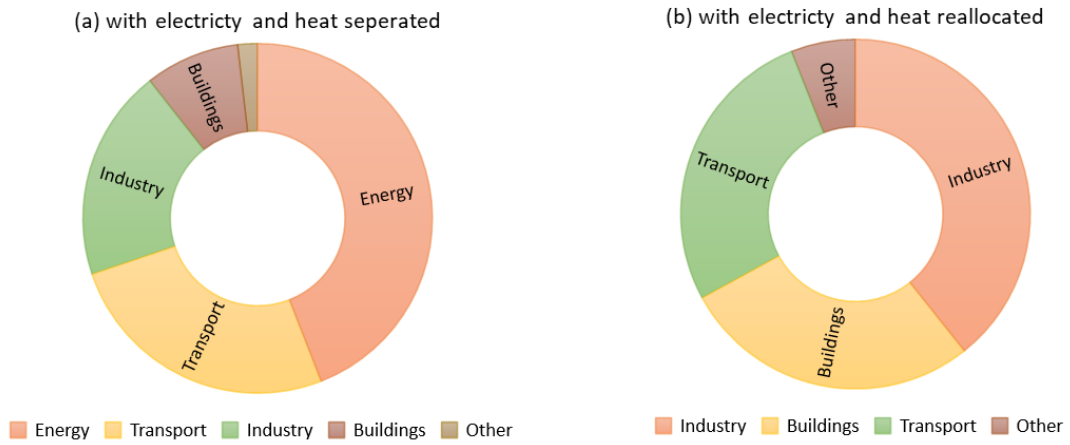
LESS MATERIAL PROJECT[1]

Industrial Emissions and Material Efficiency

by Sedat Alataş, 28 August 2022

Recent data suggest that the fossil fuel share of the industry sector's energy mix has decreased over the years, yet it is still above 65% in 2020 [1]. Therefore, as depicted in Figure 1, industrial emissions alone become responsible for a significant proportion of current global emissions. Figure 1 presents the sectoral share of global emissions. As seen in panel a, emissions from the energy sector almost consist of 50% of global emissions, which is followed by the transport sector with a share of 20%. The dominance of the energy sector on CO2 emissions shown in panel a clearly reveals why countries have so far prioritized designing more energy efficiency and renewable energy improvements as a mitigation policy [2]–[7]. On the other hand, as shown in panel b, if the energy (electricity and heat) related emissions are reallocated to other final sectors, industrial emissions take the lead with almost %40. It means that the industry sector is energy-intensive and thus might play a crucial role in achieving the net-zero targets [8]–[12].

Figure 1. Sectoral Share of Global CO2 Emissions in 2019 [13]



Many different factors including carbon leakage, strong lock-in, stranded assets issue, technical and economic dependencies, price competition, or cost sensitivity, might significantly explain why emissions from the industry are now high and expected to grow in the future. However, the main factor that makes the industry sector "hard-to-abate" is indeed closely related to the

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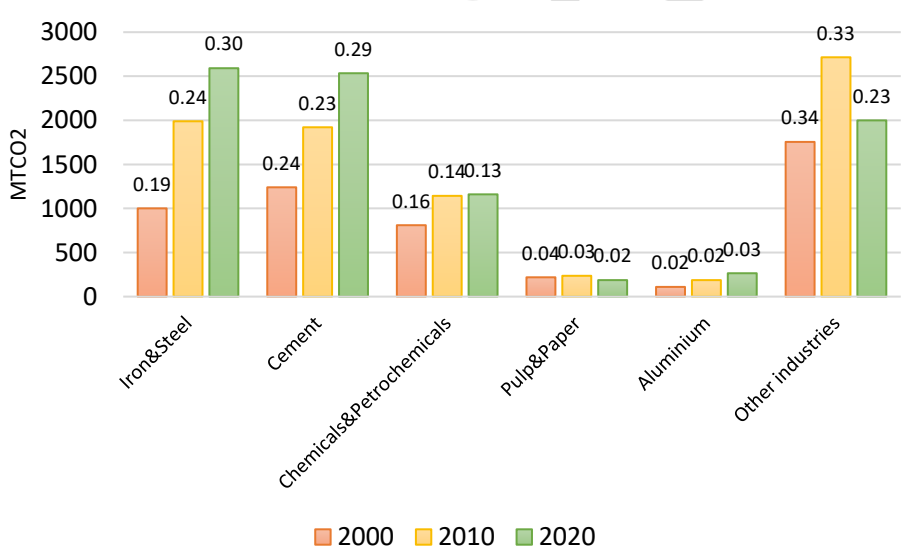
production process of the sector itself. It is because the energy consumption of the industry sector is driven by the production of some specific energy-intensive materials, such as iron & steel, cement, chemicals, and pulp & paper. For example, iron & steel and cement production together consist of more than 50% of all industrial emissions, as seen in Figure 2, as these materials need high-temperature heat to be produced. More importantly, as their energy requirement still heavily relies on fossil fuels both in the extraction and processing steps, and as alternative renewable energy sources and clean energy technologies do not still reliably and cost-efficiently meet their energy requirement, producing these materials are themselves a major source of emissions and make the decarbonization of the industry sector challenging. Therefore, industrial decarbonization, specifically in steel and cement subsectors, does not only require implementing immediate actions on reliable renewable energy or cost-efficient low-carbon technologies but also a dramatic transformation in the whole industrial production process [9]–[12], [14]–[16].

Figure 2. Direct CO2 Emissions of Industry Subsectors [1]



As suggested by the recently published IPCC report and many other articles [2], [4], [12], [17], one of the most important mitigation options (among energy efficiency, fuel switching, CCU-CCS technologies, and many others) in terms of its potential contribution to net-zero in the industry is material efficiency. Material efficiency is an important component of resource efficiency, along with energy and natural resources efficiency [18]–[20], and mainly refers to the reduction of material input for the same output. However, it is equally important to note that

material efficiency does not only reduce material use but also energy use as material production requires huge amounts of energy.

When compared to other low-carbon technologies, material efficiency strategies are more cost-effective and can be implemented in the short term. For example, CCU and CCS technologies are considered important climate policy actions in tackling global climate change. However, their mitigation potential is still controversial as they have not been successfully implemented on a large scale and are economically costly [20]. Therefore, it is considered that designing and implementing a green industrial strategy with a special focus on materials and material efficiency strategies is very important for a deep reduction of emissions and can significantly contribute to the circular economy efforts by affecting all production phases from the design stage to the end-of-life.

References

[1] International Energy Agency (IEA), "Tracking Industry 2021," 2021.

[2] J. M. Allwood, M. F. Ashby, T. G. Gutowski, and E. Worrell, "Material efficiency: A white paper," *Resour Conserv Recycl*, vol. 55, no. 3, pp. 362–381, 2011, doi: 10.1016/j.resconrec.2010.11.002.

[3] J. M. Allwood, M. F. Ashby, T. G. Gutowski, and E. Worrell, "Material efficiency: Providing material services with less material production," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 371, no. 1986, 2013, doi: 10.1098/rsta.2012.0496.

[4] T. Aidt, L. Jia, and H. Low, "Are prices enough? The economics of material demand reduction," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 375, no. 2095, 2017, doi: 10.1098/rsta.2016.0370.

[5] S. Alataş, E. Karakaya, and B. Hiçyılmaz, "What Does Input Substitution Tell Us in Helping Decarbonization and Dematerialization? Industry Level Analysis for South Korea," *Sustain Prod Consum*, vol. 27, pp. 411–424, 2021, doi: 10.1016/j.spc.2020.11.015.

[6] S. Alataş, E. Karakaya, and E. Sarı, "The potential of material productivity alongside energy productivity in climate mitigation: Evidence from convergence tests in the EU28," *Resour Conserv Recycl*, vol. 167, 2021, doi: 10.1016/j.resconrec.2020.105322.

[7] E. Karakaya, E. Sarı, and S. Alataş, "What drives material use in the EU? Evidence from club convergence and decomposition analysis on domestic material consumption and material footprint," *Resources Policy*, vol. 70, 2021, doi: 10.1016/j.resourpol.2020.101904.

[8] A. Denis-Ryan, C. Bataille, and F. Jotzo, "Managing carbon-intensive materials in a decarbonizing world without a global price on carbon," *Climate Policy*, vol. 16, pp. 110–128, 2016, doi: 10.1080/14693062.2016.1176008.

[9] S. J. Davis *et al.*, "Net-zero emissions energy systems," *Science (1979)*, vol. 360, no. 1419, 2018, doi: 10.1126/science.aas9793.

[10] C. Bataille *et al.*, "A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement," *J Clean Prod*, vol. 187, pp. 960–973, 2018, doi: 10.1016/j.jclepro.2018.03.107.

[11] Material Economics, "Industrial Transformation 2050 Pathways to Net-Zero Emissions from EU Heavy Industry," 2019.

[12] C. G. F. Bataille, "Physical and policy pathways to net-zero emissions industry," *Wiley Interdiscip Rev Clim Change*, vol. 11, no. 2, pp. 1–20, 2020, doi: 10.1002/wcc.633.

[13] International Energy Agency (IEA), "Material Efficiency in Clean Energy Transitions," Paris, 2019. doi: 10.1787/aeaaccd8-en.

[14] J. M. Allwood, J. M. Cullen, and R. L. Milford, "Options for achieving a 50% cut in industrial carbon emissions by 2050," *Environ Sci Technol*, vol. 44, no. 6, pp. 1888–1894, 2010, doi: 10.1021/es902909k.

[15] J. Feldmann and K. Kennedy, "Toward a Tradable, Low-Carbon Product Standard for Steel: Policy Design Considerations for the United States," *World Resources Institute*, pp. 1–18, 2021, doi: 10.46830/wriwp.20.00113.

[16] T. Fransen, K. Lebling, D. Weyl, and K. Kennedy, "Toward a Tradable Low-Carbon Cement Standard: Policy Design Considerations for the United States," *World Resources Institute*, pp. 1–26, 2021, doi: 10.46830/wriwp.20.00112.

[17] Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2022 Mitigation of Climate Change Summary for Policymakers," 2022.

[18] International Resource Panel (IRP), *Resource Efficiency and Climate Change Material Efficiency Strategies for a Low-Carbon Future Summary for Policymakers*. Nairobi, Kenya, 2020. doi: 10.5281/zenodo.3542680.

[19] C. Deckert, "Ecological sustainability of material resources – Why material efficiency just isn't enough," *uwf UmweltWirtschaftsForum*, vol. 24, no. 4, pp. 325–335, 2016, doi: 10.1007/s00550-016-0419-2.

[20] B. Hiçyilmaz, S. Alataş, and E. Karakaya, "Sanayide Karbonsuzlaşma: Malzeme Etkinliği Stratejilerinin Rolü," *Çevre, Şehir ve İklim Dergisi*, no. 2, pp. 81–118, 2022.