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# Decarbonisation on a Finite Planet: A Preliminary Assessment of Environmental and Social Impacts

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*Decarbonisation through the deployment of low-carbon technologies has become a central component in climate mitigation strategy. The production of these technologies, however, requires many more minerals compared to their conventional counterparts. Moreover, the technologies needed to recycle them at the end of their product lifetime are not yet fully developed. These potentially intensify various environmental and social pressures on the Earth that has already been overstretched for half a century in meeting the world's consumption demand. Managing resource extraction through sustainable and ethical mining and accelerating technological innovations for recycling are important, but alternative pathways aimed at bringing down consumption levels, possibly through a transformation in the economic system, are likely to be necessary to restore a balance with nature and avert climate and ecological crises.*

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# Introduction

Decarbonisation through the deployment of low-carbon technologies has become the most dominant strategy in addressing climate change. Decarbonisation essentially entails product substitutions, which are made possible by technological advancements. Solar and wind to replace coal plants, and electric cars to replace conventional vehicles, are among the most common examples. At present, despite the availability of environmentally friendly alternatives, decarbonisation at the global level is progressing slowly and results have been modest at best.

The most striking evidence is the continuing upward trend of greenhouse gas emissions since the end of World War II,[1] which stands in sharp contrast against the world's emission dip of up to 7 percent this year that would be made possible by pandemic lockdowns and constrained economic activities.[2] This observation suggests that slowing down the economy can reduce emission levels relatively quickly whereas decarbonisation could possibly achieve a similar result but within a longer time frame.

The arrival of the COVID-19 pandemic provides a window of opportunity for a green recovery that can speed up decarbonisation. Governments' current recovery responses, however, have not shown that a purposeful green recovery is likely[3] except in countries that were already making committed and substantial progress in low-carbon transitions even before the pandemic hit. This was seen, for example, in the European Union's and South Korea's 'green deals' that had been made part of recovery plans,[4] and the United Kingdom that pledges increased investments in wind energy as part of its recovery package.[5] Although decarbonisation may not necessarily get a deliberate push in a recovery programme, the momentum for transitions to low-carbon technologies will continue in many countries. China intending to go carbon neutral by 2060,[6] Japan pledging net-zero emissions by 2050, [7] the US presidential candidate Joe Biden campaigning for zero carbon pollution from the electricity sector by 2035 and net-zero emissions by 2050,[8] Singapore planning to import electricity from regional

[1] For illustration, see Figure 1 in the Appendix.

[2] Corinne Le Quéré, Robert B. Jackson, Matthew W. Jones, Adam J. P. Smith, Sam Abernethy, Robbie M. Andrew, Anthony J. De-Gol, David R. Willis, Yuli Shan, Josep G. Canadell, Pierre Friedlingstein, Felix Creutzig and Glen P. Peters, "Temporary Reduction in Daily Global $CO_2$ Emissions during the COVID-19 Forced Confinement," *Nature Climate Change* 10 (2020): 647-653, https://www.nature.com/articles/s41558-020-0797-x.

[3] Climate Action Tracker, *Pandemic Recovery: Positive Intentions vs Policy Rollbacks, with Just a Hint of Green*, last modified September 2020, https://climateactiontracker.org/documents/794/CAT_GlobalUpdate_Sept2020.pdf.

[4] For case studies from select Southeast Asian countries, please see: Margareth Sembiring, 'Green Recovery in Post-COVID-19 Southeast Asia?', NTS Insight, No. IN20-07 (Singapore: RSIS Centre for Non-Traditional Security Studies (NTS Centre), Nanyang Technological University Singapore, 2020).

[5] Andy Bruce, "Johnson Pitches Wind-driven Recovery from Pandemic," *Reuters*, October 6, 2020, https://www.reuters.com/article/uk-health-coronavirus-britain-johnson/johnson-pitches-wind-driven-recovery-from-pandemic-idUKKBN26Q343.

[6] Matt McGrath, "Climate Change: China Aims for 'Carbon Neutrality by 2060,'" *BBC*, September 22, 2020, https://www.bbc.com/news/science-environment-54256826.

[7] Kyodo, "U.N Welcomes Japan's Net Zero Emissions Pledge," *The Japan Times*, October 27, 2020, https://www.japantimes.co.jp/news/2020/10/27/national/un-japan-net-zero-emissions/.

[8] Emma Newburger, "Joe Biden Calls Climate Change the 'Number One Issue Facing Humanity'," *CNBC*, October 24, 2020, https://www.cnbc.com/2020/10/24/joe-biden-climate-change-is-number-one-issue-facing-humanity.html.

renewable sources,[9] and Indonesia looking to pass a presidential regulation on renewable energy by the end of the year[10] are some examples. While these are encouraging signs, the extent to which they will reduce emissions to the level sufficient to meet the 1.5°C Paris target, especially in light of the need to revive other sectors including high-carbon ones to revitalise economies after the pandemic, remains to be seen.

While much focus is given on decarbonisation's potential benefits for emission reduction, its environmental and social implications are less discussed. Considering its continuing expansion across the world in the next few decades, this Insight identifies these as an important aspect to examine. This study reflects on the current decarbonisation and emission reduction experience and considers the critical role of economic activities in contributing to greenhouse gas emissions. Given the centrality of consumption demand in economic activities, the analysis first looks at the different pressures that world's consumption has posed on the Earth. Within such a context, it then discusses various environmental and social impacts of decarbonisation.

The study observes that although transitions to low-carbon technologies will contribute to emission reduction, they will likely intensify existing environmental and social problems primarily due to their material-intensive requirements and a lack of capacity and capability to recycle them adequately at present. It thus recommends exploring alternative pathways to address such complex challenges, particularly by focusing on efforts to restore a balance with nature through an absolute reduction in consumption demand. Findings in existing literature suggest that this could potentially be achieved through a transformation of global economic system towards a steady-state economy. Further studies need to be conducted to examine the feasibility of such concept both in developed and developing countries, or to find other pathways that can address climate change and existing environmental and social challenges simultaneously since all of them are interconnected and critical to avert climate and ecological crises.

## Decarbonisation and Emission Reduction – Brief Overview of Present Status

Decarbonisation finds their applications across a broad range of sectors. Since most emissions come from energy use, the emphasis is generally placed on the energy sector. Consequently, a transition from fossil fuels to renewable sources like solar and wind becomes the most important element in decarbonisation efforts.

Policies encouraging low-carbon development have become commonplace in many countries. These have increased the share of renewables in global primary energy in the last decade although their effectiveness in bringing down emissions is still unobservable. This is seen in the general upward trend of emissions from energy use,[11] which is parallel to the increasing energy consumption[12] over the years. Furthermore, despite renewables' growing share, fossil fuels[13] still commanded about 85 percent of the total global primary energy in 2019, whereas renewables' share, excluding nuclear

[9] Audrey Tan, "S'pore to Import Electricity from Malaysia in Pilot Trial over 2 years," *The Straits Times*, October 26, 2020, https://www.straitstimes.com/singapore/environment/a-greener-energy-mix-for-singapore-with-more-solar-panels-electricity-import.

[10] Yunindita Prasidya and Norman Harsono, "Govt to Issue Green Energy Regulation This Year as Goals Remain Elusive," *The Jakarta Post*, October 26, 2020, https://www.thejakartapost.com/news/2020/10/26/govt-to-issue-green-energy-regulation-this-year-as-goals-remain-elusive.html.

[11] For illustration, see Figure 1 in the Appendix.

[12] For illustration, see Figure 2 in the Appendix.

[13] Fossil fuels include oil, coal, and natural gas.

and hydro, stood at 5 percent.[14] At this point, the extent to which renewables can successfully replace fossil fuels and bring down emissions in absolute terms, particularly by 7.6 percent every year in the next decade to reach the 1.5ºC Paris target,[15] is therefore uncertain.

The phenomenon is hardly surprising. Although decarbonisation has gained widespread support across the globe, economic growth aspiration seems to have constrained governments and businesses from making rapid low-carbon transitions. The economic growth goal necessitates governments to strategically consider which sectors to tax and subsidise, decide on infrastructure investments, and ensure just transition, among others, while facing various actors having competing interests in the domestic setting. The costs of solar and wind powers might have gone down significantly,[16] green businesses might have claimed to contribute positively to job creation, the economy, and the environment[17] and financial institutions may increasingly divest from coal and fossil fuels and favour renewable energy.[18] But until governments are confident that low-carbon alternatives do not jeopardise, or indeed can be more beneficial for economic growth-related interests, decarbonisation will generally remain slow in comparison to the scale of energy transition needed to attain the 1.5ºC Paris target.[19]

Along the same focus on economic growth, businesses are likely to embrace more sustainable alternatives if doing so gives them more benefits, or at least does not hurt their profitability. Businesses thus wait for the right incentives before making commitments to invest in green measures. These include, among others, reliable policies[20] that will minimise investment risks, metrics that can measure environmental, social, and governance (ESG) objectives[21] in financial terms clearly,[22] investment returns and executive salary[23] that are linked to environmental and societal benefits, and reputational benefits.[24] It is of little surprise, therefore, that in 2018 less than 7,000 companies of the millions worldwide declared their emissions,[25] and of these, only one in eight managed to decrease their annual emissions every year.[26] Thus, besides those that are visibly involved in low-carbon transitions, other industries may take more time to green their businesses.

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[14] BP, "Statistical Review of World Energy 2020, 69th Edition," accessed September 9, 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf.

[15] United Nations Environment Programme, *Cut Global Emissions by 7.6 Percent Every Year for Next Decade to Meet 1.5°C Paris target – UN Report*, last modified November 26, 2019, https://www.unenvironment.org/news-and-stories/press-release/cut-global-emissions-76-percent-every-year-next-decade-meet-15degc.

[16] John Woolard, "Beyond Renewables: How to Reduce Energy-related Emissions by Measuring What Matters," *World Resources Institute*, accessed October 2, 2020, https://www.wri.org/news/beyond-renewables-how-reduce-energy-related-emissions-measuring-what-matters.

[17] Joel Jaeger, "How Korea is Winning the Fight against COVID-19 while Ramping Up Climate Ambition," *World Resources Institute*, April 30,2020, https://www.wri.org/blog/2020/04/how-korea-winning-fight-against-covid-19-while-ramping-climate-ambition.

[18] Ellie Potter, "Wave of Institutional Divestment from Coal Mining, Generation Develops in 2019," *S&P Global Market Intelligence*, December 20, 2019 https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/56263503.

[19] Climate Action Tracker, *Governments Still Showing Little Sign of Acting on Climate Crisis*, last modified December 2019, https://climateactiontracker.org/documents/698/CAT_2019-12-10_BriefingCOP25_WarmingProjectionsGlobalUpdate_Dec2019.pdf.

[20] Oliver Cann, "Climate Action is Growing but More Companies and Government Ambition Required to Meet the "Net Zero" Challenge," *World Economic Forum*, December 11, 2019, https://www.weforum.org/press/2019/12/climate-action-is-growing-but-more-companies-and-government-ambition-required-to-meet-the-net-zero-challenge.

[21] Klaus Schwab, "Why We Need the 'Davos Manifesto' for a Better Kind of Capitalism," *World Economic Forum*, December 1, 2019, https://www.weforum.org/agenda/2019/12/why-we-need-the-davos-manifesto-for-better-kind-of-capitalism/.

[22] Cann, "Climate."

[23] Schwab, "Why."

[24] "ANA to Buy Jet Fuel Made from Renewable Materials by Singapore Refinery," *The Straits Times*, October 27, 2020 https://www.straitstimes.com/business/companies-markets/ana-to-buy-jet-fuel-made-from-renewable-materials-by-singapore-refinery.

[25] "Global Climate Change Analysis 2018," CDP, accessed October 2, 2020, https://www.cdp.net/en/research/global-reports/global-climate-change-report-2018.

[26] World Economic Forum, *The Net-Zero Challenge: Global Climate Action at a Crossroads (Part 1)*, (Cologny/Geneva: Switzerland, 2019), http://www3.weforum.org/docs/WEF_The_Net_Zero_Challenge_Part1.pdf.

The economic recovery from the COVID-19 pandemic is perceived to provide a window of opportunity to boost low-carbon transitions. A recovery scenario that may be compatible with the 1.5°C Paris target would involve a sweeping investment switch to low-carbon alternatives across multiple sectors including energy and electricity, land-based transport, industry, and buildings.[27] Since governments are likely to refer to their existing development plans as the basis for recovery, a potential acceleration in decarbonisation would thus depend on how far greening ideals had already been incorporated within development plans before the pandemic. Consequently, some countries may be able to make extra investments in low-carbon alternatives while some other countries will be less so, and some sectors may get greener after the pandemic while some others may not. This potential mixed outcome raises questions as to whether decarbonisation, as the dominant strategy in addressing climate issues, will be able to take place at the speed and scale necessary to achieve the 1.5°C Paris target.

## Consumption: Emissions and Other Environmental and Social Pressures

Considering the shortening time window to meet the 1.5°C Paris target, urgent and bolder measures may be necessary to complement decarbonisation efforts. The substantial emission reduction brought about by pandemic lockdowns has shown that slowing down economic activities has a parallel effect on emissions. In fact, since World War II, dramatic emission drops occurred mostly during the time of economic disruptions as seen in the 1979 second oil shock and the 2008 financial crisis.[28]

Informed by these experiences, the current approach to emission reduction may need to move away from a narrow emphasis on decarbonising the energy sector to the larger economic activities. Economic activities comprise mainly of natural resource extraction, production, consumption, and waste generation processes, but the main driver of economic activities is demand for consumption. Placing stronger measures to reduce demand for consumption, therefore, is likely to be followed by immediate emission decline.

Another reason to focus on consumption is the effect of emissions embedded in imported goods, which can lead to a significant reversal of the accounting of country's or region's emissions. For example, between 1990 and 2008, developed countries listed in the Annex B of the 1997 Kyoto Protocol[29] registered 3 percent drop in territorial emissions.[30] However, if emissions embedded in imports from developing countries were to be counted in, those Annex B countries had actually contributed to 11 percent of global emission growth in the same period.[31] Similarly, although the UK's Electricity, Gas and Water sector had contributed to 16 percent drop in domestic emissions between 1990 and 2011, emissions embedded in

[27] Climate Action Tracker, *A Government Roadmap for Addressing the Climate and Post COVID-19 Economic Crises*, last modified April 2020, https://climateactiontracker.org/documents/706/CAT_2020-04-27_Briefing_COVID19_Apr2020.pdf.

[28] Zhu Liu, Philippe Ciais, Zhu Deng, Ruixue Lei, Steven J. Davis, Sha Feng, Bo Zheng, Duo Cui, Xinyu Dou, Biqing Zhu, Rui Guo, Piyu Ke, Taochun Sun, Chenxi Lu, Pan He, Yuan Wang, Xu Yue, Yilong Wang, Yadong Lei, Hao Zhou, Zhaonan Cai, Yuhui Wu, Runtao Guo, Tingxuan Han, Jinjun Xue, Olivier Boucher, Eulalie Boucher, Frédéric Chevallier, Katsumasa Tanaka, Yimin Wei, Haiwang Zhong, Chongqing Kang, Ning Zhang, Bin Chen, Fengming Xi, Miaomiao Liu, François-Marie Bréon, Yonglong Lu, Qiang Zhang, Dabo Guan, Peng Gong, Daniel M. Kammen, Kebin He and Hans Joachim Schellnhuber, "Near-real-time Monitoring of Global CO2 Emissions Reveals the Effects of the COVID-19 Pandemic," *Nature Communications* 11 (2020): 5172, https://doi.org/10.1038/s41467-020-18922-7.

[29] The list of Annex B countries can be found on https://unfccc.int/sites/default/files/resource/docs/cop3/l07a01.pdf#page=24.

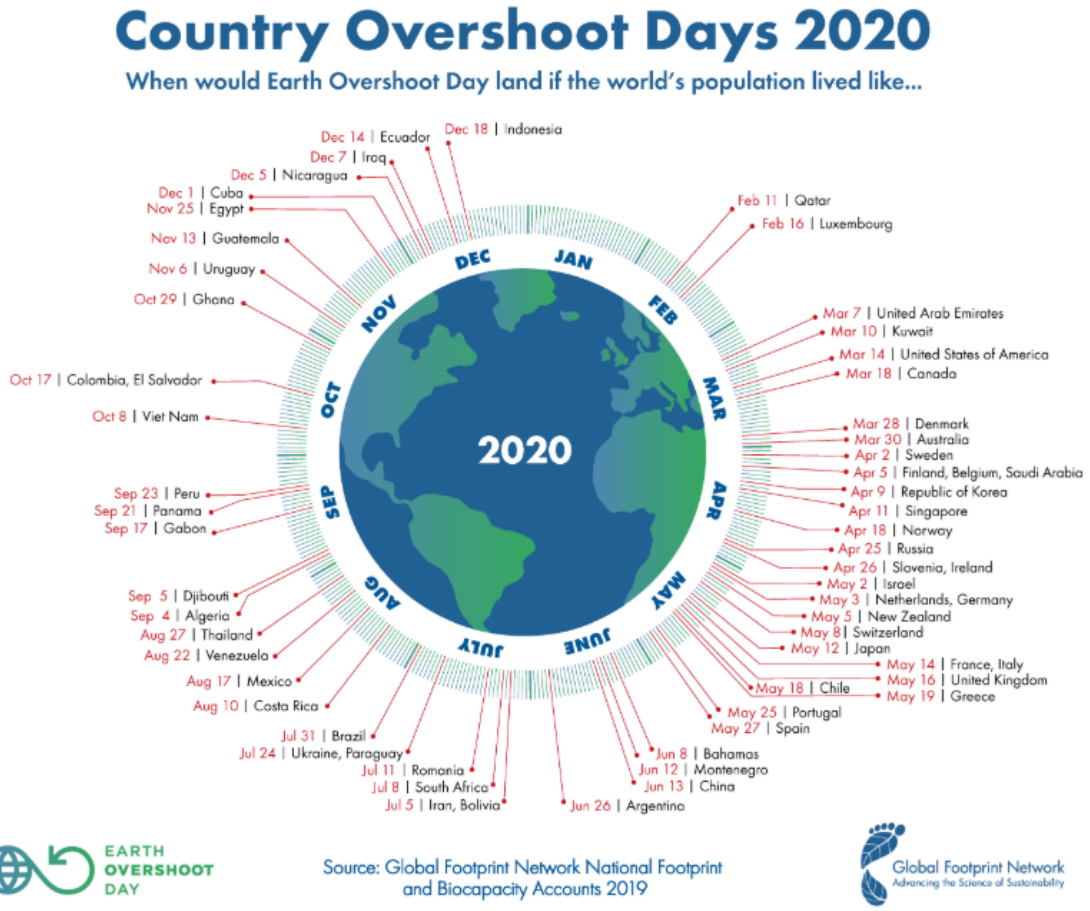
[30] Glen P. Peters, Jan C. Minx, Christopher L. Weber, and Ottmar Edenhofer, "Growth in Emission Transfers via International Trade from 1990 to 2008," *Proceedings of the National Academy of Sciences of the United States of America* 108 (21) (2011): 8903-8908, https://www.pnas.org/content/108/21/8903#F2.

[31] *Ibid*.

imports in the same sector had risen 208 percent and resulted in 10 percent increase of the UK's total carbon footprint during the same period.[32] The same phenomenon was observed for the EU's Electricity, Gas and Water sector.[33]
These observations thus suggest a phenomenon of emission shifting instead of absolute reduction in the EU and other developed countries that show declining emissions, which could partially explain why global emissions continued rising regardless. This stresses further the urgency to reduce consumption levels if meaningful emission cut at the global level were to be achieved.

Moreover, the link between increasing consumption and environmental stresses is well recognised.[34] Every year since 1970s, the world's consumption has been exacting toll on Earth's resources more than what it can regenerate, resulting in what is referred to as 'overshoot.'[35] It practically means resource depletion and accumulation of waste in the natural environment. Our consumption today sees an overshoot equivalent of 1.6 Earths, with advanced economies, and by extension the richer segments of society, disproportionately consuming more.[36] In 2016, consumption in North America and Western Europe needed an equivalent of 4.95 and 2.98 Earths respectively, whereas Asia and Africa needed 1.46 and 0.83 Earths respectively.[37] The wide disparity in the use of Earth's resources is stark that the date when the demand on nature exceeds its regenerative capacity would have fallen on 11 February 2020 if everyone in the world consumed natural resources like the population in Qatar, and would fall on 18 December 2020 if everybody in the world consumed natural resources like the population in Indonesia as shown in the figure below.[38]

[32] K. Kanemoto, D. Moran, M. Lenzen, A. Geschke, "International Trade Undermines National Emission Reduction Targets: New Evidence from Air Pollution," *Global Environmental Change* 24(2014): 52-59.
[33] *Ibid*.
[34] United Nations Convention to Combat Desertification (UNCCD), *Global Land Outlook First Edition* (Bonn: UNCCD, 2017), https://knowledge.unccd.int/sites/default/files/2018-06/GLO English_Full_Report_rev1.pdf.
[35] "Media Backgrounder: Earth Overshoot Day," Earth Overshoot Day, accessed October 2, 2020, https://www.overshootday.org/newsroom/media-backgrounder/.
[36] "Measure What You Treasure," Global Footprint Network, accessed October 2, 2020, https://www.footprintnetwork.org/.
[37] "Global Footprint Network," Ecological Footprint Explorer, accessed October 2, 2020, https://data.footprintnetwork.org/.
[38] "Country Overshoot Days 2020," Earth Overshoot Day, accessed October 2, 2020, https://www.overshootday.org/content/uploads/2020/02/GFN-Country-Overshoot-Day-2020.png; credit to Global Footprint Network www.footprintnetwork.org.




Indeed, resource consumption has tripled in the last fifty years.[39] The state of resource overextraction due to high consumption is consistent with 2.3 million km$^2$ of forest being deforested globally between 2000 and 2012 with only about 35 percent being reforested,[40] as well as other environmental problems like soil erosion, desertification, reduced cropland productivity, overgrazing, rapid biodiversity loss, overfishing and increased carbon concentration in the atmosphere.[41] It is also consistent with the global material footprint that had increased from 73.2 billion metric tons to 85.9 billion metric tons between 2010 and 2017.[42] While ecological overshoot can be maintained for a period of time, sustained overshoot will eventually lead to ecosystem degradation and possible ecosystem collapse.[43]

[39] Oberle, B., Bringezu, S., Hatfeld-Dodds, S., Hellweg, S., Schandl, H., Clement, J., and Cabernard, L., Che, N., Chen, D., Droz-Georget, H., Ekins, P., FischerKowalski, M., Flörke, M., Frank, S., Froemelt , A., Geschke, A., Haupt , M., Havlik, P., Hüfner, R., Lenzen, M., Lieber, M., Liu, B., Lu, Y., Lutter, S., Mehr , J., Miatto, A., Newth, D., Oberschelp , C., Obersteiner, M., Pfster, S., Piccoli, E., Schaldach, R., Schüngel, J., Sonderegger, T., Sudheshwar, A., Tanikawa, H., van der Voet, E., Walker, C., West, J., Wang, Z., Zhu, B., *Global Resources Outlook 2019: Natural Resources for the Future We Want,* A Report of the International Resource Panel (Nairobi: United Nations Environment Programme, 2019).

[40] UNCCD, "*Global Land Outlook First Edition*."

[41] "Media Backgrounder: Earth Overshoot Day," Earth Overshoot Day, accessed October 2, 2020, https://www.overshootday.org/newsroom/media-backgrounder/.

[42] "Ensure Sustainable Consumption and Production Patterns," United Nations, accessed October 26, 2020, https://unstats.un.org/sdgs/report/2020/goal-12/.

[43] "Media Backgrounder: Earth Overshoot Day."

The case for consumption reduction is further supported by the transgression of interconnected planetary boundaries, which refer to the limits within which the planet can function safely,[44] that the Earth is currently experiencing. At present, there is a strong indication that humanity may have exceeded the thresholds of four of the nine limits,[45] with two of them, namely climate change and biosphere integrity, being considered as the core components.[46] Violations to any of these limits can destabilise the Earth system and increase the risks of large-scale abrupt or irreversible environmental changes[47] regardless of some contestation over the role of human activities on the changing climate.

## Assessment of Environmental and Social Impacts of Decarbonisation

Within the context of an overstretched planet, decarbonisation through the development of low-carbon technologies thus presents a cause of concern. This is because such technologies require many more critical minerals compared to their fossil fuel-based counterparts.[48] An electric car requires five times more minerals compared to a conventional car,[49] and an onshore wind plant needs eight times as much compared to a gas-fired plant of the same capacity.[50] The development of electric storage batteries, which are an essential component for electric vehicles and wind and solar energy facilities, may even result in a 1000 percent increase in demands for aluminium, cobalt, iron, lead, lithium, manganese and nickel.[51]

To illustrate, based on 2018 estimates, the United Kingdom would need to consume nearly double the world's cobalt production, almost all its neodymium production, three quarter of its lithium production, and at least half of its copper production, if it is to replace all conventional vehicles, excluding large goods vehicles, with electric cars by 2050.[52] Since more and more countries are likely to phase out conventional cars and replace them with electric vehicles, resource depletion will only get intensified. Additionally, increasing demand for minerals may heighten competition for resources which may even escalate to strategic problems.

A parallel issue is waste generation. The manufacturing and deployment rates of low-carbon products are currently outpacing the development of technologies needed to recycle them. Not only recycling technologies for lithium-ion batteries are still being figured out,[53] solar panel waste is projected to amount to 8 million tonnes by 2030 and 78 million tonnes by

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[44] Johan Rockström, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart III Chapin, Eric Lambin, Timothy M. Lenton, Marten Scheffer, Carl Folke, Hans Joachim Schellnhuber, Björn Nykvist, Cynthia A. de Wit, Terry Hughes, Sander van der Leeuw, Henning Rodhe, Sverker Sörlin, Peter K. Snyder, Robert Costanza, Uno Svedin, Malin Falkenmark, Louise Karlberg, Robert W. Corell, Victoria J. Fabry, James Hansen, Brian Walker, Diana Liverman, Katherine Richardson, Paul Crutzen and Jonathan Foley, "Planetary Boundaries: Exploring the Safe Operating Space for Humanity," *Ecology and Society* 14, no. 2 (2009): Art. 32, http://www.ecologyandsociety.org/vol14/iss2/art32/.

[45] Will Steffen, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs, Stephen R. Carpenter, Wim de Vries, Cynthia A. de Wit, Carl Folke, Dieter Gerten, Jens Heinke, Georgina M. Mace, Linn M. Persson, Veerabhadran Ramanathan, Belinda Reyers, and Sverker Sörlin, "Planetary Boundaries: Guiding Human Development on a Changing Planet," *Science* 13, iss. 6223, (February 13, 2015), https://science.sciencemag.org/content/347/6223/1259855. For illustration, see Figure 3 in the Appendix.

[46] Steffen et al., 2015.

[47] Rockström et al., 2009.

[48] Tae-Yoon Kim and Milosz Karpinski, "Clean Energy Progress after the Covid-19 Crisis will Need Reliable Supplies of Critical Minerals," *International Energy Agency*, May 6, 2020, https://www.iea.org/articles/clean-energy-progress-after-the-covid-19-crisis-will-need-reliable-supplies-of-critical-minerals.

[49] For illustration, see Figure 4 in the Appendix.

[50] For illustration, see Figure 5 in the Appendix.

[51] International Bank for Reconstruction and Development/The World Bank, *The Growing Role of Minerals and Metals for a Low Carbon Future* (Washington, DC: The World Bank, 2017), https://knowledge.unccd.int/sites/default/files/2018-06/GLO English_Full_Report_rev1.pdf.

[52] "Leading Scientists Set Out Resource Challenge of Meeting Net Zero Emissions in the UK by 2050," National History Museum, last modified June 5, 2019, https://www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zer.html.

[53] "UK Needs to Act to Prevent Electric Vehicle Battery Waste Mountain - New Study," University of Birmingham, last modified November 7, 2019, https://www.birmingham.ac.uk/news/latest/2019/11/uk-needs-to-act-to-prevent-electric-vehicle-battery-waste-mountain.aspx.

2050,[54] and wind blades will see an estimated 43 million tonnes of waste by 2050.[55] In a world that is still grappling with plastic waste conundrum, which is now increasingly witnessing mounting electronic waste that has grown 40 percent in the last decade when the recycling rate only grew by mere 2 percent during the same period,[56] these additional millions of tonnes of waste from low-carbon products will certainly add extra pressures on the natural environment.

Intensifying resource extractions may compound existing social and environmental issues in producing countries. About 80 percent of world's poor live in rural area[57] where natural resources, the natural capital of the poor, [58] make up of 50 to 90 percent of their livelihoods.[59] Degrading agricultural land that has affected over 1.3 billion people, mostly in the developing countries,[60] is likely to get worsened by increasing demands for minerals driven by the development of low-carbon technologies.

The mining of nickel has turned parts of Indonesia's Sulawesi sea red with nearby fishing community being affected.[61] The demand for lithium, which is projected to rise five times between 2019 and 2025,[62] also has caused environmental degradation and affected drinking water supplies for local communities in Chile's Andes Mountain region.[63] The mining of cobalt in the Democratic Republic of the Congo, the single largest cobalt producer in the world, has seen alleged cases of environmental destruction, human right abuse, and child labour.[64]

Strengthening legal frameworks may be able to mitigate some of these issues. However, considering existing challenges in upholding environmental protection standards in many developing countries, this may not be immediately forthcoming. This is seen, for example, in the closures of several nickel mines in 2017 on the grounds of environmental violations,[65] and again in 2018 over similar issues,[66] in the Philippines.

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[54] IRENA and IEA-PVPS, 2016, *End-of-Life Management: Solar Photovoltaic Panels*, International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems, 2016, https://www.irena.org/documentdownloads/publications/irena_ieapvps_end-of-life_solar_pv_panels_2016.pdf.

[55] Pu Liu and Claire Y Barlow, "Wind Turbine Blade Waste in 2050," *Waste Management* 62(2017): 229-240 https://www.sciencedirect.com/science/article/abs/pii/S0956053X17300491#:~:text=The%20research%20indicates%20that%20there,rest%20of%20the%20world%2019%25.

[56] "Ensure Sustainable Consumption and Production Patterns."

[57] "For Up to 800 Million Rural Poor, a Strong World Bank Commitment to Agriculture," The World Bank, last modified November 12, 2014, https://www.worldbank.org/en/news/feature/2014/11/12/for-up-to-800-million-rural-poor-a-strong-world-bank-commitment-to-agriculture.

[58] Isabell Kempf, "Poverty and the Environment/Climate Change," *United Nations Environment*, accessed October 2, 2020, https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2018/05/9.pdf

[59] "What is the GDP of the Poor?," Convention on Biological Diversity, accessed October 2, 2020, https://www.cbd.int/article/biodiversityforpovertyreduction-1.

[60] United Nations Convention to Combat Desertification (UNCCD), *Global Land Outlook First Edition* (Bonn: UNCCD, 2017), https://knowledge.unccd.int/sites/default/files/2018-06/GLO English_Full_Report_rev1.pdf.

[61] Ian Morse, "Mining Turned Indonesian Seas Red. The Drive for Greener Cars Could Herald a New Toxic Tide," *The Washington Post*, November 20, 2019, https://www.washingtonpost.com/world/asia-pacific/mining-turned-indonesian-seas-red-the-drive-for-greener-cars-could-herald-a-new-toxic-tide/2019/11/19/39c76a84-01ff-11ea-8341-cc3dce52e7de_story.html.

[62] James Ellsmoor, "Electric Vehicles Are Driving Demand For Lithium - With Environmental Consequences," *Forbes*, June 10, 2019, https://www.forbes.com/sites/jamesellsmoor/2019/06/10/electric-vehicles-are-driving-demand-for-lithium-with-environmental-consequences/#485b2fc962e2.

[63] Laura Millan Lombrana, "Saving the Planet With Electric Cars Means Strangling This Desert," *Bloomberg*, June 11, 2019, https://www.bloomberg.com/news/features/2019-06-11/saving-the-planet-with-electric-cars-means-strangling-this-desert.

[64] Annie Kelly, "Apple and Google Named in US Lawsuit over Congolese Child Cobalt Mining Deaths," *The Guardian*, December 16, 2019, https://www.theguardian.com/global-development/2019/dec/16/apple-and-google-named-in-us-lawsuit-over-congolese-child-cobalt-mining-deaths.

[65] Enrico dela Cruz and Manolo Serapio Jr, "Philippines to Shut Half of Mines, Mostly Nickel, in Environmental Clampdown," *Reuters*, February 2, 2017, https://www.reuters.com/article/us-philippines-mining/philippines-to-shut-half-of-mines-mostly-nickel-in-environmental-clampdown-idUSKBN15H0BQ.

[66] Enrico dela Cruz and Kenneth Maxwell, "Philippines Implements Fresh Nickel Mining Curbs in Environment Protection Drive," *Reuters*, September 6, 2018, https://www.reuters.com/article/us-philippines-mining/philippines-implements-fresh-nickel-mining-curbs-in-environment-protection-drive-idUSKCN1LM0KY.

A reflection on the COVID-19 experience has confirmed that the poor are among the least able to cope during crises. The public health emergency has aggravated existing vulnerabilities among urban informal workers, rural agricultural households, migrants, refugees, among others, as they often lack the means to fend for themselves and are not sufficiently covered by social safety nets.[67] Along the same logic, poorer countries have much less capacity to respond to the coronavirus outbreak.[68] This is seen, for example, in the worsening poverty levels in these countries which will see more than 500 million new poor.[69] While the current situation shows the great need to strengthen social protection measures and other anti-poverty policies, the vicious cycle can only be broken by tackling the problem at its source.

Considering the significance of natural resources for the livelihoods of the poor, the efforts can begin by addressing production- and consumption-driven environmental degradations. Nature takes time to heal. Forest in average undergoes about 2 percent recovery per year whereas river and marine ecosystems recover at slightly faster rates.[70] Depending on the severity of damage being done, ecosystem may recover during human lifetime up to a thousand years.[71] Contrary to popular belief, deliberate human interventions such as tree replanting or river bank restoration do not significantly assist ecosystem recovery.[72] While in some instances they may be helpful to initiate recovery processes, ecosystem recovery is best left to nature itself.[73] This may not even result in a total recovery,[74] thereby stressing the real concerns over biodiversity loss caused by environmental destructions.

It is evident, therefore, that reducing consumption demand is critical not only to bring down emissions, but also to give nature the time and space it needs to recover from extraction damages, and to give back to the poor their dignity and resilience through sustainable livelihoods.

## Exploring Alternative Pathways

The economic miracles post-World War II and post-Great Depression certainly present a hopeful picture for a post-COVID-19 world,[75] but there is a need to be completely mindful that those eras had not yet experienced an ecological overshoot. Although a green recovery after the pandemic is widely believed to provide a pro-environment pathway to economic revitalisation, a focus on low-carbon transitions risks exacerbating existing environmental and social pressures despite their potential to bring emission levels down.

Exploring alternative trajectories is therefore imperative. In the world that has been on an ecological overshoot for at least

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[67] Stephen Devereux, Jeremy Lind, Keetie Roelen, and Rachel Sabates-Wheeler, "Covid-19 and Social Protection Needs: Who are the Most Vulnerable?," *Institute of Development Studies*, May 7, 2020, https://www.ids.ac.uk/opinions/covid-19-and-social-protection-needs-who-are-the-most-vulnerable/.

[68] Stephen Devereux, Jeremy Lind, Keetie Roelen, and Rachel Sabates-Wheeler, "Covid-19 and Social Protection Responses: Time for a Global Safety Net?," *Institute of Development Studies*, May 14, 2020, https://www.ids.ac.uk/opinions/covid-19-and-social-protection-responses-time-for-a-global-safety-net/.

[69] Andy Sumner, Chris Hoy, and Eduardo Ortiz-Juarez, "Estimates of the Impact of COVID-19 on Global Poverty," *United Nations University-WIDER Working Paper 2020/43*, 2020, https://www.wider.unu.edu/sites/default/files/Publications/Working-paper/PDF/wp2020-43.pdf.

[70] Holly P. Jones, Peter C. Jones, Edward B. Barbier, Ryan C. Blackburn, Jose M. Rey Benayas, Karen D. Holl, Michelle McCrackin, Paula Meli, Daniel Montoya and David Moreno Mateos , "Restoration and Repair of Earth's Damaged Ecosystems," *Proceedings of the Royal Society B: Biological Sciences* 285: 20172577, (2018), https://royalsocietypublishing.org/lookup/doi/10.1098/rspb.2017.2577#RSPB20172577F2.

[71] *Ibid*.

[72] *Ibid*.

[73] *Ibid*.

[74] *Ibid*.

[75] Banerjee Abhijit and Esther Duflo, "Abhijit Banerjee and Esther Duflo on How Economies can Rebound," *The Economist*, May 26, 2020, https://www.economist.com/by-invitation/2020/05/26/abhijit-banerjee-and-esther-duflo-on-how-economies-can-rebound.

half a century, reducing consumption in absolute terms offers a potentially effective solution towards restoring a balance with nature while reducing emissions. A transformation of the current global economic system to a steady-state economy[76] may be a way to achieve such a vision. Popularised by ecological economist Herman Daly in 1970s, a steady-state economy is defined as "an economy with constant population and constant stock of capital, maintained by a low rate of throughput that is within the regenerative and assimilative capacities of the ecosystem."[77] In practice, what steady-state economy concept proposes is for wealthy countries to reduce consumption absolutely by slowing down economic growth, or de-growth, so that developing countries can have the resources and space they need to grow within ecological limits. Sustainable de-growth in developed economies can be defined as "an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level, in the short and long term."[78]

Speaking of slowing down the economy amidst the COVID-19 pandemic may sound far-fetched given the economic hardship that it has already caused. However, studies show that with well-calibrated policies in work duration, anti-poverty and adult literacy programs, and health care,[79] among others, progress without economic growth is possible,[80] and it may not necessarily lead to increased unemployment, poverty and inequality. Additionally, the right adjustments to worker-employer relations may lead to decreased income inequality and stronger employment stability even in a de-growth economy.[81] Existing literature has seen a number of modelling being produced to project the plausible outcomes of a de-growth strategy. For example, a modelling of the Canadian economy shows that a targeted decline in Gross Domestic Product (GDP) combined with a high carbon tax may result in close to 80 percent reduction in greenhouse gas emissions between 2005 and 2035 while substantially reducing unemployment, the human poverty index, and the debt to GDP ratio.[82] More studies need to be conducted to see the feasibility of employing the steady-state economy concept in other developed countries.

As for developing countries, an assessment of how the economies can grow within ecological limits needs to be pursued. One possible way is to see how the mainstreaming of the circular economy model,[83] which envisions a reduction of material use in production processes through reduce, re-use, repair, refurbish and recover methods, can help to attain such a goal. Alternatively, developing countries may come up with their own concepts to achieve developmental goals within the ecological limits.

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[76] Robert Dietz and Daniel W. O'Neill, *Enough is Enough* (San Francisco, California: Berrett-Koehler Publishers, 2013).

[77] Herman E Daly, *A Steady-State Economy*, Sustainable Development Commission, UK, last modified April 24, 2008, http://www.pym.org/eco-justice-collaborative/wp-content/uploads/sites/58/2016/05/DalyteadyStateEconomy.pdf.

[78] François Schneider, Giorgos Kallis, and Joan Martinez-Alier, "Crisis or Opportunity? Economic Degrowth for Social Equity and Ecological Sustainability. Introduction to this Special Issue," *Journal of Cleaner Production* 18 (2010): 512.

[79] Peter A. Victor, *Managing without Growth. Slower by Design, Not Disaster* (Cheltenham, U.K.; Northampton, MA, USA: Edward Elgar, 2008).

[80] Tim Jackson, *Prosperity without Growth: Economics for a Finite Planet* (London, UK; Sterling, VA, USA: Earthscan, 2009).

[81] Tim Jackson, "The Post-growth Challenge: Secular Stagnation, Inequality and the Limits to Growth," *Ecological Economics* 156 (2019): 236-246, https://www.sciencedirect.com/science/article/abs/pii/S0921800918309455.

[82] Peter A. Victor, "Growth, Degrowth and Climate Change: A Scenario Analysis," *Ecological Economics* 84 (2012): 206-212, https://www.sciencedirect.com/science/article/abs/pii/S0921800911001662.

[83] See for example: Carlos Scheel, Eduardo Aguiñaga and Bernardo Bello, Decoupling Economic Development from the Consumption of Finite Resources Using Circular Economy. A Model for Developing Countries, *Sustainability* 12 (2020), 1291, https://www.mdpi.com/2071-1050/12/4/1291/htm.

## Conclusion

The COVID-19 crisis has brought enormous woes to humanity. At the same time, despite being largely unintended, the global pandemic has also reduced emissions close to the levels much needed to attain the 1.5°C Paris target. This provides a point of reflection on the current decarbonisation experiences that have yet to see emission reduction at the global level, and the potential of making substantial emission cuts through a transformation in the economic system.

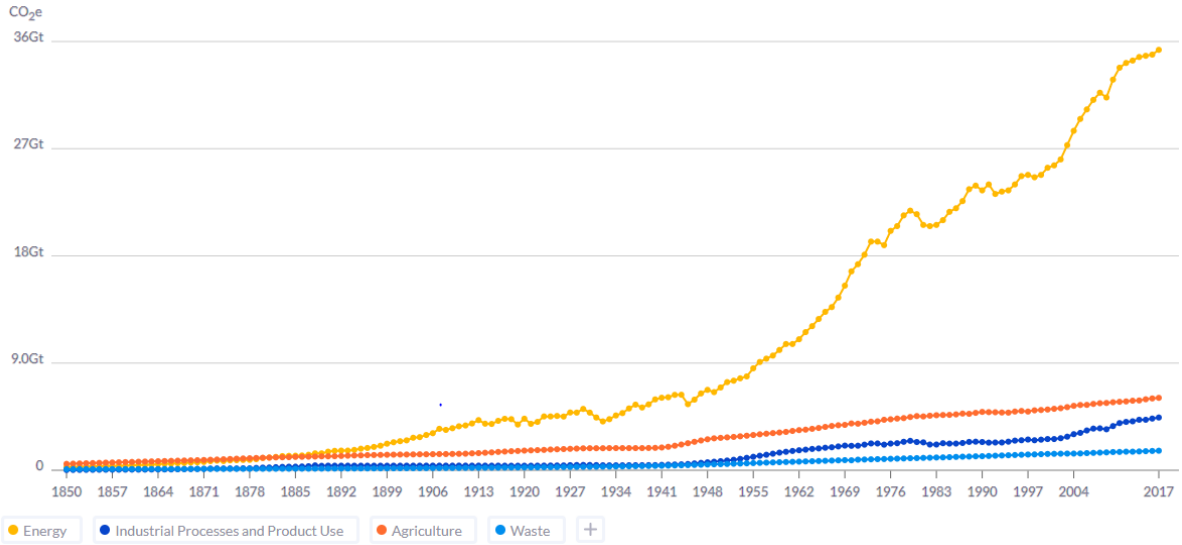
Moreover, a transition to low-carbon technologies is taking place against the backdrop of numerous environmental and social problems that the world's consumption demand, which has been exceeding what nature can regenerate for about fifty years, has been causing. Sustained ecological overshoot, which may eventually lead to environmental degradation and collapse, is being accompanied by a transgression of four out of the nine planetary boundaries that increases the likelihood of large-scale sudden or irreversible environmental changes. The continuing expansion of low-carbon technologies, which requires many more mineral resources compared to their conventional counterparts and presently does not come with adequate product end-of-life solutions, is therefore likely to compound existing environmental and social pressures.

Managing these additional challenges through, for example, sustainable and ethical mining and waste management, may be able to mitigate some of the pressures. However, considering the existing state of already depleting resources, which is often accompanied by the plight of the poor, improvement in process management alone may not be enough. Similarly, attempts at decreasing resource demand *relative* to the previous levels through greener products, increased efficiency, circular economy, net-zero emission, and sustainable resource management may help, but may not be sufficient. Instead, exploring and finding alternative pathways that aim at reducing the use of resources in *absolute* term is imperative to restore a balance with nature.

Through the study of existing literature, this Insight finds that a transformation of the global economic system towards steady-state economy may provide a viable alternative. In practice, steady-state economy envisions consumption reduction through a slowing down of the economy in developed countries and a growing of the economy in developing countries within certain ecological limits. International community, regional actors, and national governments need to urgently come together to further examine the feasibility of steady-state economy concepts in both developed and developing countries, or to find other pathways that can address climate change and existing environmental and social challenges simultaneously since all of them are interconnected and critical to avert climate and ecological crises.

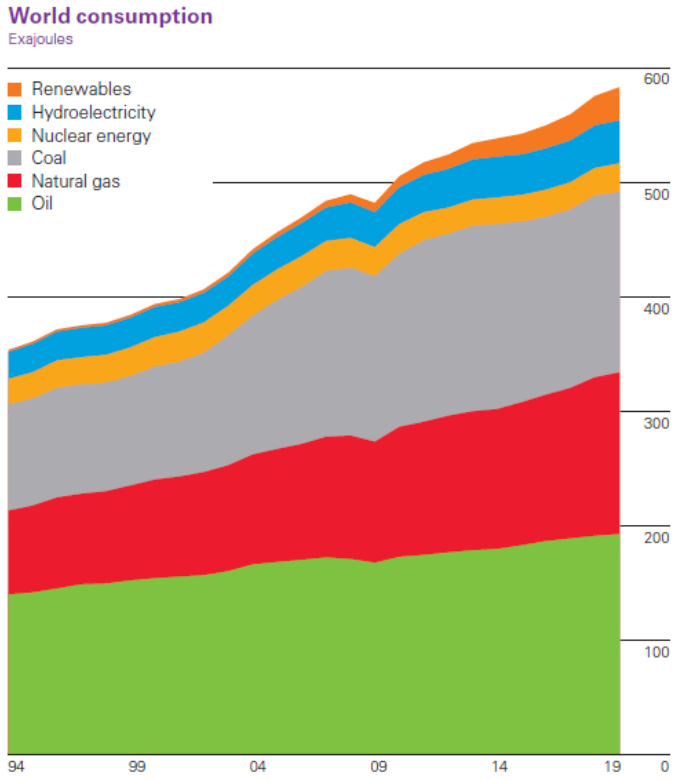
# Appendix

**Figure 1: Continuing upward trend of greenhouse gas emissions by sector (1850-2017)[84]**



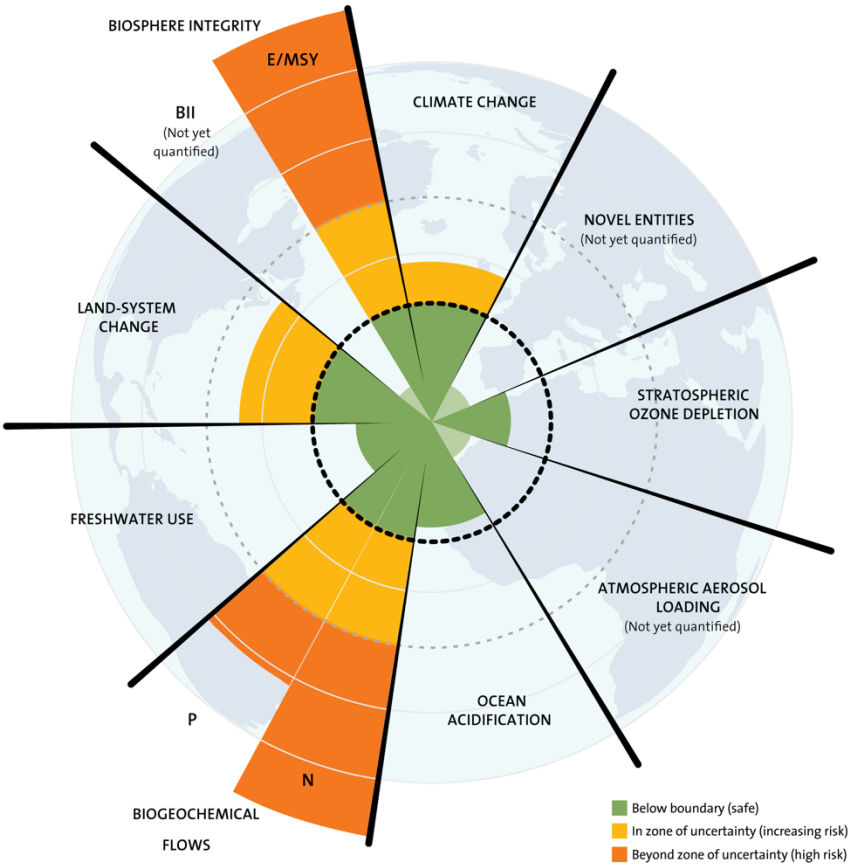

[84] "Global Historical Emissions," ClimateWatch, accessed October 2, 2020, https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&source=72.

**Figure 2: Increasing global energy consumption (1994-2019)**[85]




[85] BP, "Statistical Review of World Energy 2020, 69th Edition," accessed September 9, 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf, p. 10.

**Figure 3: Nine planetary boundaries and the four transgressed zones highlighted in yellow[86]**




[86] Steffen et al., 2015, p. 1259855-6.

**Figure 4: Amount of minerals used in selected transport technologies[87]**

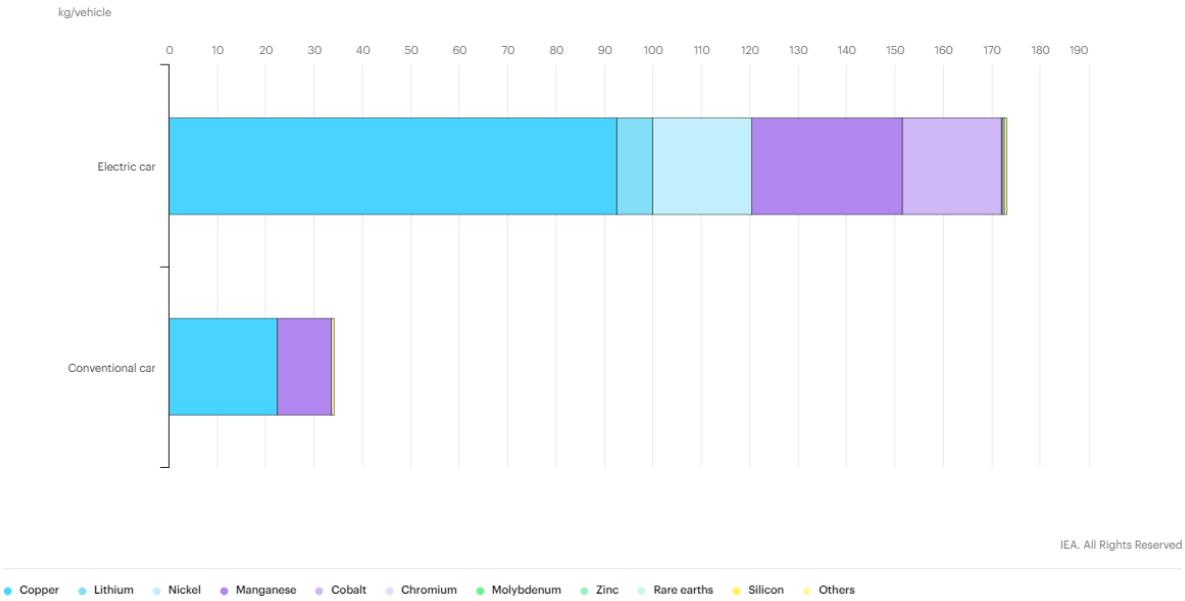
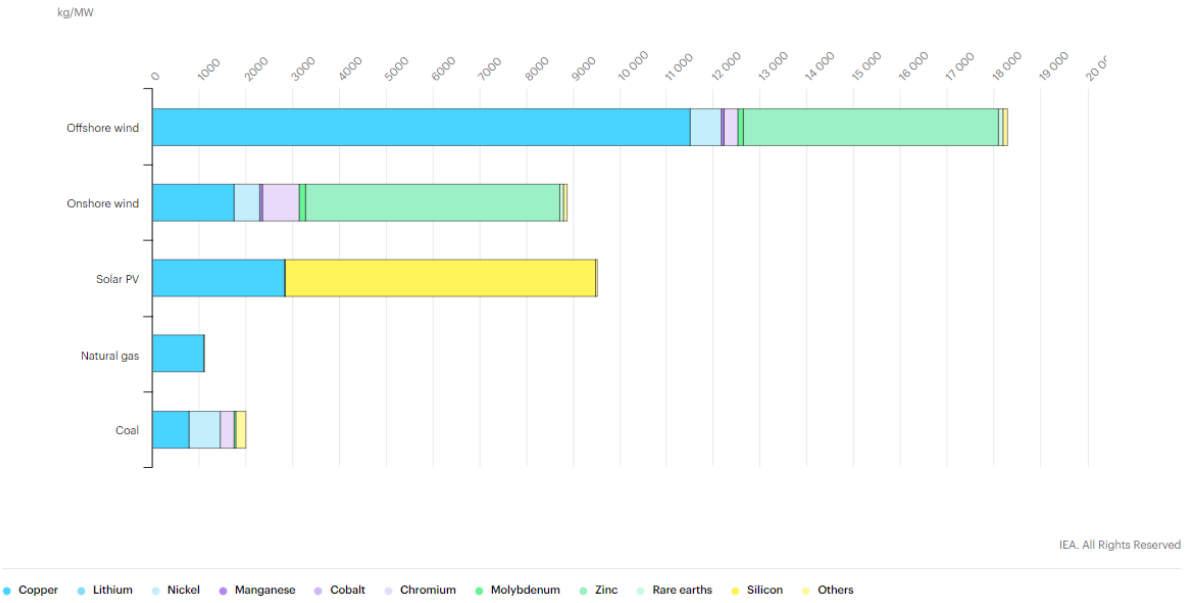



**Figure 5: Minerals used in selected power generation technologies[88]**




[87] "Minerals Used in Selected Transport Technologies," International Energy Agency, last modified May 6, 2020, https://www.iea.org/data-and-statistics/charts/minerals-used-in-selected-transport-technologies. All rights reserved.

[88] "Minerals Used in Selected Power Generation Technologies," International Energy Agency, last modified May 6, 2020, https://www.iea.org/data-and-statistics/charts/minerals-used-in-selected-power-generation-technologies. All rights reserved.

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