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The Japan Renewable Energy Institute's "Proposal for the 2030 Energy Mix"

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Introduction

On August 6, 2020 Japan's Renewable Energy Institute (REI) released a lengthy and ambitious "Proposals for the 2030 Energy Mix" (REI, 2020). The REI proposals are aimed Japan's strategic energy policy, currently under review. The proposals centre on the power sector, perhaps the most crucial element of any "green recovery" from Covid-19's massive economic impacts. The REI surveys Japan's electricity system and outlines a "sustainable electricity generation mix" consistent with what the REI views as Japan's principal challenges in the context of global energy trends and climate policy. In the REI's estimation, Japan could and should achieve a dramatic revamp of its power mix by 2030. The REI argue that more aggressive policy could allow Japan – in a decade - to attain a 45% share of renewable electricity generation (tripling solar and octupling wind). Over the same period, this massive and rapid expansion of renewable power would be backed up by a huge increase in power generation from natural gas. In tandem, both nuclear power and coal-fired generation would be completely eliminated from the power mix. If achieved, this would rank among the world's most far-reaching renewable energy programs.

The REI proposals are the most ambitious renewable-energy roadmap ever advanced by one of Japan's top energy think tanks, and thus certainly merit review. Hence this brief paper outlines the REI proposals and their context. We then ask whether the proposals are a credible and cost-effective route towards the imperative of decarbonization. Drawing on research from the International Renewable Energy Association, the Japanese PV Association, and other agencies, we conclude that the proposals are impaired by numerous unstated assumptions and omissions. A conspicuous problem is the emphasis on eliminating low-carbon nuclear, even though virtually all decarbonization scenarios maintain a role for nuclear energy (World Energy Council, 2019; IRENA, 2018). Another area of concern is the REI's failure to confront critical material logistics, in spite of their prominence in Japanese, EU, and other clean-energy industrial policies. We therefore suggest the proposal needs to be rethought, with a broader portfolio of renewables and less gas.

The REI and its Proposal

Japan's Renewable Energy Institute (REI) is a key stakeholder in the post-Fukushima energy debate. The REI was established on August 12 of 2011, specifically to promote renewable energy, by Softbank CEO Son Masayoshi, who remains its chairperson. The REI includes a globally active network of directors and advisors, and advances renewable energy via research and collaborative action. Since its founding the REI has undertaken numerous international conferences, published multiple studies and policy papers, maintained ongoing research initiatives, and offered policy advice at all levels of government. It has undertaken very detailed and informative analyses of Japanese power markets, the "Asia Super

Grid," and related matters. And among Japanese energy-related think tanks, it is notable for producing an abundance of high-quality work in both Japanese and English.

As noted in the introduction, the REI "Proposals for the 2030 Energy Mix" (hereafter "REI 2030") was released on August 6. At present, REI 2030 is only available in Japanese, but appears to be under translation for a September release in English. The August release coincides with ongoing high-level discussions on Japan's next Strategic Energy Plan. At just under 100 pages, REI 2030 is much more than a quick set of recommendations. It builds on the REI's considerable outreach and activism concerning a green recovery from the Covid-19 crisis, and addresses the global debate to a significant extent. REI 2030 is divided into 5 separate sections, with a very professional use of well-designed, reader-friendly graphics in addition to extensive but unobtrusive footnoting of assertions on prices and other relevant matters. In short, REI 2030 is a serious study of Japan's energy issues in light of global trends and challenges, and clearly aimed at influencing debate on the next Strategic Energy Plan.

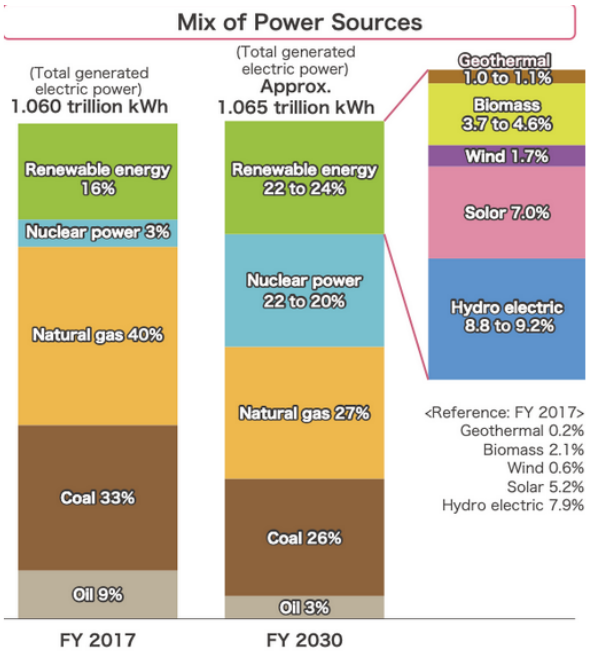
Before critiquing REI 2030's assumptions and omissions, we shall briefly examine its main arguments and their context. The core proposal of REI 2030 is to massively increase variable[1] renewable energy (VRE, meaning solar and wind) and make VRE the core of a 45% renewable energy power mix by 2030. The REI also want to eliminate coal and nuclear from the power mix over the same period. That ambition means natural gas has to fill virtually all the gap that renewables cannot. Hence the REI 2030 emphasis on using gas for 54% of power in 2030, with the remaining 1% of power supply from burning oil and oil product. The details are displayed in a separate section below, in a series of tables (1-3) and discussion of their content.

The REI justifies their ambitions for VRE by repeated emphasis that renewable energy is rapidly diffusing globally and that wind and solar are the cheapest power options. The latter assertion is not true everywhere, and especially in Japan, but we shall also take up those details later. The REI are indisputably correct that renewable energy is diffusing rapidly. The REI are also right in pointing out that several Japanese business associations, municipalities, and other actors have called for the government to substantially raise its current triennial Strategic Energy Plan target of 22-24% renewables by 2030 (with nuclear being 20-22% of a decarbonizing tandem).

That Japan's 2030 renewable target per se could and should be increased is REI 2030's most credible argument. It is indeed so credible that it is not particularly controversial in Japan. Yet simply raising the renewable target is just one item, with content being a much bigger issue. Hence, REI 2030 and other "power-shift" proposals vary greatly on which renewable generation (eg, wind, solar, hydro, biomass, and geothermal) they emphasize, what percentage of renewable is possible by 2030, whether or not to include nuclear, the role of carbon capture for thermal power (ie, coal, gas, and oil), and other extremely important details.

One reason for the uncertainty is lack of political leadership. The Abe Shinzo LDP government has been politically smart but economically imprudent in its unwillingness to touch the power-mix targets (ie, the relative shares of electricity generation) in official energy policy. Hence Japan's Strategic Energy Plan's 2030 targets for renewables, nuclear, and other power generation have remained essentially unchanged since 2015. Those targets - which now read like musings pulled out of a time capsule - are displayed in figure 1. The figure is taken directly from the English-language version of the Japanese Agency for Natural Resources and Energy (ANRE) publication "Japan's Energy 2019." The left-hand column shows the 2017 power-generation shares of renewable energy (including hydro), nuclear, natural gas, coal, and oil (which includes oil products). The middle column portrays the 2030 goals – which were first announced in July of 2015, as a supplement to the April 2014 4th Strategic Energy Plan – next to the 2017 numbers. In the right-hand column, the figure provides a break-down of "renewable energy," via a summary of the relative contributions from geothermal, biomass, and other renewables. And below that summary are the 2017 reference values for each category of renewable energy.

Figure 1: Japan's Power Mix, 2017 and 2030 Strategic Energy Plan Targets



Source: ANRE, 2020

The ANRE figure indicates that the current Strategic Energy Plan goals for 2030 project a moderate increase in renewables, to between 22 and 24%, with a much larger increase in nuclear, going from 3% in 2017 to between 20 and 22% in 2030. The nuclear role depends on the restart of remaining nuclear assets, and is a substantial decrease from pre-Fukushima nuclear shares that were 25-30%. The Strategic Energy Plan's combination of low-carbon renewables and nuclear is posited as the principal means to reduce reliance on carbon-intensive natural gas (from 40% in 2017 to 27% in 2030), coal (from 33% to 26%), and oil (from 9% to 3%). The figure also shows that, among renewables, the biggest projected growth is in geothermal, quintupling to about 1% from a low base of 0.2% in 2017. Wind is slated to more than double, from 0.6% in 2017 to 1.7% in 2030, followed by less ambitious increases in biomass, solar, and hydro.

Again, almost no one in Japanese energy policymaking circles - whether academics,

technocrats, business interests, or activists - believes these 2030 targets are credible. The current Strategic Energy Plan is version 5, adopted in July of 2018, while the next plan is already under debate and slated to be revised and adopted next year. The next Plan's targets for the 2030 power mix will almost certainly be amended. Presumably, there will be a higher projected share for renewables - particularly 24/7 hydro, geothermal, and biomass - and a lower share for nuclear together with shifts among the fossil-fuel generation mix.

There are many reasons the next Strategic Energy Plan's 2030 targets must be changed, and these reasons lend support to REI 2030's emphasis on the targets as problematic. Principally, since the 2015 announcement of the current power targets, global energy trends have accelerated, along with climate change. There are three main drivers to consider:

First, solar and wind generation costs have cheapened dramatically, resulting in what the International Renewable Energy Association (IRENA) describes as a "virtuous cycle of falling costs, increasing deployment and accelerated technological progress" (IRENA, 2020). The highly respected analysts at Wood Mackenzie forecast an addition 400 gigawatts (GW) of solar and wind capacity to be added in Asia alone by 2025, slightly over the 380 GW installed over the past five years (Davis, 2020). And in 2018, Japan's energy technocrats declared renewable energy a "principal power source" (*shuryoku dengen*) and further ramped up the investments and policy changes to accelerate its expansion.

A second development has been increasing pressure against investments in conventional coal-fired generation, the most carbon-intensive source of power. Among the major economies, only China seems to have the diplomatic and financial autonomy to buck the pressures and ramp up domestic projects and external coal finance even as it proclaims its renewable energy goals (Shepherd and Findlay, 2020). Indeed, in early July the Japanese government announced that it will seek to close 100 low-efficiency coal plants by 2030, out of a total of 140 coal plants, 110 of which are low-efficiency (S&P Global, 2020). It remains to be seen how much of Japan's coal generation will be substituted for by higher-efficiency coal, natural gas, renewables, or nuclear.

A third factor is Japan's questionable capacity to meet its 2030 nuclear targets. This seems very difficult without new build, due to decommissioning of many reactors and the slow pace in gaining regulatory approval and local-community assent to restarts.

So, while Japan's official 2030 targets have remained static for several years, the facts on the ground have changed considerably, both within Japan and globally. This context means that Japan's targeted renewable share in the 2030 power mix may come close to 30%, if not exceed it, versus the 22-24% envisioned in the current Strategic Energy Plan. Wood Mackenzie surveyed Japanese prospects in August 2020 and suggested renewables would achieve 27% by 2030 (Wood Mackenzie, 2020). The likelihood of nearing 30% renewables in Japan's power mix now seems obvious, but we should recall that just a couple of years ago it was considered bold in Japanese circles to suggest that 30% renewables might be achievable. Powerful momentum is evident in the renewable space, both within Japan and globally. This momentum explains why we now see serious, high-level arguments for over 40% renewables in Japan's power mix.

But the devil is in the details, so let us drill down on what REI 2030 is advocating. The REI 2030 depicts its sustainable scenario as 45% renewables, and cautions that meeting this target will require aggressive carbon pricing, regulatory changes, and other supportive measures. Table 1 (table 4.6 in the Japanese original), displays the REI 2030 Sustainable

Energy Mix scenario. We see from the right-hand column that in 2030 coal and nuclear are eliminated, leaving natural gas to provide 54% of power supply, renewables (largely solar and wind) 45%, and oil a marginal 1%.

Table 1: REI 2030 Sustainable Energy Mix (units: TWh)

Year	2010	2018	2030	% 2030 Power Mix
Power Demand	1,035	946	850	
Power Supply	1,149	1,051	890	
Renewable	109	177	400	45
Nuclear	288	65	0	0
Coal	320	332	0	0
Gas	334	403	480	54
Oil, others	98	74	10	1

Source: REI, 2020 (Author's translation)

Table 2 (table 4.6 in the original) is the REI depiction of the implications of Japan's current policy environment. The table 2 numbers on power generation (in terawatt-hours, or TWh) for 2010 and 2018 are the same as in table 1, as those data on power demand, supply and relative contributions to the power mix are not estimates but actual results. The main difference between the two tables is the projections for 2030 power generation and percentages of the power mix. Also, the REI data in tables 1 and 2 on 2030 overall power demand, supply, and relative percentages of the power mix are their ideal case (table 1) contrasted to their estimation of where current policy (de facto rather than de jure) is driving the system (table 2). We can see from the table 2 figures for 2030 that the REI believes renewable energy is already on track to achieve 30% of the power mix (cf the Wood Mackenzie forecast of 27%, noted above), leaving natural gas to decline slightly from 40% in 2017 to between 35 and 39% in 2030. Meanwhile, the REI projects coal to decline to 26% in 2030, from 33% in 2017. And nuclear is viewed as occupying a small share of 3 to 7%, possibly not much up from its 3% share in 2017 (but note that in April, 2020 Japan's nuclear share was 7.6%, according to METI, 2020).

Table 2: REI 2030 Current Policy Implied Energy Mix (units: TWh)

Year	2010	2018	2030	% 2030 Power Mix
Power Demand	1,035	946	980	
Power Supply	1,149	1,051	1,070	
Renewable	109	177	320	30
Nuclear	288	65	30-80	3-7
Coal	320	332	280	26
Gas	334	403	370-420	35-39
Oil, others	98	74	20	2

Source: REI, 2020 (Author's translation)

Table 3 (table 3-1 in the original) shows what REI believes to be the difference between the official energy policy, de facto energy development, and aggressive policy for each category of renewables. On the left-hand side, the table shows each type of renewable in terms of capacity (GW) and generation (TWh). The 2018 data for the respective level of capacity and generation are entered in the middle of the table. The right-hand side of the table presents REI 2030's summation of three different scenarios for 2030: 1) the current Strategic Energy Plan (in the table, SEP), 2) the Current Policy Implied Energy Mix (Implied), and 3) the REI's Sustainable Energy Mix (REI). The table shows that the REI believe aggressive policy would incentivize a near tripling of solar capacity from 56 GW in 2018 to 145 GW by 2030, far more than the 64 GW aimed at in SEP and the 102 GW the REI deem likely under current policy. In tandem, the REI believes that pro-active policy could raise wind generation capacity (both onshore and offshore) from 4 GW in 2018 to 29 GW in 2030, again much more than SEP and Implied. In the REI

scenario, other renewables such as hydro and geothermal would remain largely unchanged relative to how they judge implied policy.

Table 3: Renewables in the 2030 Power Mix, by Scenario

	Energy	2018	2030 Scenario		
			SEP	Implied	REI
Capacity (GW)	Solar	56	64	102	145
	Wind	4	10	23	29
	Geothermal	1	1-2	1	2
	Biomass	5	6-7	8	8
	Hydro	21	49	23	24
Generation (TWh)	Solar	63	75	123	173
	Wind	7	18	65	82
	Geothermal	3	10-11	4	7
	Biomass	24	39-49	51	52
	Hydro	81	94-98	82	84
	Total	177	237-252	324	398

Note: SEP= Strategic Energy Plan, Implied= Current Policy Implied Energy Mix (ie, table 1), REI=REI Sustainable Energy Mix (ie, table 2)
Source: REI, 2020 (Author's translation)

In summary, the REI advocate solar and wind as Japan's crucial decarbonizing combination, a sharp change from the Strategic Energy Plan projection of renewables (in general) and nuclear as key for decarbonization. The REI also raise the role of gas almost 30%, compared to the Strategic Energy Plan projections and what is implied by current policy. In choosing gas over nuclear, the REI have implicitly opted to trade off some element of diversified energy security, decarbonization and economic cost, to back up variable solar and wind with imported, expensive and carbon-intensive liquid natural gas (LNG). The REI justify taking low-carbon nuclear out of the mix on the grounds of negative public opinion and a vision of long-term decarbonization by 100% renewable energy. In their estimation, aggressive policy and their scenario of solar, wind and gas, and reduced power consumption, would lead to more than a 50% cut in emissions from the power sector by 2030, relative to 2018.

The REI Proposals' Assumptions and Omissions

As noted earlier, there are numerous assumption and omissions in the REI report. Below, we list them in brief before dealing with each in greater detail. We believe that the IEA, IRENA and other data overlooked by the REI study call into question the viability of its proposals.

1. One questionable assumption in REI 2030 is that solar and wind are already the cheapest power options. This assertion is certainly not correct for Japan, where even sympathetic analysts in *PV Magazin*e note that the cost of solar remains "among the highest in the world" (Hall, 2020). As for Japan's offshore wind, it is so pricey that the Japan Wind Power Association's ambitious scenario is cutting it to JPY 8/kWh by the early 2030s, compared to the JPY 5-6/kWh that prevails in Europe at present (Obayashi, 2020). The REI 2030, however, base their offshore wind cost projections on much more optimistic assumptions – from Bloomberg New Energy Finance - that Japan's offshore wind will cost just over JPY 5/kWh by 2030. In short, the Japanese wind power experts (who presumably know their business) and the REI 2030 price projections for 2030 offshore wind differ by 60%. That gap suggests the REI 2030 is opting to use the most favourable assessments to support its arguments, which in fact risks undermining them.

   A second problem on costs is that most calculations of solar, wind and other VRE generation costs overlook the larger system costs. These costs are defined as "the total costs above plant-level costs to supply electricity at a given load and given level of security of supply" (World Energy Council, 2020). The elements of these costs include the transmission,

frequency regulation, storage, and other facilities required for connecting VRE to the main power grid and backing them up when they cannot generate power. These costs vary by scale of VRE, the project locale, the amount of VRE already on the grid, and other factors. As the World Energy Council paper on "Renewable Energy System Integration in Asia" puts it, there is no free lunch. They point out that rising system costs are reflected in rising power prices. They therefore argue for clarity on the costs of integration, leading to a better-informed public debate on who should pay (World Energy Council, 2020). But the REI 2030 also does not address system costs, such as investments in transmission and storage required to connect offshore wind to the grid. Surely it is misleading to insist that the cost of solar panels and wind turbines is falling without paying attention to whether the transmission, storage and other system costs are declining as well.

2. A second questionable assumption is omission of concerns about critical material supplies and prices, even though REI 2030 is aimed at Japan's power system, a country that lacks domestic resource endowments.[2] Critical materials include copper, lithium, cobalt, nickel, rare earths, and a long list of other metals needed for clean energy. Solar and wind do not burn fuel, in contrast to fossil fuel generation, but they do require massive upfront investments in often exotic materials in order to generate energy. Recent International Energy Agency (IEA, 2020a) and other reports on these critical materials warn that ambitious policies on renewables and electric mobility imply cobalt, lithium, nickel and other critical material demand that exceeds current supply. The IEA and other analyses discuss supply constraints, geostrategic risks, human rights concerns, environmental damage (from harvesting and processing critical materials), and related issues. The IEA's concerns parallel those of the Japanese,[3] the European Union,[4] and a rapidly growing number of other actors. Indeed, the August 31 *Financial Times* reports that the EU is sounding the alarm over critical raw materials, as "[s]hortages of elements used to make batteries and renewable energy equipment could also threaten the bloc's target of becoming climate neutral by 2050" (Peel and Sanderson, 2020).

Moreover, Japan's Strategic Energy Plan includes strategies to expand and diversify access to these materials, which the REI certainly read. So one would have thought that REI 2030 would offer suggestions on maximizing the efficient use of supply-constrained materials while transforming the power system. This is because many of these critical materials are used at far greater density, per unit of energy consumption or production, in green technologies as compared to conventional power systems, internal combustion automobiles, inefficient air conditioners, and the like. And supplies of these materials have myriad other competing sources of demand, including smart phones, data centres, refrigeration and cooling, health care, and other rapidly expanding areas.

The World Bank Group has also been deeply concerned about the supply-demand balance of critical raw materials for several years. Updating earlier work, on May 11, 2020 it released "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition" (World Bank Group, 2020). The report examined scenarios of likely demand for cobalt,

copper and other materials, their potential GHG impact, and risks for shortages. One important backdrop to the report was the multiple effects of the Covid-19 pandemic, whose economic fallout led to a drop in prices for materials and reduced investment in new supply. The World Bank Group warns about constrained capacity to satisfy the need for critical materials in light of this context and accelerating moves towards a material-intensive green recovery. Against this backdrop of uncertainty, it would seem imperative that the REI 2030 call for the most materially-efficient deployment of these metals. Resource-poor Japan's renewable advocates should be among the leaders of the global debate in this respect, particularly considering the human rights abuses, environmental destruction, and other costs of critical materials.

3. A third implicit assumption of REI 2030 is that NIMBY and other opposition will not intervene. Yet solar and wind projects already face significant opposition in Japan, due to concerns about environmental damage, disaster resilience, health effects, dominance by big business, and other issues (Choushuu Shimbun, 2020). Community opposition has in fact led to a doubling of local government ordinances, from 30 in 2017 to 60 in 2019 (Nikkei Shimbun, 2020). And this opposition seems unlikely to go away. Indeed, there is significant opposition to new wind, transmission and other assets in Germany, one of the models for REI 2030. This opposition in Germany has led to difficulties in meeting goals, in addition to a very expensive plan to build transmission underground (Chu, 2020, IEA, 2020b).

   The likelihood of increased local opposition certainly does not make a significant role for VRE impossible or inadvisable. But it does suggest that REI 2030 gives too much emphasis to solar and wind at the expense of other renewables such as geothermal, hydro, and biomass. These renewables play a large role in many countries, and have the advantage of being 24/7 sources of high-quality power. It pays to recall that REI 2030 aims at removing both nuclear and coal from the power mix by 2030. The massive and rapid power-shift advocated by REI 2030 would allow for little local consultation in planning what must necessarily be very large generation, transmission, storage and other projects.

4. Curiously, REI 2030 use Spain (21% nuclear), UK (21% nuclear), and German (12% nuclear) as examples of how to grow VRE. But they fail to note how those countries' increase in wind and solar has been and continues to be facilitated by nuclear and other 24/7 baseload power and massive international power trading networks. In other words, the REI 2030 skips over the question of whether Japan can do without these assets, even as it builds its argument on the basis of them.

5. We have also seen that REI 2030 implies a massive increase in LNG use. This is a questionable choice for decarbonization. Natural gas is not only a comparatively costly fossil fuel in Japan (cf. the US). Its greenhouse-gas footprint depends on leakages in the production process as well as transmission through pipelines, conversion into LNG, shipment by LNG tanker, reconversion of LNG into natural gas, and then transmission to power-generation plant for combustion. Recent research suggests that these leakages may be higher than thought, leading to questions about the future of gas (Stern,

2019). REI 2030's plans imply huge new investments in the infrastructure to ship, transmit, and burn LNG, in order to drive extant and decarbonizing nuclear assets out of the power mix. This aim does not seem consistent with climate goals.

6. A related problem is that the REI 2030 also simply assumes that LNG costs and supply will not be significantly impacted over the next decade. This is a gamble, and should be addressed as such. Certainly Covid-19 flattened LNG demand and thus prices, and may do so again in a second wave of infection and lockdowns. But LNG has become a focus of energy demand growth globally, and particularly within Asia (Iwamoto, 2019; Timera Energy, 2020). Over the next few years, that demand could lead to higher prices, especially because of stalled projects and growing opposition to new development, particularly in the US (Cocklin, 2020).

In short, the evidence suggests REI 2030 needs to deepen its analysis of hurdles and opportunities for decarbonizing Japan's power mix. Perhaps it is possible for Japan to eliminate both coal and nuclear from its power mix in a decade and still have a viable economy. But surely the narrowing of the power mix - to the precarious tripod of LNG, solar and wind - needs to be rethought, in light of critical materials, costs, NIMBY, and other patent risks. A broader portfolio of power sources seems imperative. After all, it was not so long ago when nuclear supplied a quarter of Japan's power and was poised to ramp up. We learned from Fukushima (and now Covid-19) that fat-tail events happen, which is why the key to resilient energy systems is diversity. Were Japan to pursue the REI 2030 "sustainable scenario," it could soon find itself in a severe crisis brought on by NIMBY, escalating costs, and other challenges. The REI 2030 overlooks far too many risks in aiming to get 54% of Japan's power mix from costly LNG in order to back up a 45% renewable share composed almost entirely of intermittent solar and wind.

References

Bullard, Nathaniel (2020). "Renewable Power Will Soon Come Out on Top (https://www.bloomberg.com/news/articles/2020-06-11/solar-and-wind-power-top-growth-in-renewable-energy-worldwide)," Bloomberg News, June 11.

Choushuu Shimbun (2020). (in Japanese) "Tyrannical Renewable Energy: Local Communities Have Become a Hayfield For Big Business (https://www.chosyu-journal.jp/shakai/17867)," Choushuu Shimbun, July 2:

Chu, Lenora (2020). "German conservatives resist wind power, but not for reasons you'd think (https://www.csmonitor.com/World/Europe/2020/0213/German-conservatives-resist-wind-power-but-not-for-reasons-you-d-think)," The Christian Science Monitor, February 13.

Cocklin, Jamison (2020). "LNG Developers Cast Wary Eye on U.S. Pipeline Woes as Second Wave Projects Advance (https://www.naturalgasintel.com/lng-developers-cast-wary-eye-on-u-s-pipeline-woes-as-second-wave-projects-advance/)," Natural Gas Intelligence, August 14.

Davis, River (2020). "Renewables are Primed for Growth in Asia (https://www.wsj.com/articles/renewables-are-primed-for-growth-in-asia-11598785200)," *Wall*

Street Journal, August 30:

Hall, Max (2020). "Japan's struggle to drive down renewables costs, (https://www.pv-magazine.com/2020/08/20/japans-struggle-to-drive-down-renewables-costs/)" PV Magazine, August 20.

Hammer, Stephen and Stephane Hallegate, 2020, "Planning for the economic recovery from COVID-19: A sustainability checklist for policymakers (https://blogs.worldbank.org/climatechange/planning-economic-recovery-covid-19-coronavirus-sustainability-checklist-policymakers)," World Bank, April 14

IEA (2020a). "Clean energy progress after the Covid-19 crisis will need reliable supplies of critical minerals (https://www.iea.org/articles/clean-energy-progress-after-the-covid-19-crisis-will-need-reliable-supplies-of-critical-minerals)," International Energy Agency, May 6:

IEA (2020b). "Germany 2020 (https://www.iea.org/reports/germany-2020)" International Energy Agency, February.

IRENA (2020). "Costs (https://www.irena.org/costs)," International Renewable Energy Agency, August 10.

IRENA (2018). "Global Energy Transformation: A Roadmap to 2050 (https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf)," International Renewable Energy Agency, April.

Iwamoto, Kentaro (22019). "Singapore aims to be Asia LNG hub as demand soars, (https://asia.nikkei.com/Business/Energy/Singapore-aims-to-be-Asia-LNG-hub-as-demand-soars)" Nikkei Asian Review, December 30.

METI (2020). (in Japanese) "Power Survey Data, Summary of Results for April 2020 (https://www.enecho.meti.go.jp/statistics/electric_power/ep002/pdf/2020/0-2020.pdf)," Ministry of Economy, Trade and Industry Japan, August 3.

Nikkei Shimbun (2020). (in Japanese) "No" to Renewable Energy: Local Ordinances Double Since 2017 (https://www.nikkei.com/article/DGXMZO59797630Q0A530C2SHA000/)," May 30.

Obayashi, Yuka (2020). "Japan Aims at 10 GW Offshore Wind Capacity by 2030, up to 45 GW in 2040 (https://www.oedigital.com/news/480602-japan-aims-at-10-gw-offshore-wind-capacity-by-2030-up-to-45-gw-in-2040)," Offshore Engineer, July 31.

Peel, Michael and Henry Sanderson (2020). "EU sounds alarm on critical raw materials shortages (https://www.ft.com/content/8f153358-810e-42b3-a529-a5a6d0f2077f)," Financial Times, August 31.

REI (2020). (in Japanese) "Proposals for the 2030 Energy Mix (https://www.renewable-ei.org/pdfdownload/activities/REI_2030Proposal.pdf)," Renewable Energy Institute, Japan, August 6.

S&P Global (2020). "Japan starts regulatory discussions on phasing out inefficient coal-fired power plants (https://www.spglobal.com/platts/en/market-insights/latest-news/coal/080720-japan-starts-regulatory-discussions-on-phasing-out-inefficient-coal-fired-power-plants)," S&P Global Platts, August 7.

Shepherd, Christian and Stephanie Findlay (2020). "Virus drives shift away from coal except in China (https://www.ft.com/content/ceef4a42-6a15-4745-b196-74ade49d5f94)," Financial Times, August 3.

Stern, Jonathan (2019) "Challenges to the Future of LNG: decarbonisation, affordability and profitability (https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/10/Challenges-to-the-Future-of-LNG-NG-152.pdf)," Oxford Institute for Energy Studies, October.

Timera Energy (2020) "Asian LNG demand resilience in 5 charts (https://timera-energy.com/asian-lng-demand-resilience-in-5-charts/)," Timera Energy, May 25.

WBG (2020), "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition (https://www.worldbank.org/en/news/press-release/2020/05/11/mineral-production-to-soar-as-demand-for-clean-energy-increases)," May 11, World Bank Group.

Wood Mackenzie (2020) "Japan to exceed 2030 renewables target supported by US$100 billion investments (https://www.woodmac.com/press-releases/japan-to-exceed-2030-renewables-target-supported-by-us$100-billion-investments/)," Wood Mackenzie, August 19.

World Bank Group (2020), "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition (https://www.worldbank.org/en/news/press-release/2020/05/11/mineral-production-to-soar-as-demand-for-clean-energy-increases)," May 11, World Bank Group.

World Energy Council (2020). "Renewable Energy System Integration in Asia (https://www.worldenergy.org/assets/downloads/Renewable_Energy_System_Integration_in_Asia_ExecSum_FINAL.pdf)," World Energy Council.

World Energy Council (2019). The Future of Nuclear: Diverse Harmonies in the Energy Transition (https://www.worldenergy.org/publications/entry/world-energy-scenarios-2019-the-future-of-nuclear-diverse-harmonies-in-the-energy-transition). World Energy Council.

Yomiuri Shimbun (2020). "Japan unearths rare metals essential for lithium-ion batteries off Pacific island, (https://the-japan-news.com/news/article/0006750962)" Yomiuri Shimbun, August 22.

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Notes

[1] Another term is "intermittent," and both variable and intermittent refer to the fact that power output from solar and wind assets fluctuates with levels of sunlight and wind-speed.

[2] Japan does have undersea reserves in its Exclusive Economic Zone. The need for critical materials is so powerful that Japan has already undertaken seabed mining, announcing the world's first successful excavation in August of 2020. See Yomiuri Shimbun, 2020.
[3] Japan's JOGMEC and other agencies publish numerous studies, as do the carmakers (eg, Toyota), battery suppliers (eg, Panasonic), metal firms (eg Mitsubishi Materials) and other concerns.
[4] See, for example, EURACTIV's November 2018 work on "Metals in the circular economy (https://www.euractiv.com/section/circular-economy/special_report/metals-in-the-circular-economy/)."