeply flawed argument that reduced supply (and resultant higher price) of fossil fuel energy will force rapid substitution to renewables. In fact, high energy costs are driving massive increases in the cost of renewables because solar panels, wind turbines, and batteries are made from raw materials based on fossil fuels. Higher cost raw materials drive increases in the costs of producing all forms of energy. We are in a self-defeating feedback loop."[7)]

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3) On stranded assets, see "Stranded Assets," Carbon Tracker, August 23, 2017: https://carbontracker.org/terms/stranded-assets/

4) One example is research from Stanford University, cited in Paul Brown, "Renewable energy could power the world by 2050," ONE, April-June, 2022: https://www.onlynaturalenergy.com/renewable-energy-could-power-the-world-by-2050/

5) One of the best analysts on this issue is Vaclav Smil, in for example "Beyond Magical Thinking: Time to Get Real on Climate Change," Yale Environmental 360, May 19, 2022: https://e360.yale.edu/features/beyond-magical-thinking-time-to-get-real-about-climate-change

6) Europe's dilemma is discussed in detail in "A 10-Point Plan to Reduce the European Union's Reliance on Russian Natural Gas," International Energy Agency, March, 2022: https://www.iea.org/reports/a-10-point-plan-to-reduce-the-european-unions-reliance-on-russian-natural-gas

7) Craig Golinowski, "Energy Security = National Security: How the West Needs to Reindustrial-

The higher renewable and battery costs that Golinowski refers to rose to double-digit levels in May 2022, with further cost increases expected in the coming years. Supply-chain problems that had seemed transitory a year before, the consequence of a global pandemic, increasingly became recognized as a structural problem: current and projected material demand among many critical minerals is greatly exceeding supply from existing mining and refining capacity.

Resource-poor Japan is especially vulnerable to energy insecurity, because it has virtually no resources and energy network connections with neighbouring countries. Japan is therefore pursuing a broad portfolio of options to decarbonize while remaining economically viable. Japan has long been derided as a laggard for its unwillingness to abandon incremental and comprehensive decarbonization in favour of the European emphasis on dramatic green ambitions. The evidence suggests that Japan's approach is grounded in far more than simply protecting so-called vested energy interests. The idealistic assertion that only political will stands between the present and a decarbonized future needs to be interrogated. That means Japan's clean-energy collaboration with Asia is important to study.

Like Thoreau's emphasis on melding practicality and ideals, Japan's approach is not an argument against idealism. Quite the contrary, Japan highlights the imperative of building solid foundations for achieving politically and economically sustainable transitions towards the seemingly impossible goal of net-zero.

Green rules get complicated

Figure 1 shows us that at least 26 green taxonomies are in place or under development, particularly in Europe and Asia. The EU's taxonomy is best known, and has been the focus of global attention through being paired with the Green Deal and aggressive climate diplomacy. But the EU taxonomy is in fact one of many. The EU is of course trying to harmonize its green taxonomy with China's, but that is proving to be a difficult process due to wide variations in such rules as those pertaining to social standards.[8)]

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ize, Rethink Energy Policy," *Power*, June 1, 2022: https://www.powermag.com/energy-security-national-security-how-the-west-needs-to-reindustrialize-rethink-energy-policy/

8) See the detailed comparative sections in "Common Ground Taxonomy – Climate Change Mitigation," IPSF Taxonomy Working Group, International Platform on Sustainable Finance, November 4, 2021: https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/

Source: Caminha, 2022.[9)]

Figure 1 The proliferation of green taxonomies

And at present the EU green taxonomy's influence appears to be waning due to internal discord over green nuclear and green gas in addition to the growing clout of Asia. Asia is the locus of 60% of global growth by 2030, 60% of global population, and over half of global emissions. Asia also has a far higher weight of industry than Europe, vastly different resource endowments, and a far younger fleet of coal plant. So its decarbonization pathways are necessarily different from the EU.

Japan and Asia's priorities centre on decarbonization that addresses the specifics of Asia. One major initiative to this end is the Japan and ASEAN countries' collaboration in the Asia Transition Finance Group.[10)] This collaboration seeks to harmonize regional green taxonomies, and its final report is expected in October of 2022. The collaboration seeks to build the foundations of an environmentally and socially sustainable energy transition consistent with climate science and the Paris goals while also assuring security of energy supply and af-

documents/211104-ipsf-common-ground-taxonomy-instruction-report-2021_en.pdf

9) Mariana Caminha, "New report: Global Green Taxonomy Development, Alignment, and Implementation," Climate Bonds Initiative, March 15, 2022: https://www.climatebonds.net/2022/03/new-report-global-green-taxonomy-development-alignment-and-implementation

10) See the overview at "Asia Transition Finance," AGGPM Public Private Forum, April 25, 2022: https://www.meti.go.jp/press/2022/04/20220425001/20220425001-3.pdf

fordability. This Japan-led cooperation to harmonize green taxonomies from the bottom up includes carbon-capture, use and storage (CCUS) as a green investment category and a strengthening emphasis on transition finance mechanisms to allocate capital towards very complex and multi-faceted elements of a protracted decarbonization. The influence of Asia on the scope of sustainable finance seems likely to expand further, as Indonesia holds the G20 presidency in 2022 followed by India in 2023.

Pragmatism and energy security

The past year's developments do indeed suggest a strong turn to pragmatism, one that advantages the Japanese and ASEAN approach. For one thing, the powerful and idealistic Euro-American antipathy against nuclear power appears to be crumbling in the face of evidence that nuclear supplies over one quarter of EU power and fully half of US low-carbon power. A flurry of policy changes supporting extant nuclear's extension and new build are evident in EU countries and the US, while the Chinese have deliberately highlighted nuclear as essential to their decarbonization.[11] Additionally, the enthusiasm to divest from fossil fuels is clearly waning, as underinvestment over the past few years has brought price spikes and threatens to weaken public support for climate goals.[12] A further complication is that the rush to variable renewables and electric vehicles has exposed the crisis in supplies of critical minerals. This has led to massive price spikes that have already raised solar, wind and battery costs by double digits. Even more greenflation is baked in, so 2021's loud chorus of claims that green energy will dramatically reduce costs has been replaced by concessions that costs "will be much higher than most realize."[13] And equally profound is the evidence that idealism paid little attention to energy security. Pragmatism now has far more appeal, with all countries scrambling to keep the lights on and the air conditioners running.

The abrupt turn to pragmatism has also drawn attention to the enormity of net-zero's implications. Over 80% of global primary energy is derived from fossil fuels, virtually the

11) Luis Nicolas Jachmann, "Nuclear Energy: Back in the Mix?," Green European Journal, May 27, 2022: https://www.greeneuropeanjournal.eu/nuclear-energy-back-in-the-mix/

12) Schalk Cloete, "Fossil Fuel divestment is premature: instead, enable investment to keep prices low, and tax consumption," energypost.eu, April 12, 2022: https://energypost.eu/fossil-fuel-divestment-is-premature-instead-enable-investment-to-keep-prices-low-and-tax-consumption/

13) Patrick McGarry, "Greenflation Is Leading To Volatility In The Markets," energycentral.com, May 11, 2022: https://energycentral.com/c/um/greenflation-leading-volatility-markets

same level as a decade ago.[14] The idealistic claim that only political will stands in the way of a rapid greening has thus yielded to a more sober assessment of the scale and scope of decarbonization's engineering challenge. Referring to the data on oil's nearly unassailable role in shipping and aviation, petrochemicals and other areas used to be derided as apologetics for the oil majors. But no amount of hectoring can change the fact that demand for fossil-based product remains robust. And non-OECD countries' massive and youthful demographics, coupled with rising incomes, imply demand continuing over decades.

The math of capacity factors

Further complicating idealistic scenarios of a decarbonized world powered by solar and wind is the inconvenient math of capacity and capacity factors. The increasingly gigantic announcements of current and projected solar and wind capacity belie the dismal data on the actual volumes of electricity they can deliver. Since rooftop solar's capacity factor in Europe is a mere 12%, versus 77% for nuclear plant, a gigawatt of installed solar capacity actually generates less than 1/6th the electricity of a gigawatt of nuclear capacity.[15] The difference between capacity and capacity factors is crucial to understanding what it takes to keep the lights on, yet proponents of variable renewable-centered decarbonization routinely ignore it. Indeed, even specialist literature in Japanese often refers to the country's 70 gigawatts of installed solar capacity as equivalent to 70 gigawatts of nuclear plant.

But these inconvenient empirical facts are only the tip of a larger iceberg of system-level issues. Variable renewables like solar and wind deliver their power intermittently, in accordance with fluctuating solar intensity and shifting wind speeds. Yet existing power systems have been built on the basis of large-scale, centralized thermal generation that produces 24/7 baseload power to match the aggregate demand of customers at the other end of the grid. We cannot simply swap out, one to one, intermittent solar and wind for baseload thermal power. Not only are the capacity factors dramatically different, but coping with the variability of intermittent renewables requires very expensive changes to the grid and its

14) See the summary data in "Report: Global fossil fuel use not yet in decline, despite renewable energy pledges," Edie Newsroom, June 16, 2021: https://www.edie.net/report-global-fossil-fuel-use-not-yet-in-decline-despite-renewable-energy-pledges/

15) See the data on p. 5 in Power Statistics and Trends, Eurelectric, December 2015: https://www.eurelectric.org/media/1992/power-statistics-and-trends-the-five-dimentions-of-the-energy-union-lr-2015-030-0641-01-e.pdf

ancillary structures, in addition to getting business and household consumers to undertake significant behavioural changes. Thus inspiring stories about Iceland, Norway, and other countries – whose power mixes are almost wholly renewable – need to be informed by the fact that they achieved it with 24/7 baseload hydro and geothermal,[16] whose development is dependent on geography and geology. As pragmatists are increasingly pointing out, idealists do a disservice to the decarbonization debate by obscuring these facts in idealistic PR promising a quick and cheap transition with intermittent solar and wind.[17]

Critical minerals and greenflation

Another very important item obscured, and often simply denied, by the idealist narrative is the increasingly profound challenges posed by the 30-odd critical minerals, such as copper, lithium, cobalt, rare earths, and so on. Variable renewables and storage batteries are especially dependent on these materials in their construction, and these materials have myriad other applications in military technology, health care systems, robotics, aerospace, digital transformation, and other technologically sophisticated areas. As a rule of thumb, the more sophisticated the device, the greater the density of critical minerals required for building it. These minerals are not about to be exhausted, as most of them have plentiful reserves and resources. Yet developing the mining and refining capacity to produce critical minerals takes many years, including feasibility studies, environmental assessments, infrastructure installation, and other steps. That lengthy lead time for bolstering upstream mining and refining supply contrasts sharply with the mere two years it takes to build a gigafactory at the downstream end of the supply chain. One result is a rapidly expanding gap between lithium supply and demand in the battery space.

On May 18, 2022, the International Energy Agency released the world's most recent and comprehensive study on critical minerals, warning that the mining, refining and other supply chain constraints threaten to drive solar, wind, battery, grid, and other prices even higher into the double digits already evident. They warn that rising critical minerals demand

16) See Jenny Rood and Juliette Victor, "Hydroelectricity in the Nordic countries," Nordics.info, Arhus University, February 25, 2019: https://nordics.info/show/artikel/hydroelectricity

17) See, for example, the arguments of Columbia University's Lucas Toh in "Let's Come Clean: The Renewable Energy Transition Will Be Expensive," State of the Planet, Columbia Climate School, October 26, 2021: https://news.climate.columbia.edu/2021/10/26/lets-come-clean-the-renewable-energy-transition-will-be-expensive/

over the previous 14 months had already led to triple digit price increases for lithium and cobalt. Because of the long lead times for mines, and the minimal prospects for recycling and substitution, the impact of greenflation in variable renewables and electric vehicles is virtually certain to worsen and be protracted as opposed to transitory.[18)]

Compounding these problems is China's domination of the mining and refining space, thanks to its many decades of robust industrial policy concerning critical minerals. China has the patience and deep pockets that could see its dominance actually strengthen in spite of the recent uprush of concern in the EU, North America, and elsewhere to reshore or at least diversify critical mineral supply chains.

Chinese dominance of critical minerals was summed up in a detailed June 4, 2022 *The Globe and Mail* article titled "Squeeze in minerals to hinder ability to meet soaring EV demand, sales target":

> "'China's stranglehold on the supply of these key elements was three decades in the making,' said Lewis Black, chief executive officer of Toronto-based Almonty Industries Inc., a mining company with operations in Spain, Portugal and South Korea, and one of the largest producers of tungsten outside of China. He said China priced materials so low in the 1980s, it drove other mines around the world out of business. It became convenient to buy from China and Russia, countries that were not encumbered by the environmental standards common in Western countries. As a result, China has captured an 'almost unassailable' market share. 'China spent 30 years building this virtual monopoly and they're not going to give it up easily,' Black said."

The article further quoted experts' warning that opening new mining capacity in democracies generally requires many years. Moreover, firms that seek to invest in mining capacity find themselves confronted with myriad environmental regulations, the need for painstaking consultation with environmental organizations and local communities, and other challenges. It also pointed out that mining alone is not enough; it has to be complemented with processing and refining capacity. These latter assets also take years to build and bring on line. The result is that even in a resource-endowed country like Canada, it will take at least a decade to achieve significant increases in local critical mineral supplies.[19)]

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18) Tae-Yoon Kim, "Critical minerals threaten a decades-long trend of cost declines for clean energy technologies," International Energy Agency, May 18, 2022.

19) Douglas Firby, "Squeeze in minerals to hinder ability to meet soaring EV demand, sales targets,"

These facts have long been highlighted by the IEA and other observers. Wood Mackenzie Senior Vice President and Vice Chair of Metals and Mining, Julian Kettle, warned of skewed investment incentives and policy signals on May 23, 2022: "Policymakers and wider society want to accelerate the transition to deliver the Paris climate commitments. Yet the ability and willingness to ensure it happens are lacking. Miners are constrained by investor reticence to sanction faster growth at the expense of dividends, long project lead times and rising above-ground risk. Policymakers are sending the wrong signals, claiming they are open for business and then constraining the development of mining projects that would deliver the metals required. They're not fully on-board on the need for a massive expansion of primary extraction."[20] The issues were succinctly summarized by Canadian mining expert Nelson Bennett on May 24, 2022: "The problem for Canada, the U.S. and Europe, all of which are developing critical minerals strategies, is that no amount of money can buy time. Emissions reductions targets set by numerous governments will require so much copper, cobalt, nickel, lithium and other critical metals for things like electric car batteries and wind turbines that the new mines needed to provide the raw materials probably can't be built in time to meet the targets."[21]

In this bracing context, Japan policymakers are suddenly very worried. Japan figured it had largely resolved its critical mineral issues in the decade since China threatened to shut off exports of rare earths. But Japan's confidence rested on untested assumptions about the power of recycling and substitution. These counter-measures actually take a decade or two to gain traction, since at present net-zero countries are just beginning to install a massive stock of renewables and EVs using current technologies. The emergence of huge price spikes and other dismaying signals so early in the so-called green shift has shaken Japan's confidence. Its lead energy and mineral agencies thus suddenly decided to undertake Japan's first-ever survey of Japan-specific critical mineral needs from June to October.[22] One rea-

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The Globe and Mail, June 4, 2022: https://www.theglobeandmail.com/drive/article-soaring-ev-demand-sales-targets-to-come-up-against-squeeze-in-raw/

20) Julian Kettle, "Could Big Energy and miners join forces to deliver a faster transition?," Wood Mackenzie, May 23, 2022: https://www.woodmac.com/news/opinion/could-big-energy-and-miners-join-forces-to-deliver-a-faster-transition/

21) Nelson Bennett, "Canada's minerals extraction in situation critical," *Mining*, May 24, 2022: https://www.mining.com/canadas-minerals-extraction-in-situation-critical/

22) See (in Japanese) "JOGMEC and others to survey long-term rare metal demand," *Nikkan Kogyo Shimbun*, May 4, 2022: https://www.nikkan.co.jp/articles/view/00635538

Table 1 Materials required to build 1 million EVs (tonnes)

	Copper	Niobium	Lithium	Nikkel	Cobalt
Required materials (For 1 million EVs)	83,000	775	7,150	28,000	11,000
Domestic consumption (Based on METI data)	1,060,000	4,624	7,939	113,000	11,000

Source: *Nikkan Kogyo Shimbun* (based on METI data)[23)]

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son is seen in table 1, which calculates the material required to produce 1 million EVs,[24)] versus Japan's total domestic consumption of the given material.

Japan's abrupt emergence of overt worry seems likely to hasten its aim to join in the global move to seabed mining.[25)] Japanese exploratory initiatives have already found massive resources of rare earths, cobalt, manganese, copper and other critical minerals within the country's huge exclusive economic zone, where it is free to mine without restrictions. One big challenge here is building robust and cost-effective equipment that can withstand deep-sea conditions. Another complication is convincing customers that seabed mining has less ESG impact than its terrestrial counterpart. But Japan is definitely hastening to address its sudden insecurity concerning critical minerals.

Copper as a benchmark

We noted earlier that renewable capacity does not equal output, due to the math of capacity factors. These issues were highlighted by Juan Carlos Jobet, the former Chilean Minister of Energy and Mines and current Dean of the School of Business & Economics at Universidad Adolfo Ibáñez. During a May 13, 2022 Columbia University Center on Global Energy Policy event, Jobet warned that even with ramped-up USD 70 billion extra investment, Chile's share of global output will fall from 28% to below 25% by 2030. Without that investment by 2030, Chile's output likely declines by 40% from current levels, and the global community faces a very dire challenge on securing copper for decarbonization. Jobet ex-

23) See (in Japanese) "JOGMEC and others to survey long-term rare metal demand," *Nikkan Kogyo Shimbun*, May 4, 2022: https://www.nikkan.co.jp/articles/view/00635538

24) As an example of scale, Toyota alone plans to produce 3.5 million EVs by 2030. See Hiroaki Kuwajima, "Japan's Auto Makers Race to Make Up Lost Ground on EVs," Nippon.com, May 13, 2022: https://www.nippon.com/en/in-depth/a08003/

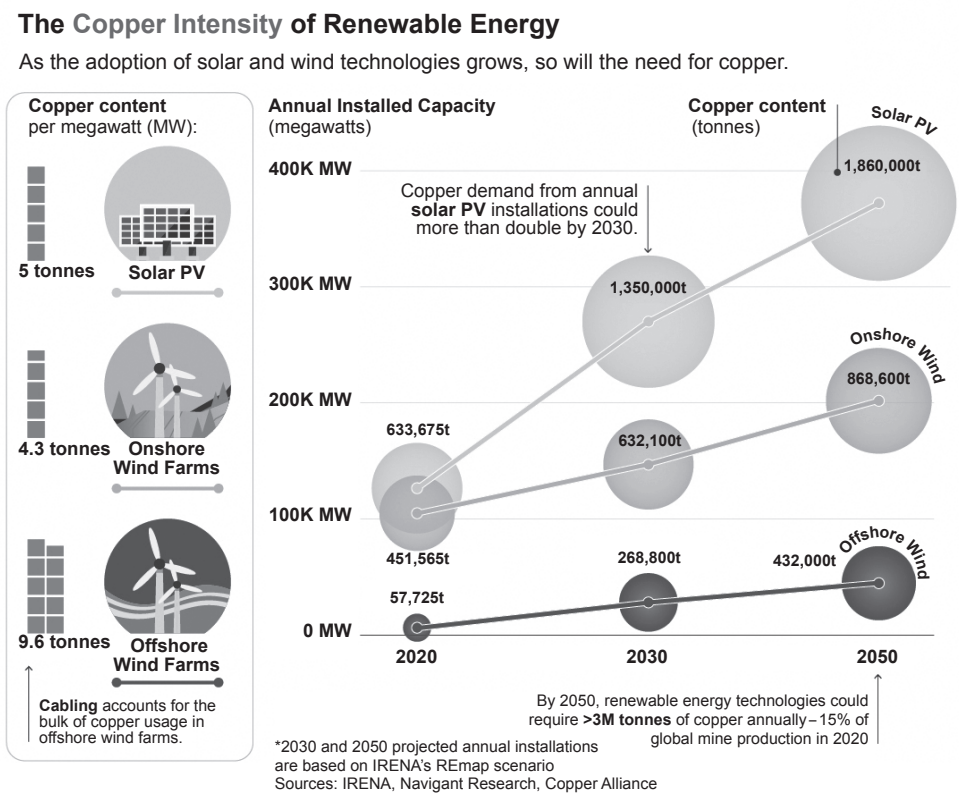
25) Ishita Kapoor, "New Mining Techniques: Exploring the Deep Sea," Center for Social and Economic Progress, June 1, 2022: https://csep.org/blog/new-mining-techniques-exploring-the-deep-sea/

plained the role of copper and capacity factors for intermittent renewables as follows:

> "Take renewable power generation. According to the International Energy Agency (IEA), a solar PV or onshore wind plant requires twice as much copper per megawatt (MW) as a coal or natural gas plant; and offshore wind needs over five times more copper. And that is per MW of capacity, but since coal or gas plants can run up to 24 hours and solar and wind only between six and 14 (and 14 only if you are in the windy Chilean Patagonia), one needs to multiply those numbers by 1.5 to 4 times to get the same amount of available power by unit of copper. Massively deploying renewables will require a lot of copper.
>
> Or take electromobility, the key to reduce emissions in transportation, responsible for 15 to 20 percent of global CO_2: more than twice as much copper is used in an electric vehicle than in a conventional internal combustion engine vehicle.
>
> And if the world is going to use electricity to run its cars, to cook, to heat spaces, it will need a lot of transmission and distribution infrastructure to move the electricity from where the sun shines or the wind blows to homes, offices, and industries. That infrastructure will require a lot of copper too.
>
> The conclusion is simple: It will be a copper-based energy transition, if a transition is to happen at all." [26]

Jobet's arguments about the role of copper are backed up by the evidence. Figure 2 shows us that copper required for solar and wind is measured in tons/MW, and is projected to double between 2020 and 2030 and then almost triple by 2050. The 2020 global capacity for solar is estimated to be about 126.7 GW of capacity representing 633.7 tonnes of copper, based on data from the International Renewable Energy Agency (IRENA) and Navigant Research. This is expected to increase to 372 GW by 2050, resulting in a tripling of copper use in solar to 1.86 million tonnes. But "[t]he largest percentage increase in copper requirements comes from offshore wind farms. IRENA's REmap scenario requires 45,000 MW of annual offshore wind installations in 2050, which translates into 432,000 tonnes of copper – a 648% increase from 2020 levels." The figure includes the concern that copper demand for wind and solar alone in 2050 could represent 15% of the current global output, and it is un-

26) Juan Carlos Jobet, "Q&A | Copper Supply and the Energy Transition," Columbia Center on Global Energy Policy, May 13, 2022: https://www.energypolicy.columbia.edu/research/qa/qa-copper-supply-and-energy-transition



Source: Visual Capitalist, 2021[27)]

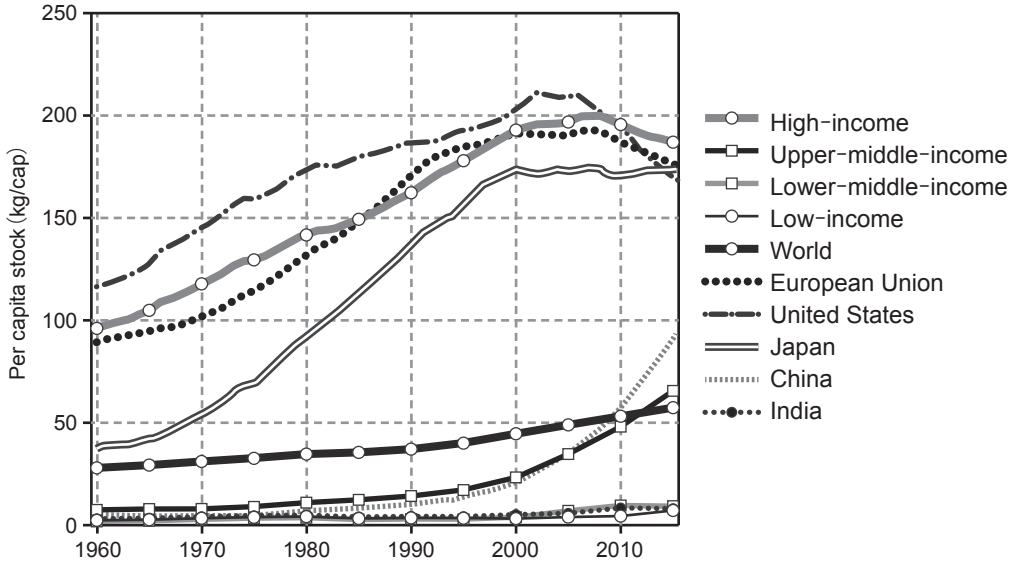
Figure 2 Copper and renewable energy

clear where that supply would come from.

Copper demand and supply for wind and solar are yet to be properly modeled in tandem with other uses. It is important to do so because copper has myriad applications apart from renewables, and its per-capita diffusion in populous and growing developing countries is likely to increase dramatically. As we see in figure 3, a recent study shows that the per-capita stock of copper in high-income countries for 2015 is nearly four times the global average.

One indication of the likely trajectory for other countries is provided by China, whose stock increased from negligible levels in the 1990s to just under 100 kilograms/capita in 2015. Not all countries are likely to reproduce the rapid diffusion. But that is not necessary for copper supplies to become a problem. The upper-income countries' consumption is slated to in-

27) Visual Capitalist, "Visualizing the Copper Intensity of Renewable Energy," May 20, 2021: https://www.visualcapitalist.com/copper-intensity-of-renewable-energy/



Source: Watari, et al, 2022[28]

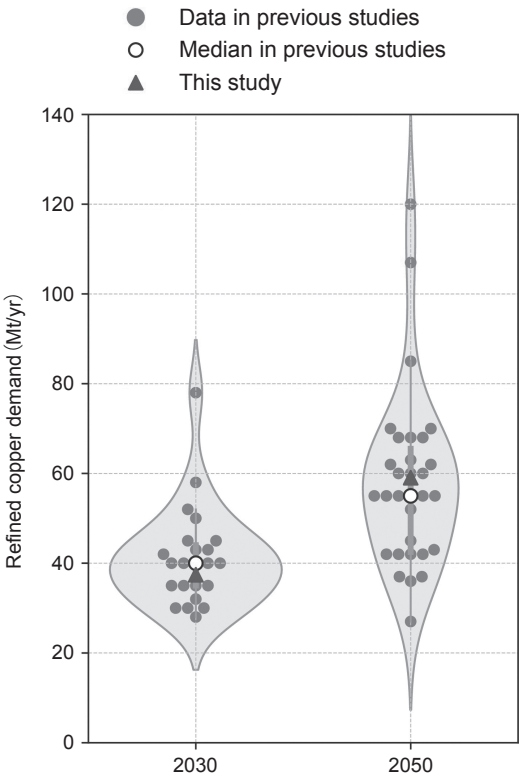
Figure 3 Per-capita copper and income levels

crease due to electrification and digital transformation. At the same time, it seems that most of the rest of the global population is likely to increase its per-capita footprint. Even though that diffusion may be far less than in rich countries, the several billion population of the non-rich world means that even low per-capita numbers lead to massive overall amounts.

Indeed, the assumptions of the recent study include estimating that decarbonization technologies will account for 18% of total copper demand in 2050. That is why the data in figure 4 show that copper demand in 2030 will be just under 40 million tonnes/yr and increase to just under 60 million tonnes/yr by 2050. The study is focused on exploring means to reduce the greenhouse gas emissions from producing so much copper, so overlooks the challenges highlighted by Chile's Juan Carlos Jobet. The study data also indicate that copper demand could dramatically exceed what is assumed, since a lot of previous work has forecast copper demand to be well over 40 million tonnes/yr in 2030.

The study looks to material substitution, efficiency, and recycling, especially rethinking the reliance on copper-intensive electric vehicles. But it seems equally important to ask if there are not additional copper-demand drivers being overlooked, such as in digitalization

28) Takuma Watari, et al, "Global copper cycles and greenhouse gas emissions in a 1.5 ℃ world," *Resources, Conservation and Recycling*, Volume 179, April 2022: https://www.sciencedirect.com/science/article/pii/S0921344921007266



Source: Watari, et al, 2022[29)]

Figure 4 Copper demand estimates, 2030 and 2050

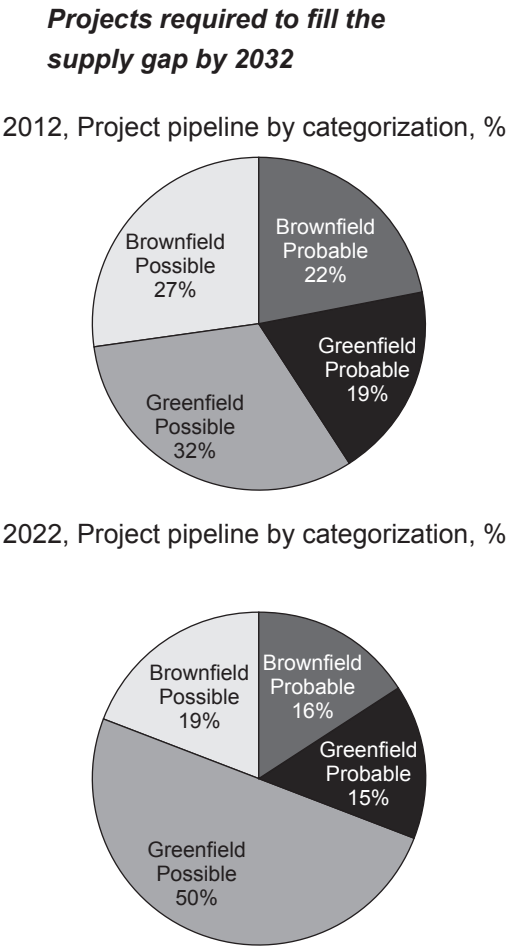
and space. Copper alloys are a very important item for space and aviation,[30)] and current projections for the number of satellites in earth's orbit warn that it could be as many as 100,000 by 2030 (compared to about 3,000 at present).[31)]

As we see in **figure 5**, one of the major problems with copper supply is that projects have increasingly become possible rather than probable. The figure shows that in 2012, 41% of global new greenfield and brownfield capacity was probable as compared with a startling drop to 31% probable in 2022. Analysts warn that this decline in probable projects reflects the extent to which anti-mining ESG sentiments, geopolitics, and other factors are weighing

29) Takuma Watari, et al, "Global copper cycles and greenhouse gas emissions in a 1.5 ℃ world," *Resources, Conservation and Recycling*, Volume 179, April 2022: https://www.sciencedirect.com/science/article/pii/S0921344921007266

30) See the examples at "Space and Aviation," Saglammetal, 2022: https://www.saglammetal.com/en/space-and-aviation

31) Nathaniel Scharping, "The future of satellites lies in the constellations," *Astronomy*, June 30, 2021: https://astronomy.com/news/2021/06/the-future-of-satellites-lies-in-giant-constellations



Source: Els, 2022[32)]

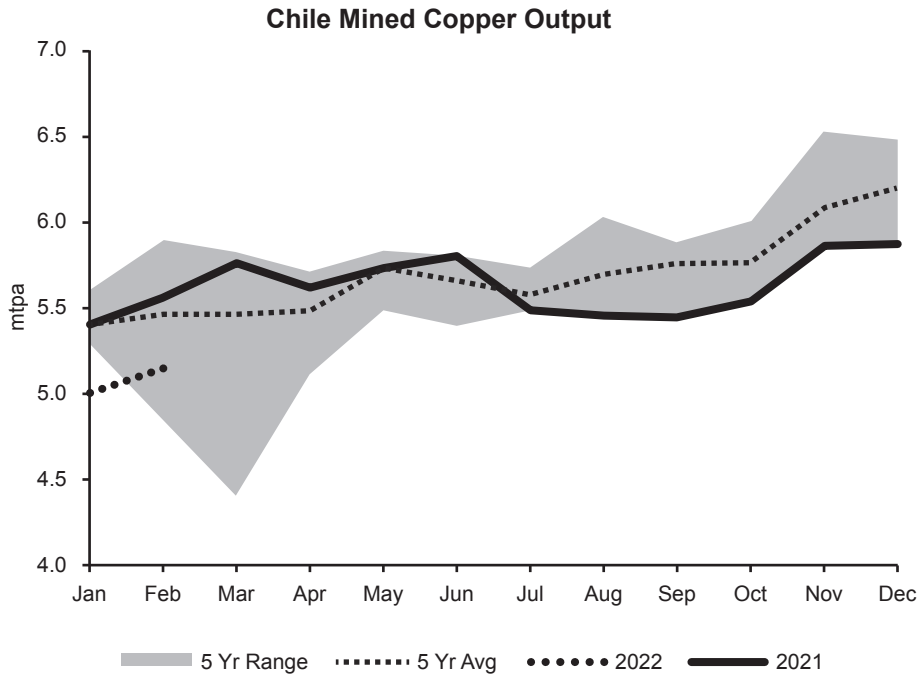
Figure 5 Declining probabilities in copper mining

on investments.[33)]

Figure 6 adds immediacy to the warnings from Chile's Juan Carlos Jobet. The figure shows that Chile's combination of political uncertainty, declining ore grades, aging mines, and other issues has led to declining copper output. Output in latter 2021 fell below the 5-year average. And output in 2022 is even lower. Analysts thus warn that "Chile's crown as the world's largest producer of copper is at risk as the country's output continues to be lower

32) Frik Els, "Copper mining, like politics, is now the art of the possible," Mining, May 4, 2022: https://www.mining.com/copper-mining-like-politics-is-now-the-art-of-the-possible/

33) Cited in Frik Els, "Copper mining, like politics, is now the art of the possible," Mining, May 4, 2022: https://www.mining.com/copper-mining-like-politics-is-now-the-art-of-the-possible/



Source: Cochilco, BMO Capital Markets

Source: Jamasmie, 2022[34]

Figure 6 Declining copper mining in Chile

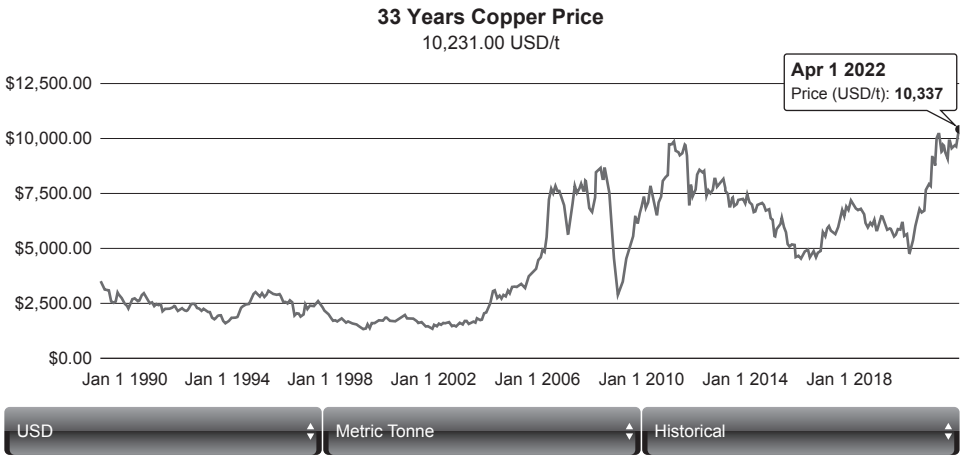
than expected despite the billions of dollars invested in new projects in the past 18 years."[35]

Not surprisingly, the price of copper has risen to historically high levels, as portrayed in figure 7 which shows the price from January 1, 1990 to April 1 of 2022. The price is subject to volatility as estimates of global growth rise and fall in the current uncertain recovery from the COVID-19 pandemic and the impact of the Russian invasion of Ukraine. But there is almost no doubt that copper's price will be underpinned by greenflation driven by decarbonization demand. In addition, there are other factors such as the Chilean government's proposed new royalty "to help finance its ambitious social agenda."[36]

34) Cecilia Jamasmie, "Chile heads towards two 'lost decades' of copper output growth," Mining, April 14, 2022: https://www.mining.com/chile-heads-towards-two-lost-decades-of-copper-output-growth/

35) Cited in Cecilia Jamasmie, "Chile heads towards two 'lost decades' of copper output growth," Mining, April 14, 2022: https://www.mining.com/chile-heads-towards-two-lost-decades-of-copper-output-growth/

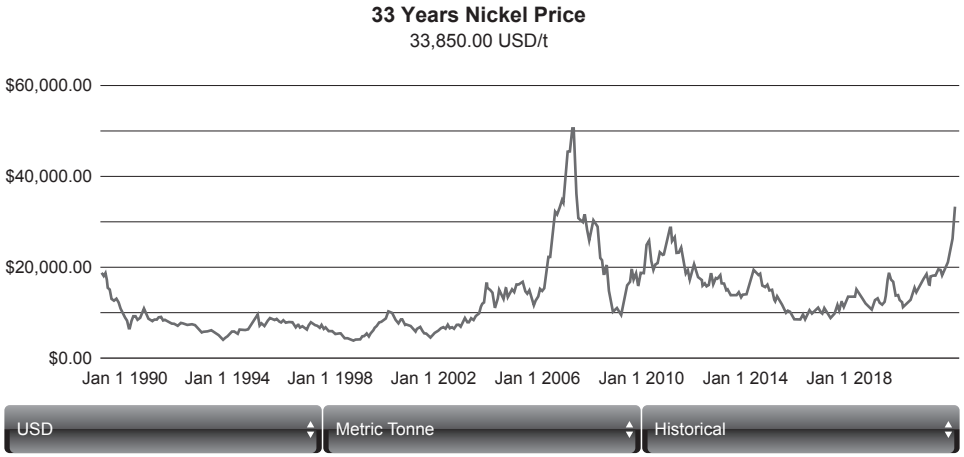
36) Fabián Andrés Cambero and Isabel Woodford, "Chile government to consider copper producers' cost variations in new royalty bill," *Reuters*, June 10, 2022: https://jp.reuters.com/article/chile-



Source: Mining.com[37]

Figure 7 Copper price 1990-2022, USD/ton

Yet copper is only one of the important critical minerals for decarbonization. Nickel is another crucial metal, especially in battery storage, a growing demand pull on its traditional role in stainless steel. Figure 8 shows that nickel's price has yet to spike over the peak it reached just before the 2008-2009 global financial crisis. But it is clearly on an accelerating



Source: Mining.com[38]

Figure 8 Nickel price 1990-2022, USD/ton

copper-royalties/chile-government-to-consider-copper-producers-cost-variations-in-new-royalty-bill-official-idUSL6N2XX0AP

37) All critical mineral prices are available at Mining.com: https://www.mining.com/commodity/

38) All critical mineral prices are available at Mining.com: https://www.mining.com

trend, as of April 2022. The outlook in May of 2022 was for further increases in demand: "Primary nickel demand is expected to grow 11% year on year to 3.17 million mt as stainless steel output is set to climb 9%. The ever-growing nickel intake in batteries may jump 27% on the year."[39] Outlooks for supply suggested a surplus. But a lot of the material may be of inadequate quality to use in energy projects.

Aluminum is an additional critical mineral that is key for renewable energy projects and myriad other areas of decarbonization. Figure 9 shows that its price escalation has led to historically high prices. These prices are also somewhat volatile due to uncertainties about global economic recovery. However, green demand is expected to underpin prices.

Source: Mining.com[40]

Figure 9 Aluminum price 1990-2022, USD/ton

Generally overlooked in the focus on lithium and rare earths are such seemingly prosaic critical minerals as tin. But as we see in figure 10, the price of tin has recently greatly exceeded its historic highs. Tin is – so to speak – the "glue" of electronics and other devices key to decarbonization and digitalization, as it is the essential solder in their manufacture. The supply is increasing, but not at a pace to match demand.[41]

39) Ekaterina Bouckley, "Nickel market to swing to mild surplus persisting beyond 2022: Nornickel," S&P Global, May 24, 2022: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/052422-nickel-market-to-swing-to-mild-surplus-persisting-beyond-2022-nornickel

40) All critical mineral prices are available at Mining.com: https://www.mining.com

41) Andy Home, "Column: Tin still flying high despite resurgent production," *Reuters*, April 21, 2022: https://www.reuters.com/markets/commodities/tin-still-flying-high-despite-resurgent-produc

Source: Mining.com [42]

Figure 10 Tin price 1990-2022, USD/ton

Source: Mining.com [43]

Figure 11 Zinc price 1990-2022, USD/ton

Zinc is yet another overlooked critical mineral. But figure 11 shows that its price is reaching historic highs. Recent reports on zinc warn that it is not getting the investment attention it requires: "In some quarters, zinc is considered the secret base metal that is critical to reaching net-zero carbon emission targets. But recent zinc inventories have dropped dramatically.

The essential metal is used to make more efficient solar panels and smaller and lighter

tion-2022-04-20/

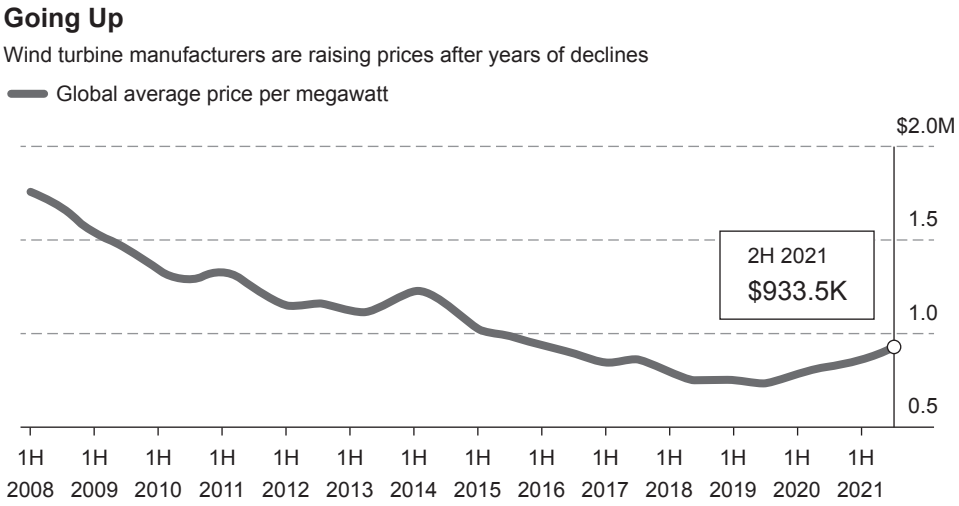
42), 43) All critical mineral prices are available at Mining.com: https://www.mining.com

batteries, which is causing demand to increase while simultaneously the supply chain is getting crunched. Demand for zinc is expected to triple by 2030 as net-zero targets come into effect." [44)]

Increasing renewable prices and risks of a green bubble

As critical mineral prices climb, the costs of decarbonization via solar, wind and batteries is increasing. One example of this is evident in figure 12, which portrays 2008-2021 prices for wind power. The data show that the long decline in the global average price per megawatt (USD/MW) bottomed out in 2019 and then began to rise. By the second half of 2021, prices were at their highest level since 2015.

The undue focus on solar, wind and batteries has also led to serious concern at the Bank for International Settlements (BIS). BIS leaders warned on June 8, 2022 that over-



Source: BloombergNEF

Source: Mathis, et al, 2022 [45)]

Figure 12 Increasing wind power prices (USD/MW)

44) Colin Sandell-Hay, "Potential Zinc Shortage Raising Global Concerns for Critical Mineral," The Assay, May 27, 2022: https://www.theassay.com/articles/feature-story/potential-zinc-shortage-raising-global-concerns-for-critical-mineral/

45) Will Mathis, Ryan Beene, and Josh Saul, "Wind Power's 'Colossal Market Failure' Threatens Climate Fight," *Bloomberg News*, April 25, 2022: https://www.bloomberg.com/news/articles/2022-04-25/wind-power-s-colossal-market-failure-threatens-climate-fight

investment in fossil fuels and other "brown" assets is complemented by risks from assets that purport to be "green." They describe the latter as posing a systemic risk due to an overestimation of the speed of decarbonization.[46)]

The turn to pragmatism

Going "green" means different things to governments and businesses around the world. The latest policy developments in Japan confirm that it and its Southeast Asian allies' vision of energy transition pathways diverge markedly from those animating Brussels, London and Washington.

Japan set the scene with a new international platform. On April 25, 2022, Tokyo hosted the first Asia Green Growth Partnership Ministerial Meeting (AGGPM) Public-Private Forum.[47)] The event included speeches from energy-related officials from the 10 member states of the Association of South East Asian Nations (ASEAN), as well as Japan. It also featured announcements of ambitious business partnerships between Japanese and ASEAN companies in the fields of carbon capture and storage, ammonia, hydrogen and renewable energy.

But possibly the most impactful aspect of the Forum was that it served as the launch event of the Asian Transition Finance Study Group's (ATFSG) mid-term report on transition pathways. This grouping of Asian and global commercial banks is far more than yet another industry initiative. Led by Japan's biggest financial player, MUFG, the Group is strongly backed by Japanese government agencies and has direct input from key stakeholders in the ASEAN. That includes the ASEAN Taxonomy Board and the Sustainable Finance Institute Asia.[48)]

The Group's report, which is due to be followed up with a final version in October, is essentially an outline of decarbonization strategies for Asia. Japan and its ASEAN partners make it clear that they seek pragmatic and appropriate solutions for their region while also respecting global climate goals reflected in the Paris Agreement.

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46) See Claudio Borio, Stijn Claessens and Nikola Tarashev, "Finance and climate change risk: managing expectations," Bank of International Settlements speech, June 8, 2022: https://www.bis.org/speeches/sp220607.htm

47) On the details, see Japan METI's website: https://www.meti.go.jp/english/press/2022/0425_001.html

48) The membership is detailed in "Asia Transition Finance," AGGPM Public Private Forum, April 25, 2022: https://www.meti.go.jp/press/2022/04/20220425001/20220425001-3.pdf

What the report represents

Global warming is accelerating, and the World Meteorological Association warns we have a 50% risk of breaching 1.5 degrees within the next 5 years.[49] Asia will powerfully shape what happens in those years and beyond, as it represents 60% of the global population, over half of all emissions, and 60% of global growth through to 2030.[50]

Despite these big numbers, most countries in Asia have not set out specific decarbonization pathways, in contrast with the EU. Yet even the EU's net-zero pathways are already complicated by pitfalls and potholes, as evinced by the crisis concerning Russia.

So the ATFSG's work seems crucial. The ATFSG report explicitly points to the EU's much higher level of economic development than Asia and dramatically different resource endowments. The ATFSG is committed to building on the European experience, but melds questions of sustainability with an emphasis on energy security, reliability of supply, and affordability. The result, judging by the mid-term report, will be decarbonization roadmaps quite unlike Europe's.

Terms of Investment

Another reason the ATFSG cannot be ignored is its work on a regional green taxonomy. A taxonomy is essentially a rulebook to guide investments toward technologies that are deemed in line with climate goals, or simply "green".

To some, this effort might seem superfluous, since the EU has already drafted such a green taxonomy. The EU taxonomy's scope extends from climate mitigation and adaptation, through to the circular economy, and on into protecting and restoring biodiversity and ecosystems. For many, the EU's taxonomy seemed on the cusp of becoming the essential manual for decarbonization. But the EU taxonomy is now under critical scrutiny after European Commission pragmatists added nuclear and low-emissions natural gas to the "green" list,

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49) "WMO update: 50 : 50 chance of global temperature temporarily reaching 1.5 ℃ threshold in next five years," World Meteorological Organization, May 9, 2022: https://public.wmo.int/en/media/press-release/wmo-update-5050-chance-of-global-temperature-temporarily-reaching-15°c-threshold

50) See "Key Indicators for Asia and the Pacific 2021," Asian Development Bank, August 4, 2021: https://www.adb.org/sites/default/files/publication/720461/ki2021.pdf

provoking fierce opposition that portends a very hot summer in the European Parliament.

Whichever way the EU's internal debate concludes, Japan has been concerned that Europe's taxonomy rules and related regulation do not fit the realities in Asia. Asian partners generally agree that allowing EU definitions of green to become the global standard would hinder Asia's ability to develop economically. Japanese policymakers have built on this sentiment and institutionalized work towards creating a taxonomy specific to Asia.

Japan's initiative is not as rebellious as it sounds. After all, we saw in figure 1 that the EU's taxonomy was only one of at least 26 in place or under development as of March 2022, according to Climate Bonds. Each taxonomy contains its own details on defining sustainable investment across the power, transport, mining and other sectors.

Many green taxonomies

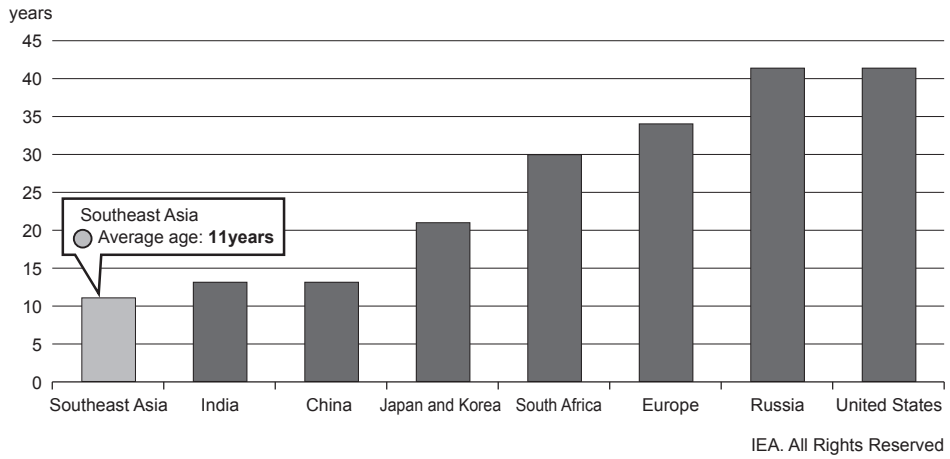
Among the proliferating taxonomies, there are also attempts at harmonization. We saw earlier that the EU and China seek to synchronize their respective approaches through a Common Ground Taxonomy. This initiative is complicated by quite dissimilar rules, such as those regarding social standards, not to mention China's inclusion of nuclear but exclusion of gas.

For the Japan-led ATFSG, similar challenges abound in trying to marry various national interests and characteristics. Still, there are areas where the region already shows wide agreement. In the emerging ASEAN+Japan taxonomy, carbon-capture is deemed a "green" investment. The reason is clear in light of the fact that a large fleet of comparatively new coal-fired power plants generates almost half of the Asia-Pacific's electricity.

The regional average age of a coal plant in Asia is under 15 years, compared to the 30-40 year ages of coal plant in the EU and US, according to the International Energy Agency (IEA), which regards carbon capture as an essential technology for achieving climate goals (figure 13).

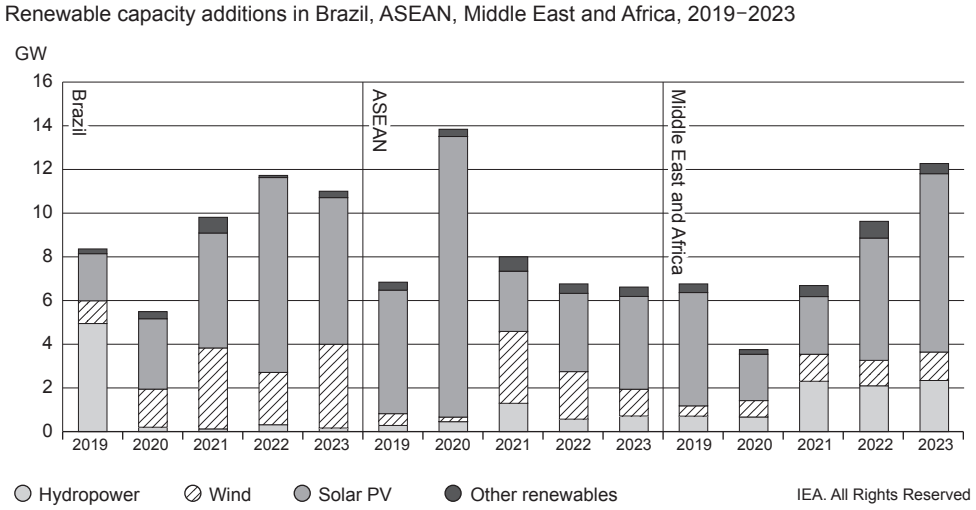
The IEA's research on Asian countries shows that the region is unlikely to retire those coal-fired assets for at least a couple of decades. The capital costs are far from being recovered and industry-heavy Asia needs ample 24/7 baseload power. Thus, incentivizing carbon-capture to cope with coal is deemed a regional imperative.

The standard counter-argument to carbon capture is that it is unfeasible and that Asian countries should simply deploy more wind, solar and other renewables. Yet that assertion overlooks not only the hard fact of Asia's very young coal plant but also the most recent



Source: IEA, 2021[51)]

Figure 13 Average age of coal plant, by region



Source: IEA, 2022[52)]

Figure 14 Renewable capacity additions, by region, 2019–2023

outlook for renewables. As figure 14 shows, the May 2022 IEA Renewable Energy Market Update projects that ASEAN installation of renewables will plunge from a peak of about 14

51) See "Average age of existing coal power plants in selected regions in 2020," International Energy Agency, October 8, 2021: https://www.iea.org/data-and-statistics/charts/average-age-of-existing-coal-power-plants-in-selected-regions-in-2020

52) Renewable Energy Market Update, International Energy Agency, May, 2022: https://www.iea.org/reports/renewable-energy-market-update-may-2022

GW in 2020 to below 7 GW in 2022 and 2023. The IEA report also points to elevated material costs and interest rates as potentially posing significant challenges in the years ahead.

In short, the evidence on critical minerals, extant assets, growth requirements, and other indices all suggest that Asia needs a broad portfolio of decarbonization technologies. It cannot look to intermittent renewables as the major energy source, in contrast to the EU.

More diversity is always better?

As suggested earlier, there is a downside to the proliferation of taxonomies. As decarbonization prices rise due to commodity costs and interest rates, multiple taxonomies mean investors face extra costs due to onerous reporting requirements. Yet the ATFSG's ASEAN+Japan initiative – together with other regional efforts – indicates that harmonization is being built from the bottom-up, reflecting necessarily diverse routes to decarbonization.

The scope for overall harmonization of these regional initiatives exists in the International Platform on Sustainable Finance (IPSF), under whose auspices the China and EU taxonomies are being harmonized. The IPSF was indeed established in 2019 to achieve this overall goal of coordination. At present, it includes Japan, the EU, China, India, Indonesia, and other governments representing half the global population and 55% of both global GDP and global emissions.[53)]

Moreover, geopolitical inclusiveness and diversity are on the ascendant in policymaking within the IPSF. In 2022, Japan, the EU, and Switzerland began co-leading an IPSF working group on transition finance, with no announced end-date. Its agenda includes drafting recommendations for the G20 Sustainable Finance Working Group that meets in Jakarta next month under the Indonesian G20 presidency. The next year, 2023, sees India assume the G20 presidency. This "duplex of Asian G20 presidencies"[54)] is likely to drive Asian priorities into the work of harmonizing taxonomies and defining sustainability.

This diversity of institutions and technologies, if managed well, could increase the global buy-in for decarbonization through broader stakeholder consultation and R&D investment. The patent risk of watering-down decarbonization goals seems at least balanced by an

53) The membership and other relevant items are detailed at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/international-platform-sustainable-finance_en

54) See Akshay Mathur, "G20 returns to Asia," Observer Research Foundation Raisina Debates, October 30, 2021: https://www.orfonline.org/expert-speak/g20-returns-to-asia/

expanding portfolio of financial tools and targets. Indeed, green bonds are already complemented by sustainable bonds, transition bonds, and other instruments to foster the multi-decadal, capital-intensive nature of decarbonization processes.

In short, the old policymaking adage of "never let the perfect be the enemy of the good" surely applies to the sausage-making at work in making inclusive green taxonomies.

Conclusion

We have seen that the idealistic narrative of green has foundered in the face of hard evidence that raw-material costs are rising, energy security is imperative, and broader decarbonization portfolios are necessary. A pragmatic appreciation of the scope and scale of decarbonization has emerged. Moreover, defining green has gone from being dominated by Eurocentric ideals to a diverse global debate, which the ATFSG epitomizes. Asian influence over ESG rules and green taxonomies is likely to increase because of the region's growing confidence and economic weight. By contrast, the EU is hobbled by internal disagreements over nuclear and natural gas. A more Asian definition of green seems likely to reduce the risk of a green bubble in the critical minerals sector, driven by over-reliance on intermittent renewables. It may also increase support for multi-decadal energy transitions, and offers the exciting prospect of truly radical decarbonization innovations from the region.