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Decarbonization by 2050: Looking Back to Look Ahead◆

Kenneth B Medlock III*

Carbon neutrality is now dominant in commercial and political discourse. There is a growing list of net-zero commitments by large firms – including BP, Shell, Equinor, Repsol, Eni, Occidental Petroleum, Cenovus, Canadian Natural Resources, Southern Company, Entergy, Total, Lundin Petroleum, Dominion Energy, NRG, Baker Hughes, Duke Energy and Williams – all of which have significant fossil fuel portfolios. In addition, a growing number of large banks and investors – including Morgan Stanley, JPMorgan, Citigroup, BlackRock, Pimco and Bank of America – have pledged to review the climate impacts of future capital allocations.

Many governments around the world are also expressing net-zero intentions, with various pathways under consideration – including greater use of renewables, electrification, hydrogen, and carbon capture technologies. The European Union (EU), perhaps the most aggressive in its intentions, is contemplating ways to drive lower carbon intensity in the products it imports, including a border carbon adjustment mechanism.

The COVID-19 pandemic has also had a lasting impact. The human and economic tolls are well-documented and staggering. Recovery has many governments looking to link economic stimulus with green energy initiatives and policies to address environmental concerns. This is especially true in the developed countries in the Organization of Economic Cooperation and Development (OECD).

While the fiscal wherewithal to focus on green recovery will vary by region, simultaneous efforts to improve energy access in developing nations present an important juxtaposition. The world of energy is one of "haves" (OECD) and "have-nots" (non-OECD). Although the paradigm is shifting, a large fraction of the global community still lacks access to modern energy services, most of whom are in the non-OECD. Access to modern energy services is critical for economic growth and improved living standards. Economic progress supports the investment required to expand energy access; hence a virtuous cycle. The concomitant growth in energy use need not be in conflict with net-zero commitments. Indeed, the dual goals of economic growth and environmental sustainability are paramount, which begs the question, "Is net-zero attainable?"

◆ This article builds from arguments presented in Medlock, III, Kenneth B., "Energy Transition, COVID-19, Comparative Advantage, and a World of Uncertainty," *Oxford Energy Forum: COVID-19 and the Energy Transition*, Issue 123, pp. 63-66. (https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/07/OEF123.pdf).

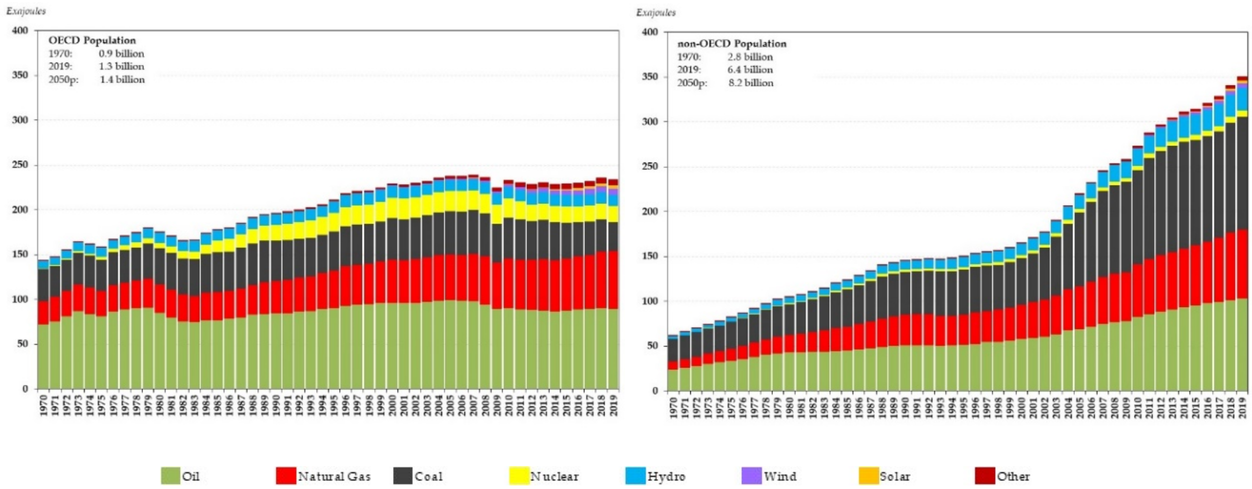
* Senior Director, Center for Energy Studies, Rice University's Baker Institute / Distinguished Fellow, IEEJ

History Sets the Stage

Previous investments define the *legacy* of energy systems around the world. The *scale* of existing global energy infrastructure is massive and heterogeneous, supporting a range of economic activities, health and human services, and lifestyles across multiple geographies. As such, energy ecosystems are built on a legacy that is difficult to replace, costly to dismantle, and impossible to ignore in energy transitions. There are multiple options to reduce the carbon intensity of energy use, and *technologies* that can leverage existing legacy infrastructures are most likely to see rapid uptake.

As indicated in Fig. 1, OECD demand has virtually stagnated over the past two decades, but non-OECD demand (especially in developing Asia) has seen steep growth, overtaking OECD demand in 2007. Moreover, demand growth has been largely driven by fossil fuels. In 1970, the EU and North America accounted for 26.4% and 36.2% of global energy demand, respectively, while developing Asia accounted for 7.1%. By 2000, the shares shifted to 18.7% for the EU, 28.9% for North America, and 19.1% for developing Asia, and by 2019 the EU accounted for 11.8%, North America 20.0%, and developing Asia 36.9%. The rest of the world (RoW), comprised of about 3.0 billion people at varying levels of economic development, has held steady in the 30% range. But as the economies of developing Asia mature, the energy needs in the RoW will continue to increase, particularly in developing regions where energy access is still lacking. Such an outcome is supported by various projections of population and economic growth.[1]

Fig. 1 Global Primary Energy Use by Source, OECD and Non-OECD (1970-2019)[2]

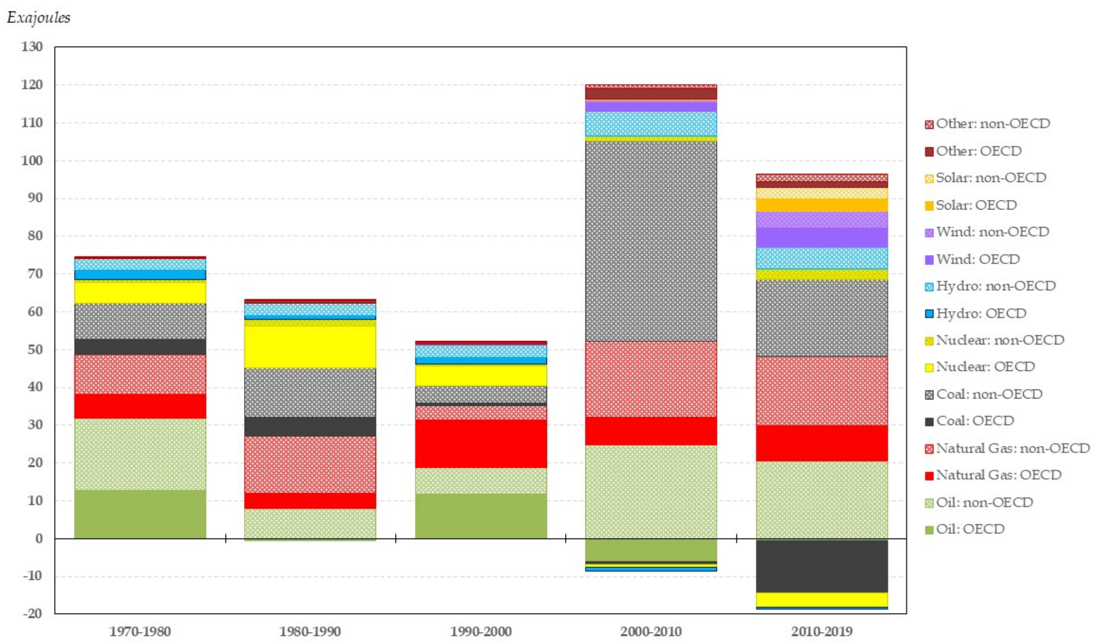


1 These include projections from the United Nations (https://population.un.org/wpp/), the International Monetary Fund (https://www.imf.org/en/Publications/WEO), and the International Energy Agency (https://www.iea.org/reports/world-energy-outlook-2020), to name three.

2 All energy data used in this paper are from the BP Statistical Review of World Energy (2020). Population data are compiled from OECD.stat.

Fig. 2 indicates how various sources of energy have changed by decade in the OECD and non-OECD since 1970. Notably, 1970s, 80s and 90s saw increases in every form of energy in both the OECD and non-OECD. Since 2000, oil, coal and nuclear have all seen declines in the OECD, but increased use of oil, coal and nuclear in the non-OECD has more than offset the declines in the OECD. For example, since 2000, OECD coal use declined by 30% as non-OECD coal use increased by 240%, now accounting for almost 80% of global coal use. So, the combined effects of population growth,[3] economic growth,[4] and gains in average individual wealth[5] drove up demand for all forms of energy by 285% from 1970 to 2019, even as energy efficiency improved.

Fig. 2 Change in Energy Use by Source, OECD and Non-OECD (1970-2019)



Figs. 1 and 2 indicate the depth of the challenge of getting to net zero by 2050, and help highlight how multi-faceted achieving such a goal will need to be. Over the last 30 years, the *share* of fossil fuels in the global primary energy mix declined from 86.0% to 84.3%, but *total* demand for fossil fuels increased as total energy demand grew by 70%. Hence, achieving net zero will require a much more rapid shift in energy composition over the next 30 years if it is to be done solely through eliminating fossil fuels.

This is even more pronounced when one considers the pace at which wind and solar have expanded since 2010 and the implications for total supply. The growth in wind and solar energy have been nothing short of astounding, reaching average annual rates in excess 16% and 39%,

[3] Global population grew from 3.7 billion to 7.7 billion. See United Nations, *World Population Prospects 2019* (https://population.un.org/wpp/).

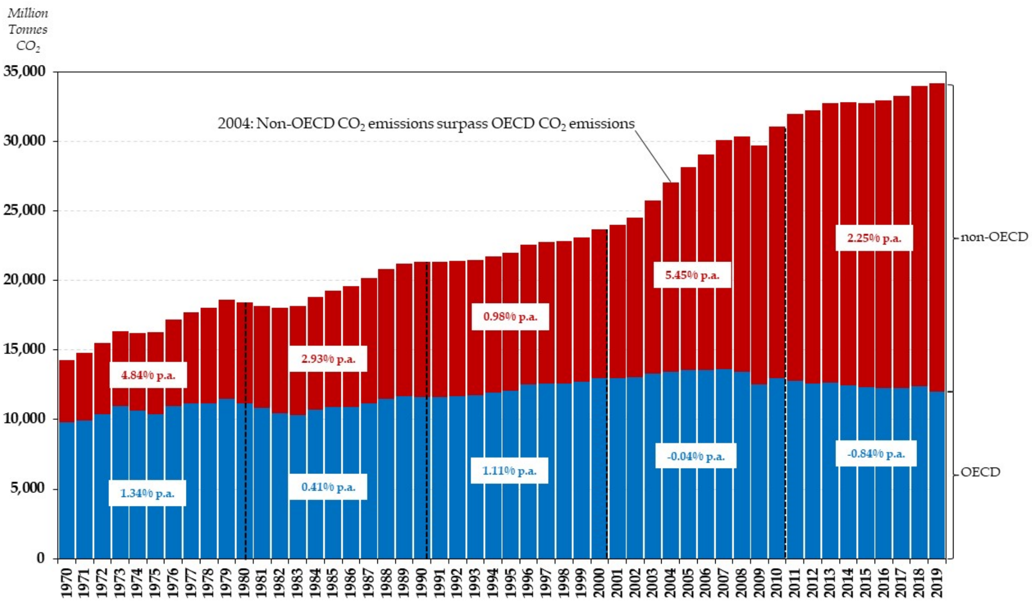
[4] Global gross domestic product increased from 2010$19.211 trillion to 2010$84.865 trillion. See World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD).

[5] Global per capita income increased from about 2010$5,200 to about 2010$11,000.

respectively. Nevertheless, wind and solar combined to contribute an additional 15.6 exajoules to the total global energy portfolio from 2010 to 2019 while fossil fuels contributed 54.3 exajoules even though oil, coal and natural gas grew at much lower average annual rates of 1.2%, 0.5% and 2.4%, respectively. So, scale matters.

This all has direct implication for global carbon dioxide (CO_2) emissions. OECD CO_2 emissions have declined since 2007, and in 2019 were at their 1995 levels (see Fig. 3). By contrast, non-OECD emissions have more than doubled since 1995. In fact, given the scale of non-OECD emissions in 2019, even if OECD emissions were slashed to zero, global emissions would still be at 1995 levels. Hence, the fact that growth in energy demand and CO_2 emissions is being driven by developing non-OECD nations, means that a large part of any strategy to reach net-zero emissions globally must be executed in developing countries.

Fig. 3 Global CO_2 Emissions, OECD and non-OECD (1970-2019)



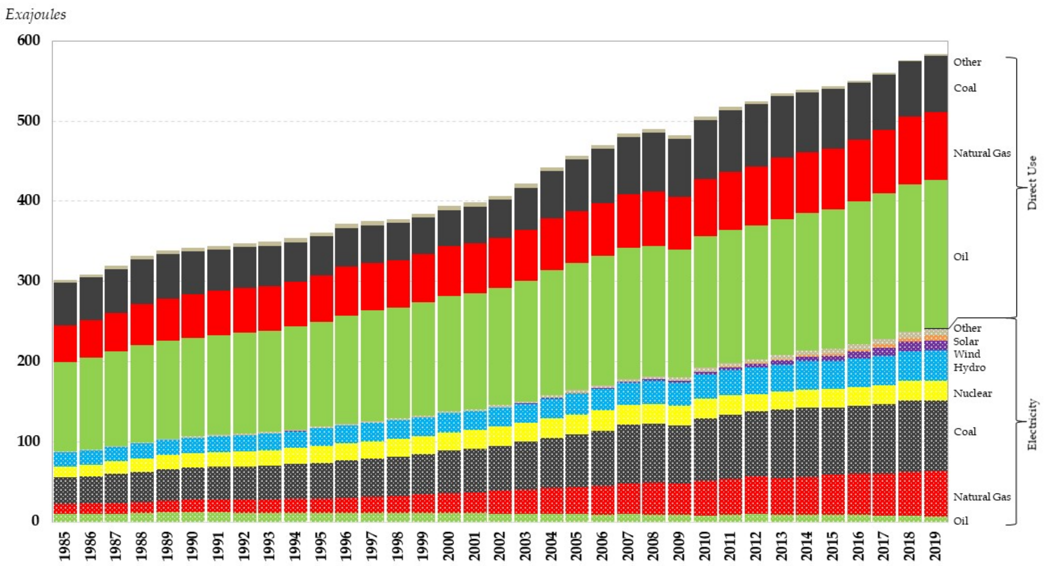
Strategies to Achieve Net Zero Must be All-Encompassing

There are a number of options to drive reductions in CO_2 emissions. To date, renewable energy technologies, such as wind and solar, have grown significantly, but they have been largely confined to the electric power sector. Direct government support has been immensely important for the observed growth, but existing power grids have been equally important, if not moreso. In regions with well-established electricity value chains (from generation to transmission and distribution to end-use), intermittent, non-dispatchable renewable resources can be successfully integrated and managed as part of a broader power generation portfolio. The experience in these regions has engendered a common strategy for achieving net zero: increase electrification in all sectors.

Fig. 4 indicates that electricity accounted for 41% of total energy in 2019. Continued growth in electrification will require massive infrastructure investments to move into sectors where direct combustion of fossil fuels accounts for 99% of all non-electric energy use. In addition, the investment required for greater electrification must be sufficient to replace aging infrastructure, displace fossil fuels, and expand generation capacity and distribution networks to also meet new demands, most of which must occur in developing economies.[6]

All of the preceding is not meant to disparage net-zero aspirations; rather, it is meant to properly frame the discussion about how to get to a desired outcome. Net-zero cannot *only* be about renewable energy technologies. Re-envisioning the combustion of fossil fuels – for instance in ways that allow hydrogen to serve as an energy source while carbon is used in other high-value added ways – is one possible option. Other possibilities include greater investment in carbon capture and storage technologies, expanding nuclear energy options, and development of natural carbon sinks.

Fig. 4 Global Energy and Electricity by Source (1985-2019)



In the end, the long understood but oft forgotten principle of comparative advantage will define how transitions and net-zero goals manifest in different parts of the world. Some regions favor a build-out of intermittent renewable resources (i.e.- wind and solar) that can leverage transmission connections with low-to-zero carbon dispatchable resources (i.e.- natural gas, hydro and nuclear) or perhaps even batteries or hydrogen technologies for load stability. Hydrogen, and its multitude of colors (blue: methane reformation with carbon capture; green: renewable-powered hydrolysis; yellow: biomass conversion; and turquoise: pyrolysis combustion yielding hydrogen and carbon black) also holds promise. Suffice it to say that there is a portfolio of options available,

[6] Non-OECD population is about 6.4 billion people, or 83% of global population, and non-OECD economies total $34.1 trillion, or roughly 40% of the global economy. Moreover, almost all population increase and the majority of global economic activity are projected to originate in the OECD.

but regional comparative advantages should drive adoption of least cost pathways and render energy transitions, and hence net-zero strategies, to be different everywhere. If this is not the case, stated net-zero aspirations will remain unrealized.

Writer’s Profile

Kenneth B Medlock III

Dr. Medlock, III is the James A. Baker, III and Susan G. Baker Fellow in Energy and Resource Economics and senior director of the Center for Energy Studies at Rice University’s Baker Institute, co-director of the Master of Energy Economics program, and adjunct professor in Economics and Civil and Environmental Engineering. He is Distinguished Fellow at IEEJ and on the Advisory Board of the Payne Institute at Colorado School of Mines. He has published numerous articles, has testified multiple times on Capitol Hill, has spoken at OPEC, and frequently speaks at venues around the world. He has received several awards for scholarly achievements, most recently the 2019 Lifetime Achievement Award for the Advancement of Education for Future Energy Leaders from the Abdullah Bin Hamad Al-Attiyah Foundation. He is a member of the AEA and NPC. He received his Ph.D. in economics from Rice University in May 2000.