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Is Japan a Climate Leader? Synergistic Integration of the 2030 Agenda

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Abstract

In recent years, Japan has been labeled an "environmentally backward country." Yet Japan's integration of decarbonization and all-hazard-resilience is more advanced than critics generally admit. The evidence shows that, when compared to its peer countries, Japan is achieving significant climate mitigation and adaptation via a multilevel industrial policy. Moreover, Japan's synergistic integration of mitigation and adaptation to climate is important for the 2030 Agenda, which comprises the Paris Agreement, Sustainable Development Goals, and the Sendai Framework on Disaster Risk Reduction. That is not to say Japan's present pace of reductions in emissions and waste, increased resilience against climate and other hazards, and performance on other metrics is sufficient to meet the goals of the 2030 Agenda. However, the evidence assessed in this paper suggests that Japan deserves closer scrutiny for potential lessons in collaborative, cost-effective and equitable mitigation and adaptation.

Introduction

Japan is increasingly derided as an "environmentally backward country." Yet Japan's integration of decarbonization and all-hazard-resilience seems more advanced than critics generally admit. One reason Japan is a leader is that its central government is explicitly committed to climate action as a growth strategy, one of many areas where its national leadership contrasts with much of Anglo-America's, Europe and many developing nations.[1] Second, Japan's scarcity of conventional energy and critical raw material resource endowments compels action, particularly resource-efficiency. Third, Japan embeds climate mitigation and adaptation in a larger, multilevel paradigm of National Resilience, local Sustainable Development Goals (SDGs), compact cities, and the Smart Society 5.0, concepts explored below (DeWit 2019).

To be sure, Japan could and should be cutting its greenhouse gas emissions far more aggressively, coupled with even more inclusive and equitable adaptation. That said, Japan appears to be at the forefront of global specialist thinking on policy and stakeholder integration with important implications for climate and related crises. Synergistic integration of mitigation and adaptation to climate and other crises is a goal of expert debate on the 2030 Agenda, which comprises the Paris Agreement, Sustainable Development Goals, and the Sendai Framework on Disaster Risk Reduction (Handmer, et al. 2019; Mora, 2018; Murphy, 2019). Exploiting potential synergies between mitigation and adaptation can cut costs and maximize the benefits (environmental justice, disaster resilience, material-efficiency, innovation) of counter-measures. Addressing multiple problems simultaneously is crucial to alleviating climate crises equitably and efficiently, making the best use of scarce material, fiscal, intellectual, and other resources. In this regard, Japan offers important lessons that risk being obscured by the often tendentious "backward country" narrative. Hence this paper, the first of a series,[2] challenges that apparently dominant narrative with a comparative analysis of Japanese performance on emissions, waste flows, and material efficiency.

Japanese Energy-Environmental Policy

Japan was once regarded as an undisputed environmental leader (Schreurs, 2004). But in recent years, Japan's environmental performance has come to be ranked quite low among the developed countries. Japan is routinely relegated to the bottom tier by such climate activist organizations as German Watch and the Climate Action Tracker that compare Paris Agreement commitments on emissions reduction. German Watch's "Climate Change Performance Index 2020" ranks Japan as 51st in 2020, well below virtually all EU countries (including Poland) and most of Asia (including China, India, and Indonesia).[3] And the 2020 data in the Climate Action Tracker rank Japan even below the world's top coal-exporter Australia and tar-sands heavyweight Canada. These extremely negative assessments have also shaped global media coverage of Japan and even expert opinion on what to expect from Japan.[4]

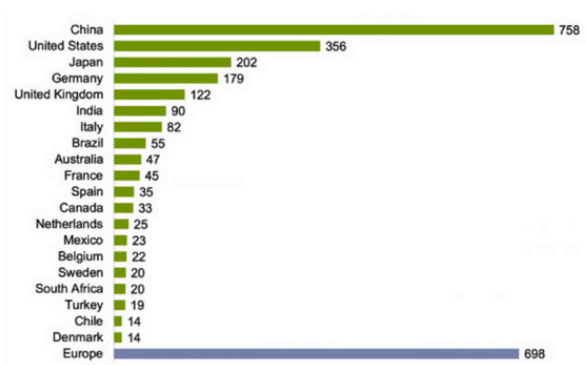
The negative assessments often rely on Japanese expert and activist advice concerning their own country's performance, which bolsters the assessments' apparent validity. In the domestic sphere, these commentators routinely argue that Japan is an "environmentally backward country" (*kankyou koushinkoku*). One prominent proof of Japan's alleged backwardness is the comparatively low penetration of renewables in the power sector, versus higher percentages and much more aggressive commitments in Germany and other countries. The critics charge that Japan's national government is reluctant to expand renewable energy, let alone commit to 100% renewables. They generally describe this reluctance as being at the behest of vested interests in the power and related sectors. Many also argue, quite explicitly, that Japan's national government is more committed to restarting nuclear plant and expanding coal-fired power than to reducing greenhouse gas (GHG) emissions and combatting climate-driven crises. The "backward" narrative expresses little interest in the 2030 Agenda synergistic integration of mitigation and adaptation. It is largely focused on the single (and often very misleading)[5] metric of renewable energy in the power mix (Green Watch 2019, Kikonet 2019, Oshima and Takahashi, 2016: 34, Takao 2016).

To be sure, this perception of Japan is questioned by some specialists, even on the metric of comparative renewable energy deployment. Christine Lins, former Executive Secretary (2011-18) of the global renewable energy policy network, REN21, is herself on record (in Japanese, at least) as explicitly denying backwardness. Lins pointed out that in 2016 Japan was 4th in the world in renewable investment (see the data in FS-UNEP 2017). While 4th is not 1st, it certainly was a striking increase on Japan's performance in 2009 and earlier. In 2009, Japan ranked 15th among the G20, investing less than USD 1 billion in renewable energy, far less than China's USD 34.6 billion and Germany's USD 4.3 billion (Pew, 2010). REN 21's Lins politely critiqued the backwardness narrative, suggesting it was natural for Japanese renewable enthusiasts to regard their country's deployment as inadequate, but that viewed internationally Japan is a global leader (quoted in Matsuki 2017).

And Lins was right. As we see in figure 1, over the decade 2010-2019, Japan's renewable investment of USD 202 billion was exceeded only by China (USD 758 billion) and the US (USD 356 billion). Germany lagged behind (USD 179 billion), followed by the UK (USD 122 billion).

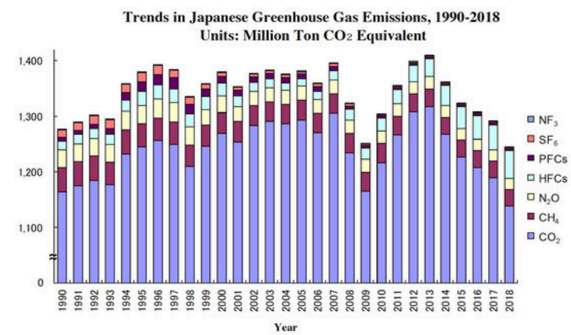
Figure 1 Renewable Energy Capacity Investment, 2010-First Half 2019

Units: USD billion



Source: UNEP/BNEF, 2019[6]

Table 1 Japan's Greenhouse Gas Emissions, 1990-2018



Source: MoE, 2019[7] (author's translation)

But the proof of the mitigation pudding is in the eating, rather than comparing spending on renewables. So before we turn to examine Japan's synergistic integration of mitigation-adaptation governance and technology to implement the 2030 Agenda, let us first check whether the country has actually cut its CO2 and other greenhouse gas (GHG) emissions. Table 1, translated from the Japanese Ministry of the Environment's November 2019 comprehensive GHG survey, calculates all GHG emissions in CO2 equivalents.[8] The table shows that Japan's total GHG emissions for 2018 declined over the previous year by 3.6%. Of this total, CO2 declined by 4.2% overall and 4.5% in the energy sector.

That decline may not seem significant, and certainly isn't nearly as rapid as climate science shows is needed to limit warming to well below 2°C.[9] But in fact, Japan's drop in CO2 matched Germany's 4.2% cut for the same period. And note that Germany benefited (according to its Environment Minister) from exceptionally warm weather. That weather helped Germany end 4 years of stagnation in emissions reductions, largely because warm weather reduced heat demand.[10] By contrast, Japan's cut in total GHG emissions, and in CO2 specifically, is continuous from 2013. As we see in table 1, 2013 saw a peak in Japan's CO2 emissions, due to the idling of most nuclear plant and the consequent turn to increased reliance on coal, natural gas, and oil in the power sector. The table shows that by 2018 Japan's emissions were quite close to the level of 2009, when the global financial crisis (aka "Lehman shock") drove Japanese growth rates down by nearly 5% (Saito, 2018). Japan's power sector is clearly central to changes in its GHG emissions, so the next table focuses on what changed in electricity generation.

Table 2: Japan's Power Generation By Generation Type, 2010-2018

Japan's Electricity Generation By Type, 2010-2018

Units: 100 million kWh

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018/2017
Total Electricity Generation	11,495	10,902	10,778	10,848	10,587	10,408	10,526	10,605	10,471	−1.3%
Nuclear	2,882	1,018	159	93	0	94	181	329	649	+97.3%
Coal	3,199	3,058	3,340	3,566	3,537	3,551	3,452	3,472	3,262	−6.0%
Natural Gas	3,339	4,113	4,320	4,432	4,549	4,253	4,337	4,218	4,025	−4.6%
Oil	983	1,583	1,885	1,578	1,175	1,023	1,020	889	761	−14.4%
Renewable Energy	1,091	1,131	1,074	1,179	1,326	1,486	1,536	1,696	1,773	+4.5%
Hydro	838	849	765	794	835	871	795	838	810	−3.3%
Solar	35	48	66	129	230	348	458	551	627	+13.8%
Wind	40	47	48	52	52	56	62	65	75	+15.3%
Geothermal	26	27	26	26	26	26	25	25	25	+2.7%
Biomass	152	159	168	178	182	185	197	219	236	+8.1%

Source: MoE, 2019[11] (author's translation)

Changes in Japan's Power Sector

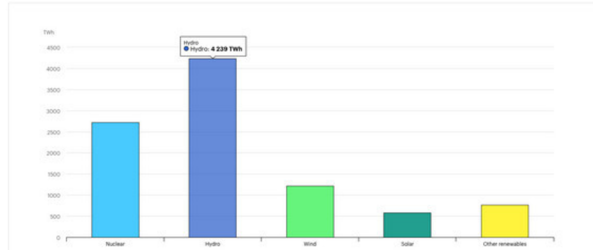
Table 2 is from the same MoE survey of Japan's energy and emissions data for 2018. It measures total electricity generation and the various categories (fossil fuel, renewable and nuclear technologies) over the period 2010-2018. The table shows the steep drop of nuclear generation from the 3-11 shock, leading to the shutdown of all nuclear plant in 2014. As is also evident from the table, nuclear's decline led to greater reliance on coal, natural gas and oil generation. These fossil-fuel power sources – many of them old, mothballed plants - were ramped up to fill the gap in power supply. Oil-fired generation in fact more than doubled between 2010 and 2012, and expensive natural gas generation increased by 136% between 2010 and 2014.

To be sure, after 3-11, conservation/efficiency gains and non-hydro renewable energy (notable solar power) helped somewhat to alleviate the massively increased reliance on fossil fuels. But it is important not to overstate the role of conservation/efficiency and renewables. After 3-11, reduced power consumption was in large part driven by price increases whose impact on low-income households led to hardship, and possibly well over 1,000 deaths (Neidell, et al, 2019). Filling all of the gap with renewables was not in the cards. Popular opposition to wind was a major barrier to expanding the least-cost and most effective of the non-hydro renewables (DeWit, 2018).[12] And the table reveals that even by 2018 comparatively expensive solar[13] was only able to supply 6% of Japan's total power generation. Solar-power output did double between 2012-13, and continued increasing at significant rates into 2018. Indeed, by the end of 2018, Japan's solar capacity was third in the world with 56 gigawatts (GW) of solar capacity; this level was topped only by China (176GW) and the US (62GW), and exceeded capacity in Germany (45GW).[14] However, Japan's capacity additions (which are not the same as output)[15] declined from 7.9 GW in 2016, to 7.5 GW in 2017, reaching 6.7 GW in 2018.[16] And deployment of solar in Japan seems likely to slow further due to reduced subsidies, declining availability of land, increasing local opposition, limits on pumped-hydro storage capacity, constraints in the transmission grids, and other factors (DeWit, 2020).

What is also clear from table 2 is that Japan nearly doubled its power generation from nuclear assets in 2018, while also greatly reducing the role of oil and other fossil fuels in the power sector. Indeed, between 2017-2018 oil's role in the Japanese power sector declined by 14.4%, while coal also dropped by 6%. Even natural gas declined by 4.6%. The evidence indicates nuclear restarts in the years 2015-2018 contributed significantly to decarbonization, particularly in the latter year when nuclear generation increased by 97.3%. Moreover, nuclear restarts did not prevent solar and other renewables from expanding. In 2018, solar generation rose by 13.8% even as nuclear nearly doubled. This suggests that – contrary to anti-nuclear claims – Japan does not have to choose either variable renewables[17] or nuclear.[18]

Some Japanese policymakers also seek to increase low-cost and very low-carbon large-scale hydro output, roughly 8% of the power mix.[19] They do not advocate building new large-scale power generation dams, but rather refurbishing and reinforcing existing multipurpose dams, as part of the integrated mitigation-adaptation programme to address the country's hydrologic threats. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) aims to bolster the Japanese dam network's role in flood control and stable water supply, linking dams, rivers and waterworks via advanced radar systems, sensor networks, and supercomputers. This project is called the "Dam Revival Vision," and was adopted by MLIT on June 26 of 2017. The project has been funded in subsequent budgets, and also aims at perhaps doubling hydro generation from existing assets. It is a clear example of Japan's adaptation-led maximization of synergies between mitigation and adaptation.[20]

Figure 2: Global Low-Carbon Power, by Generation Type, 2018



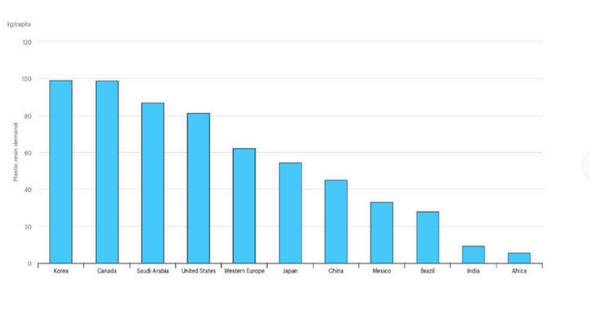
Source: IEA, 2019[21]

Figure 2 offers some evidence that Japan's possible further increase of nuclear and hydro in its power mix makes decarbonizing sense. The figure is the International Energy Agency (IEA) summary of global decarbonizing power, showing the relative contributions of each generation type. It is evident that hydro and nuclear are the two most prominent. In 2018, hydro provided 4,239 TWh of low-carbon electricity, followed by nuclear at 2,724 TWh. By comparison, the total contribution of solar, wind and other renewables added up to 2,561 TWh. Since the critical material footprint[22] of variable renewables is much higher than nuclear and hydro, and Japan has virtually no domestic endowments of critical materials, it seems advisable to expand the decarbonizing portfolio with these options as much as possible. While nuclear and large hydro do have risks, these risks need to be assessed in light of accelerating climate risks associated with expanded fossil-fuel consumption, critical raw material production (Paliacos, et al., 2019), extreme weather, and feedback effects such as escalating permafrost melt (Schuur, 2019). As Bloomberg New Energy Finance Senior Contributor Michael Liebreich and others have begun to argue, it is unclear whether non-hydro renewables can decarbonize the energy economy quickly and efficiently and thus "we need to talk about nuclear power" (Liebreich, 2019). Vaclav Smil has long warned, on the basis of material evidence, that it is most unwise to ignore the "fundamental physical realities" of energy transitions (Smil, 2019a). And as we note in more detail below, trying to decarbonize with solar, wind, electric cars and the like imply massive increases in the production of cobalt, lithium, copper, rare earths and other critical war materials. The increased production volumes risk imposing even more onerous environmental burdens on people living in areas where critical raw materials are mined and processed (Sovacool, et al. 2020).

Japan's Per-Capita Waste

Waste is a second, if subordinate, battleground in the global struggle to reduce GHGs. In recent years Japan has also been depicted as a laggard on waste disposal, especially plastics. One prominent area of criticism is the absence of bans or pricing on single-use plastics as shopping bags.[23] The narrative is so powerful that even the daily business journal Nikkei Shimbun has taken to using "backward country" rhetoric in some of its headlines.[24]

Figure 3: Per-Capita Demand for Major Plastics, 2015

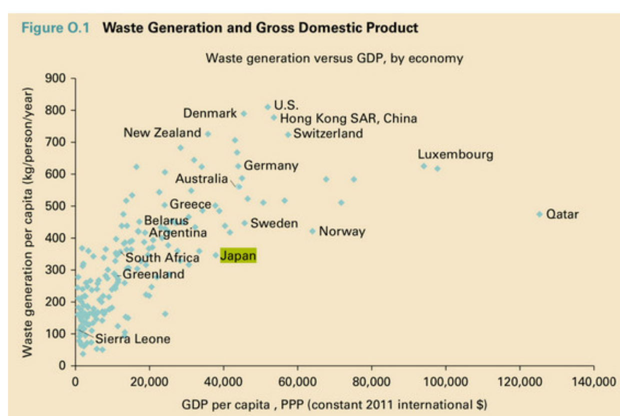


Source: IEA, 2020[25]

Figure 3 offers one data point that questions the "backward country" narrative. The data summarize the apparent consumption (production less exports plus imports) of kilogrammes (kgs) of plastic resins per capita for 2015. Japan's level is actually lower than that of Western Europe, which is generally depicted as the locus of environmental activism and consciousness, and of course lower than that of the United States.

Moreover, Japan's performance is highly evaluated in World Bank comparative studies of waste-management. As figure 4 shows, Japan's per-capita generation of waste (in kgs/yr) is considerable lower than its peer countries in the OECD. The World Bank also points out that only 1% of Japan's waste is landfilled, particularly due to space restrictions. Japan's comparatively low per-capita waste is either recycled or incinerated in very advanced waste-to-energy facilities that generate power and heat.

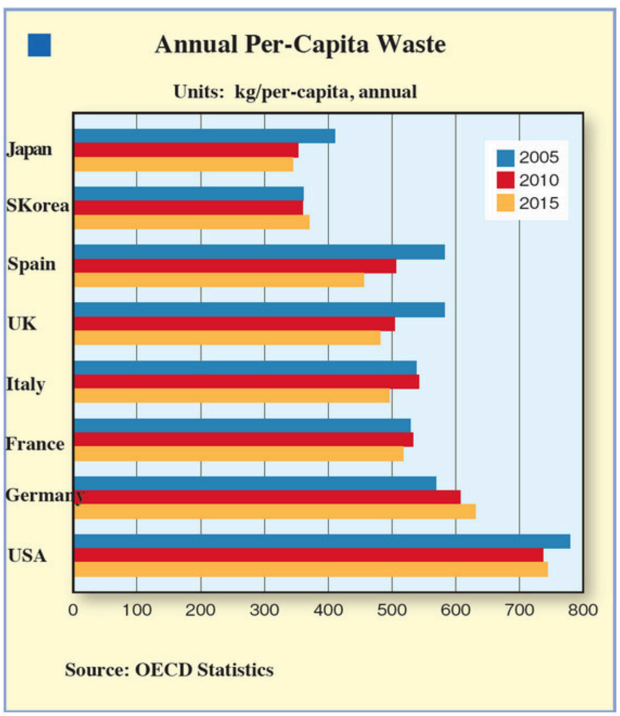
Figure 4: Comparative Waste Generation and Gross Domestic Product, 2016



Source: Silpa, et al., 2018

Figure 5 suggests that Japan's coordinated approach has also led to significant reduction in per-capita waste volumes over time. The data show that between 2005 and 2015, Japan's volumes were lower than its peer countries in the OECD. Indeed, the European members of the OECD reveal considerably higher levels than Japan. And it is striking that Germany's per-capita waste volumes actually increased over 2005 and 2015. Germany is generally regarded as the global leader on renewable energy, the circular economy, and other metrics of environmental sustainability.

Figure 5: Comparative Waste, Per-Capita, for 2005, 2010 and 2015



Source: PWMI, 2019[26] (author's translation)

The OECD measured 2015 per-capita annual household waste in Japan at 344 kg, versus an OECD average of 523 kg. Japan's waste volume had not only declined significantly compared to its over 400 kg per-capita level in 2005; it was also much less than that of Germany, where per-capita waste had increased from under 600 kgs in 2005 to well over that in 2015. All the other major EU countries (France, Italy, Spain, the UK) recorded declining per-capita waste volumes, but even these levels were well over 450 kgs in 2015.

Researchers point out that Japan's effective waste-management is due to coordinated intergovernmental collaboration: "Japan's efficient solid waste management practices can be largely attributed to effective cooperation between its national and local governments. The central and urban public authorities coordinate along several dimensions, from data collection to financing."[27] The rhetoric of backwardness risks obscuring these important lessons in effective multilevel governance. Overlooking Japan's lessons in waste reduction would seem unwise, as a recent study warned that global waste volumes are likely to increase 420% by 2050, reaching an astonishing 32 billion tonnes.[28]

In contrast to the rhetoric on backwardness, the OECD's 2019 publication on "Waste Management and the Circular Economy" argues that Japan was well in advance of its peers in adopting "comprehensive circular economy policy frameworks." The OECD points out that Japan was a first-mover in adopting clear and detailed mechanisms for setting targets and monitoring their achievement.[29]

Indeed, Japan has a long policy background on the circular economy, or "circular society" (*junkangata shakai*) in Japanese. This paper does not assume that the objective of circularity can in fact be achieved, since it is a biophysical impossibility to recapture the energy, water, and other material flows that compose agriculture, industry, and virtually all other aspects of human activity (Smil, 2013; 2019b).[30] What we are interested in here are reduced volumes of per-capita waste and increased material-efficiency.

The Japanese circular-society policy's underpinnings in administrative law date back to the August 1994 implementation of the "Environmental Basic Law" (*kankyou kihon hou*) followed by the January, 2001 enactment of the Law for the Promotion of the Circular Society (Fundamental Framework Law) (*junkangata shakai keisei suishin kihonhou* [*kihonteki wakugumihou*]). This legal framework has since served as the basis for integrating a range of regulatory policies on recycling cars, construction materials, household appliances and other items into full-fledged plans to maximize waste-reduction and material-efficiency. These plans are developed under the aegis of the Japanese Ministry of the Environment (MoE). The first of these "Plans for the Promotion of the Circular Society" (*junkangata shakai keisei suishin keikaku*) was adopted by the Japanese Cabinet on March 14, 2003. Each plan covers a 5-year period, and has regularized follow-up on progress made in achieving such targets as increased rates of recycling. The most recent plan is the fourth, which was enacted on June 19, 2018 by the Japanese Cabinet.[31]

Japan's 4th plan recognizes multiple challenges the country confronts, such as the need for international collaboration, regional economic sustainability, the implementation of Society 5.0, and the like. The plan's 5 pillars address regional circularity, international resource circulation, lifecycle resource circularity, proper waste management, and disaster waste management. The plan notes that Japan's resource-productivity (or volume of resources used for generating wealth) has increased over the decades. It warns that this rate of increase is slowing down. Hence the plan targets 4 key goals by 2025. The first is to generate JPY490,000/ton of value from resource inputs. This target is an increase on the JPY 380,000/ton goal for 2015, and would represent a doubling of the 2000 target. The second major goal concerns the cyclical use rate in the resource base. This metric measures the fraction of recycled material in the overall volume of resource inputs. The 2025 target is 18%, up from the 16% target in 2015 and roughly an 80% increase over the 2000 level.

The third goal concerns the cyclical use rate as a percent of the overall waste volume. This metric calculates the rate of recycling within the waste stream from the overall economy. The 2025 goal is 47%, up from the 44% target in 2015 and an approximate 30% increase over the year 2000.

The fourth target of the 4th plan is the final disposal amount, which measures the material volume that goes to landfill. The 2025 target is 13 million tons, a marginal increase on the 14 million ton goal of 2015, but a 77% reduction in landfill waste volumes over 2000.

Within these overall goals and data are numerous other important metrics. One is the economic scale of what Japanese policymakers depict as the circular economy. The Japanese plan aims to double the JPY 40 trillion size of the circular economy in 2000 by 2025, after having achieved an increase to JPY 47 trillion as of 2014. Other targets include a further reduction in average daily per-capita household waste from 653 grams in 2000 to 440 grams in 2025, having achieved a level of 507 grams as of 2016. Another important goal is reduction of average per capita daily municipal waste volumes, which incorporates material outside of the household waste stream. The 2025 goal is 850 grams per-capita/day by 2025, significantly down from the 1,185 gram average in 2000. The average achieved in 2016 was 925 grams. Well, of course, targets are simply targets. The experience of most nations in the wake of the Paris agreement has been a failure to approach self-proclaimed but unenforced targets for GHG reduction and other measures of climate crisis. By contrast, Japan has consistently achieved or approached targets over a much wider range of parameters than those set by most other nations.

Indeed, Japan appears to be doing well in many areas. For example, in 2012 it was already recycling and reducing almost all of its construction and demolition waste. Asphalt waste recycling in 1995 was 80.7% versus 99.5% in 2012, concrete waste 64.6% in 1995 but 99.3% in 2012, wood waste 38.9% in 1995 but 94.4% in 2012.[32]

Japan's Performance in Comparative Perspective

As noted earlier, these data might seem counter-intuitive for many readers: in recent years not only has Japan has been depicted as a laggard on environmental matters but it rarely draws attention to its environmental achievements. One prominent area of criticism leveled at Japan is the absence of bans or pricing disincentives on single-use plastics as shopping bags.[33] Not only does this criticism overlook the fact, as highlighted by the UK Environmental Agency[34] and the Danish Ministry of Environment and Food,[35] that substitutes (such as cotton bags) tend to be much more environmentally damaging from a life-cycle standpoint. But the argument also overlooks the fact that Japan's landfilling of all industrial waste (including plastic) is only 3%. As a result, little plastic waste leaks out into the environment. Total volumes of plastic waste declined from over 10 million tons in 2005 to 9.03 million tons in 2017, while the rate of recycling (including thermal recycling) increased over the same period from 58% (2005) to 86% (2017).[36] Like the Europeans, Japan burns a lot of its waste stream to generate energy, a practice that is generally more environmentally effective than trying to recycle many complex amalgams and other such materials. The latter may seem virtuous, but requires much more energy for collection, handling, processing and other stages than is saved. Japanese energy generation capacity for burning waste rose from 1.491 GWs in 2004 to 2.089 GWs in 2017. In the latter year, 2017, these assets generated a total of 9.207 GWh of power, or roughly 3.1 million households' worth of demand.[37]

Though Japan's approach is not well understood, there are some comprehensive evaluations in English. One example is Duston Benton and Jonny Hazel's April 2015 summary of "The circular economy in Japan."[38] Benton and Hazell observe that circular economy policymaking is well-known in Europe, but that Japan also offers many lessons. They note, as we saw earlier, that Japan's rates of recycling are very high and its waste streams comparatively low. They identify several key incentives for these high levels of achievement. One is that Japan is topographically ill-suited to massive landfills and other means of large-scale waste disposal. The country's population density and related concerns have driven the search for alternatives. A second factor is resource endowments. Japan is a leading industrial power, but has to import virtually all the metals and other materials for producing goods, often over considerable distances. The consequent costs and risks result in a comparatively high level of incentives to use materials efficiently and recycle as much as possible. Benton and Hazell also point to a generalized culture of collaboration on these goals, but also stress that it is underpinned by vulnerability. The latter was underscored from 2010, when Chinese restriction on rare earth shipments to Japan forced the Japanese to devise materially leaner production processes and secure alternative sources of supply.

Material Density Issues

Japan's evolving policy frameworks on critical materials[39] - or "rare materials" as the Japanese industrial-policy technocrats refer to them – are especially important for the 2030 Agenda. These materials – which include copper, lithium, cobalt, nickel, and others - are distinct from rare earths in definition, albeit with some overlap (e.g., scandium, yttrium, lutetium). These metals are key to the power systems, transport networks, and other elements of the built environment. Recent work on these materials sketch a significant challenge confronting the shift in energy regimes, as decarbonizing and distributing energy requires significantly greater volumes (per GW, per vehicle) of copper, lithium, cobalt etc than does conventional generation, transmission, transport, and so on,

For example, recent IEA 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.[40] The IEA's concerns parallel those of the Japanese,[41] the European Union,[42] the California Business Roundtable,[43] and a steadily growing number of other actors. 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, automobiles, and the like. And supplies of these materials have other competing sources of demand, including smart phones, jet engines, health care, and multiple other areas. The IEA and other analyses discuss supply constraints, geostrategic risks, human rights concerns, environmental damage (from harvesting and processing critical materials), and other issues. These challenges are all central to any prospect of sustainable development. The emerging facts suggest that any credible, rapid shift to sustainable energy and efficiency will require prioritizing the use of constrained critical materials. Doing that will almost certainly require Japanese-style comprehensive governance.

The first imperative is to reduce undue reliance on any particular material via substitution. The Japanese did this in the wake of 2010, when rare earth price rose and Chinese policies on rare earths indicated increased risks of export bans against Japan. In response, the Japanese invested heavily in alternatives. These strategic investments resulted in such innovations as new magnet technologies that greatly reduce the role of neodymium.[44]

Yet substitution has its limits, because of the enormous projected increase in demand for nearly all these materials. One example is seen in the effort to use nickel to reduce reliance on cobalt in electric vehicle batteries. In collaboration with Panasonic, the US automaker Tesla has been at the forefront of this initiative. Indeed, Tesla's goal is to entirely eliminate the role of cobalt in electric-vehicle (EV) batteries, and it is achieving notable success in this objective. However, the initiative has encountered something of a "whack a mole" phenomenon. This is because supplies of nickel are increasingly constrained, posing a challenge to large-scale substitution of cobalt in the high energy-density batteries required for electrified transport. Global demand for nickel in EV batteries is projected to increase from 3% of all sources of demand (such as stainless steel, non-ferrous alloys, and other products) in 2018 to 12% by 2023, as global automakers are expected to introduce over 200 new EV models. But the volatility of prices for nickel have been a drag on investment in increased mining capacity. In consequence, metals analysts warn that "[t]here is no new nickel in the pipeline" even as other specialists highlight the time required to find alternatives.[45]

Because options for substituting critical materials appear limited, and perhaps very problematic, increased attention to strategic, spatially-smart use of these scarce materials is required. The circular economy literature features some new work that attempts to examine the spatial issue across countries. This literature seeks to promote what it defines as circularity (and carbon neutrality) within the far-flung supply chains that link prominent critical-material producers and exporters, such as Australia, to consumer countries within the global resource network.[46] This macro-level perspective on critical materials is important, but surely needs to be supplemented with a micro-level focus that starts from cities. The Japanese megacity of Tokyo is one example of the latter.

Tokyo and the Compact City

Greater Tokyo is an environmental leader when seen in comparative light. Tokyo's policymakers work in a multilevel collaboration, which includes all levels of government, and explicitly recognizes that Tokyo and the national community confront increasingly serious crises.[47] One recent example of this collaboration is seen in the January 15, 2020 inauguration of a cooperative committee between Tokyo and the MLIT (Ministry of Land, Infrastructure, Transportation and Tourism). The committee focuses on building a disaster-resilient capital region, in light of seismic, climate and other hazards. Tokyo's planning, policy implementation and international engagement also show they are keenly aware of a rapidly urbanizing world whose 20th century energy- and resource-intensive growth paradigm is patently unsustainable. These domestic and international factors give Tokyo (and Japan as a whole) multiple incentives to excel in the development and diffusion of the elements of the global 2030 Agenda.

Evidence of the above is abundant. As a megacity, Tokyo's per-capita energy, water and waste flows are considerable below the average of such peers as Shanghai, New York City, London, Paris, and others.[48] TMG also installed Japan – and the world's – first urban cap and trade scheme that includes the commercial and industrial sector, "including office buildings, which are often concentrated in megacities."[49] Tokyo and other Japanese cities are generally built in a compact manner that fosters efficient resource use and limits sprawl.

One recent analysis of the importance of compact city-building is seen in the UNEP's (United Nations Environment Programme) International Resource Panel (IRP) 2018 report on "The Weight of Cities: Resource Requirements of Future Urbanization." The IRP report warns that the historic trajectory for urban sprawl is 2%/yr, which would see urban land use expand from 1 million km2 to 2.5

million km2 by 2050. That 1.5 million sq2 increase in urban space would be approximately 3 times the 506,000 km2 area of the entire country of Spain. In tandem with that, urban material consumption is on track to grow from 40 billion tonnes in 2010 to 90 billion tonnes by 2050. But the IRP argue that "compact, resource-efficient cities" could reduce these totals by 36-45%. Against this daunting numerical backdrop, the IRP report notes that "Japanese cities have the densest and most connected street patterns," with Tokyo's "level of transit connectivity and intensity of use" being the highest in the world. As a result of these structural factors, "Japan has the highest world energy productivity (ratio of energy consumption to added value), close to three times the global average."[50] The Tokyo Metro transit network (primarily subway) reflects this: its 382 kilometer length is far less than Shanghai's 639 kilometers, and even New York's 401 kilometers; but in 2018 its annual ridership of 3.463 billion was the world's largest, dwarfing that of second-ranked Moscow (2.369 billion), 3rd-ranked Shanghai (2.044 billion), and 6th-ranked New York City (1.806 billion).[51]

Tokyo's commitment to increasing its efficiency and circularity is seen in its FY 2019 budget, which features a 3-tiered approach to maximizing relevant amenities. These three are "safety city," "smart city," and "diver-city" (the latter a combination, in Japanese script, of "diverse" and "city"):

> 1. The safety-city budget centres on a large investment of JPY 300 billion in disaster-resilient water networks, carbon-sequestering levees, and other items.
>
> 2. The smart city component of the budget totals JPY 326 billion. The largest portion (JPY 207 billion) of this spending focuses on building up transport efficiency by integrating tele-work, transit-demand management and other smart initiatives.
>
> 3. The diversity-city aspect totals JPY 353 billion. Of this, fully JPY 174 billion is devoted to augmenting the national government's initiatives in providing free child-care and kindergarten education. At first glance, these items may seem extraneous to climate objectives. But relieving child poverty, increasing women's opportunities, and enhancing work-life balance are in fact crucial elements of sustainability.[52]

In addition, Tokyo has been using the impending 2020 Olympics as a deadline and venue for realizing multiple recycling and related projects. One is the Tokyo 2020 Medal Project, which aims to produce the projected 5000 gold, silver and bronze Olympic medals from recycled materials. For this objective, by March 31 of 2019, 78,985 tonnes of discarded mobile phones and other electronic devices were collected by 1,621 (over 90%) of Japan's 1,741 local governments (via e.g., 18,000 discard boxes). Moreover, collections via agreement with the major mobile carrier NTT Docomo resulted in the recovery of 6.21 million used mobile phones. All these recovered items will supply 100% of the roughly 32 kg of gold, 3,500 kg of silver, and 2,200 kg of bronze needed for the 5000 medals.[53]

Tokyo's "Medal Project" is being used deliberately to accelerate the normalization of recycling old electronic devices and other items in order to recover critical materials. Japanese

Ministry of the Environment assessments suggest that Japan has quite large volumes of gold, silver, platinum, antimony, indium, tantalum, and critical materials in its so-called "urban mines" of devices set aside without disposal. Indeed, concerning global "urban mine" volumes of gold, silver, lead, and indium, it appears that Japan's share exceeds other countries and regions sampled in the assessment, even the United States and China. Moreover, Japan's share of copper was 2nd, and its share of platinum and tantalum were 3rd.[54] The importance of accelerating the recovery and reuse of these materials is self-evident, particularly in the context of the increasing risks of scarcity in nickel and other critical material supplies.

Japan's Project for Promoting Compact Resource-Efficiency

We have seen how Tokyo invests heavily in smart city initiatives, seeking to build on its compact, resource-efficient advantage. The drivers for its action are aligned with the larger national incentives examined earlier. One prominent driver of Tokyo's material-efficiency and smart policy is institutionalized recognition of the need to cope with massive numbers. Tokyo's population, economic output and other metrics are enormous. These facts are the fruits of planning, and making them more sustainable and circular will also largely derive from smarter planning and policy integration.

Tokyo's planning embraces the scale of the global climate and resource crises. These numbers include population increases, higher levels of urbanization, and massive material requirements. For example, the global population has risen from 3 billion in 1960 to 7.7 billion in 2019 and appears likely to reach 10 billion by 2050.[55] Over the same period, the rate of urbanization has mushroomed. The United Nations Department of Economic and Social Affairs, Population Division, compiles surveys of "World Population Prospects." The Division's May 16, 2018 revision and subsequent updates indicate that global urbanization was roughly 30% in 1950, but had risen to 55.3% in 2018. It projects that urbanization is likely to increase to 60% by 2030 and then roughly 66% by 2050. It projects that most of this increase will be concentrated in the Asia-Pacific, whose megacities (10 million or more residents) are expected to swell from 20 in 2018 to 27 in 2030.[56]

The increase in total global population, together with the share living in cities, has profound implications for sustainability. The United Nations Environmental Programme (UNEP) has warned that cities already "consume 75% of the world's natural resources, 80% of the global energy supply and produce approximately 75% of the global carbon emissions."[57] Imagine if ongoing development in India and elsewhere proceeds along conventional lines. The OECD's 2015 report on Material Resources, Productivity and the Environment revealed that, in 2011, the average, daily per-capita consumption of materials in OECD countries was as follows: 10 kg of biomass, 18 kg of construction and industrial minerals, 13 kg of fossil energy carriers, and 5 kg of metals.[58] The UNEP's International Resource Panel (IRP) is equally stark in its 2018 report on "The Weight of Cities: Resource Requirements of Future Urbanization. And as noted earlier, the IRP working group on cities determined that continued conventional urbanization would increase annual urban resource requirements from 40 billion tonnes in 2010 to 90 billion tonnes in 2050.[59]

Japan is seeking to export its compact, resource-efficient urbanization globally. One indicator of this is seen in Japan's collaborative work with the World Bank, on disaster-resilient urban "lifeline" infrastructure. The World Bank has long argued that compact design affords more green space, enhances the efficiency of material use, and reduces disaster and other risks. In June of 2019, the World Bank quantified the benefit of this kind of urbanization, in low and middle-income countries, as potentially USD 4.2 trillion in avoided costs from damage and disruptions. The ratio of investment cost versus avoided cost was calculated at 1:4, meaning investment in resilient infrastructure more than paid for itself over the lifecycle.[60]

Japanese national-level policy stakeholders are collaborating on these initiatives, securing explicit recognition of the need for resilience and lifecycle assessments via the 2019 G20 Summit. They are also working to enhance the circularity of the approach through green infrastructure and other means. For example, in July of 2019 the Japanese Federation of Construction Contractors (JFCC) published a summary of green infrastructure's role in bolstering grey infrastructure's disaster-risk reduction (DRR) capacity, building biodiversity, and etc. Reflecting the comprehensive, integrated approach visible in Japan's national planning, the JFCC's publication placed green infrastructure in the larger context of DRR, enhancing biodiversity, bolstering public health, and multiple other objectives.[61] Indeed, in parallel with the JFCC's action, the Japanese MLIT instituted a special green infrastructure deliberation committee from December 26, 2018. The MLIT's committee's met 4 times and released an interim report in April of 2019 that highlighted the same items in the JFCC report.[62] And on the academic side, the Japanese Academic Association for Civil Engineering launched a special research project on melding grey and green infrastructure, a project that delivered a thorough report in March of 2019.[63]

The above consensus on green infrastructure links the Japanese state, the country's construction firms, and its top institutions of civil engineering. And they all place green infrastructure within the larger paradigm of circular, DRR, compact city development. The MLIT and JFCC emphasize the social capital and other co-benefits of green infrastructure. They assess green-grey, or simply green, solutions as having lower lifetime costs (thus bolstered local fiscal resilience) in addition to multiple co-benefits (e.g. biodiversity, local agriculture, CO2 absorption) that grey infrastructure alone does not and generally cannot offer.

And this consensus reflects the fruits of what these stakeholders have already done. Tokyo's "system of systems" integration of critical infrastructures includes a lot of green-grey hybrid solutions to flood and other hazards, and the new JFCC report has active links to them. The JFCC report in fact has 33 links to policies and projects.

In fact, compact and resource-efficient community has long been an element of Japan's National Spatial Planning and other policy regimes, and is incorporated in Japan's National Resilience and Society 5.0 industrial policies (Barret, DeWit, Yarime, 2020; DeWit 2018). Japan's comprehensive approach to resilience places the objective within multiple other goals, and matches that with integrated institutions and ample public finance.

Japan's paradigm is also increasingly the focus of official development assistance. Another counter to the "backward" narrative is seen in the Overseas Development Institute's ranking of Japan as first in the category of "global cooperation." This category measures support for multilateral institutions, tackling climate change by mitigation and adaptation, and combatting the spread of infectious diseases.[64]

Japan's integrated approach seeks to maximize the co-benefits for a very broad range of stakeholders, giving the paradigm enduring political legitimacy. This multilevel, cross-sectoral engagement enhances the potential for inter-personal, inter-regional, and inter-generational equity. We have seen that Japan's comprehensive initiatives are not well understood, in large part due to the power of the "environmentally backward country" narrative. But Japan offers useful lessons for the simultaneous problem solving that is the essence of the 2030 Agenda. Thus it seems well worth paying closer, unbiased attention to what Japan's actually doing as opposed to what it is said to be doing.

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Notes

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[2] Subsequent papers will focus on Japan's all-hazard National Resilience programme, Metropolitan Tokyo's "Zero Emission Tokyo Strategy," critical raw material challenges, and related issues.

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[4] The Climate Action Tracker data are available at the following URL: https://climateactiontracker.org

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[14] See the comparative statistics at "Solar PV," Renewable Energy Institute: https://www.renewable-ei.org/en/statistics/re/?cat=sun

[15] GW capacity additions are not equal to kWh power generation, because e.g. solar electricity

generation/capacity (or "capacity factor") varies with ambient conditions. A simple explanation of the capacity factor is available at the US Energy Information Agency's website: https://www.eia.gov/todayinenergy/detail.php?id=39832

[16] See the figure on "Net global solar PV capacity additions, 2016-2018," in IEA online Solar PV Tracking Report, May 2019: https://www.iea.org/reports/tracking-power-2019/solar-pv

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[18] On this alleged choice between nuclear or renewables, see Matsubara (2018), p. 6.

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