Working Memorandum on Cost of Global Energy Services:
Estimated for the World Bank Disruptive Energy Transition Assessment (and other studies)
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Whether for use within an input-output framework[1] or for an assessment of global energy transition or transformation,[2] it would be useful to know the scale of energy expenditures compared to either total economic output or overall Gross Domestic Product (GDP) within a given national, or even the global economy. But alas, for the global there is not consistent time series data for energy expenditures (as opposed to key energy prices or scale of energy consumption). For example, in the United States we know that in 2018 the American economy spent perhaps $1.3 trillion for all uses of energy in that year. And we know that by 2050 it is projected to spend, in real terms (that is, in 2018 dollars) as much as $1.6 trillion.[3]

Neither the International Energy Agency (IEA) nor the Energy Information Administration (EIA) publishes energy expenditures for the entire global economy. Hence, there is no definitive and trusted number that lays out the aggregate total of energy expenditures as a percent of the world economy. Drawing on a 2010 post by the Institute for Energy Research, citing energy journalist Robert Bryce, total global energy use in 2008 was 11.29 billion tons of oil equivalent, which is about 82.8 billion barrels, using the conversion factor of 7.33 barrels per ton. And then assuming an average oil price of $60 per barrel, energy expenditures were estimated at $4.968 trillion. The world GDP in 2008 was ~$61 trillion (assuming current year dollars). Thus, the energy share of the global economy was about 8.2 percent according to that method.[4]

In many countries, as noted in that post, energy expenditures may have been second only to health care costs, which was then pegged at ~16 percent of GDP for the U.S., but "in the 8 to 11 percent range for many European countries and Canada." This means that energy prices, like health care, have a large effect on the economy and policies that promote energy price increases may result in negative consequences to economic growth. Still, it is hard to know how big energy expenditures might be.

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[1] As one example, see: Laitner, John A. "Skip", Steven Nadel, Harvey Sachs, R. Neal Elliott, Siddiq Khan. 2012. The Long-Term Energy Efficiency Potential: What the Evidence Suggests. ACEEE Research Report E104, Washington, DC: American Council for an Energy-Efficient Economy. http://aceee.org/research-report/e121.

[2] As an illustration here, see: Laitner, John A. "Skip," Benoît Lebot, Matthew McDonnell, and Meagan Weiland. 2018. Smart Policies and Programs as Critical Drivers for Greater Energy Efficiency Investments (2018). https://theresourceimperative.com/2018/02/15/smart-policies-and-programs-as-critical-drivers-for-greater-energy-efficiency-investments/.

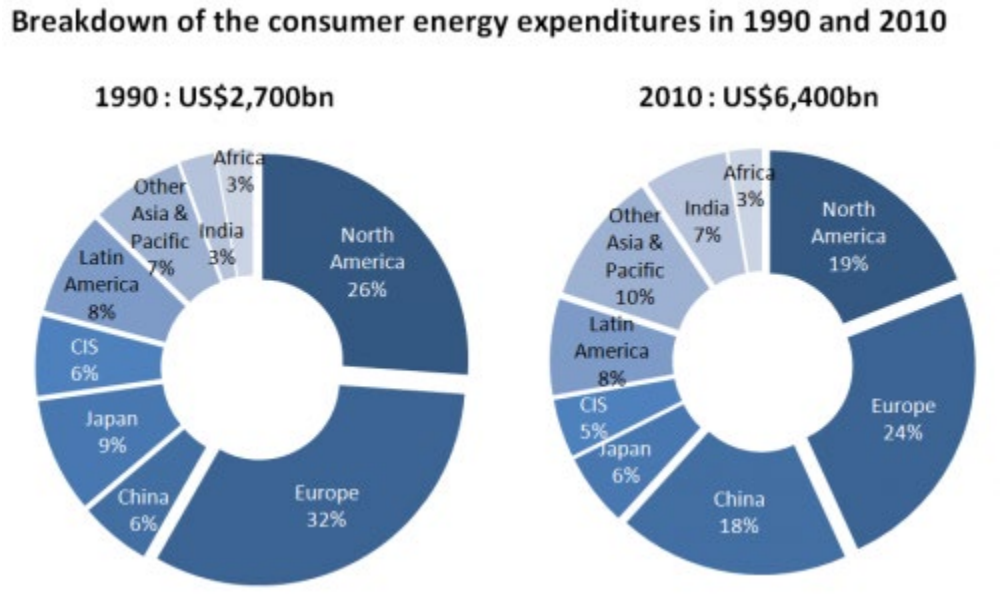
[3] As documented in Reference Case Table 3 on Energy Prices by Sector and Source, in Energy Information Administration (EIA). 2019. Annual Energy Outlook 2050. Washington, DC: U.S. Department of Energy. https://www.eia.gov/outlooks/aeo/.

[4] See the full post at https://www.instituteforenergyresearch.org/uncategorized/a-primer-on-energy-and-the-economy-energys-large-share-of-the-economy-requires-caution-in-determining-policies-that-affect-it/#_edn3

So, in this last regard we construct a "thought experiment" to help us build out a meaningful estimate of real expenditures for energy services over the period 2018 through 2050.

In the Spirit of a Fermi Thought Experiment

Drawing on ad hoc but available data as a resource, we can generate a reasonable pattern to help use achieve a sense of the scale of energy expenditures across the global economy. And, in that regard, we tap into the ideas of what have been termed a "Fermi Thought Experiment."[5] We begin with a working estimate from Leonardo Energy, as summarized in the infographic that follows.[6]



Looking at 1990 expenditures of $2,700 billion (in US $2005 Purchasing Power Parity) increasing to $6,400 billion (again in US $2005 PPP), roughly estimated at ~10% of world GDP in 2010. In a workbook created, "World Energy Expenditures 2018.xlsx", and converting data to 2018 values and also trending to estimated energy consumption in 2018, we have the following updated values. . .

1990 3,482 billion US$2018ppp
2010 8,254 billion US$2018ppp
2018 8,589 billion US$2018ppp

And then assuming that energy consumption increases 1 percent per year, and that real energy prices increasing 0.5 percent each year over the period 2018 to 2050, by the year 2050 total expenditures might grow to $13,853 billion (in 2018 USD PPP). These assumptions draw on trends projected in the EIA's International Energy Outlook 2017, their Annual Energy Outlook 2019, and International Energy Agency's (IEA) World Energy Outlook 2018.

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[5] Von Baeyer, Hans Christian. 1993. The Fermi Solution. New York: Random House. http://trove.nla.gov.au/work/23599851?selectedversion=NBD9822409

[6] See, http://www.leonardo-energy.org/resources/798

An Estimate for a Stanford University Study

There is another estimate of global energy expenditure made available by Stanford University's Mark Jacobson and his colleagues in 2017.[7] Although not a feature of the study – it is focused on a 100 percent Wind, Water, Solar roadmap for 139 countries and the world economy – it provides an estimate of 2012 energy consumption, calculated at 12,105.3 GW. That translates into about 106 trillion kilowatt-hours. To which we can multiply by a levelized cost of electricity, estimated 9.68 cents/kWh (in 2013 $). As we multiply those two numbers we have a likely world energy bill of about $10.3 trillion for 2012. And assuming business as usual conditions in which total energy consumption grows to 176 trillion kWh by 2050 with an average cost of 9.78 cents/kWh in that year (but also in 2013 $). That provides a projected 2050 global energy bill of $17.2 trillion. There are some uncertainties with these estimates, but they provide a useful comparison.

[7] Jacobson, Mark Z., Mark A. Delucchi, and Zack A.F. Bauer et al. (WWS). 2017. "100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World." Joule (2017), http://dx.doi.org/10.1016/j.joule.2017.07.005.