Mark Mills Compares

Hydrocarbons and Renewables

Robert Lyman 12/16/24

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MARK MILLS COMPARES HYDROCARBONS AND RENEWABLES

EXECUTIVE SUMMARY

Mark Mills is a Professor of Engineering and Applied Science at Northwestern University in Evanston, Illinois. He also is a Senior Fellow at the Manhattan Institute and one of the leading analysts and commentators on energy and climate issues. A few years ago, he wrote three lengthy articles that addressed the implications and challenges related to the proposed transition of the world economy from its present dominant reliance on hydrocarbons (i.e. oil, natural gas and coal) to so-called “clean energy and renewables” to meet growing energy needs.

This article will use quotations from Mark Mills’ articles to illustrate his views on the differences between hydrocarbons and renewable energy, in particular industrial wind turbines and solar energy.

To completely replace hydrocarbons over the next 20 years, **global renewable energy production would have to increase by at least 90-fold. For context: it took a half-century for global oil and gas production to expand by 10-fold.**

Hydrocarbons – oil, natural gas and coal – are the world’s principal energy resource today and will continue to be so for the foreseeable future. Wind turbines, solar arrays, and batteries, meanwhile, constitute a small source of energy, and physics dictates that they will remain so. Meanwhile, there is simply no possibility that the world is undergoing – or can undergo -a near-term transition to a “new energy economy”.

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Mark Mills is a Professor of Engineering and Applied Science at Northwestern University in Evanston, Illinois. He also is a Senior Fellow at the Manhattan Institute and one of the leading analysts and commentators on energy and climate issues. He has a remarkable ability to cite illustrative examples that help readers with no or little technical training understand important engineering and scientific questions. A few years ago, he wrote three lengthy articles that addressed the implications and challenges related to the proposed transition of the world economy from its present dominant reliance on hydrocarbons (i.e. oil, natural gas and coal) to so-called “clean energy and renewables” to meet growing energy needs. In 2019 he wrote The *New Energy Economy: An Exercise in Magical Thinking*. He followed this in 2020 with *Mines, Minerals and “Green” Energy: A Realty Check.* Finally, in 2022, he wrote *The “Energy Transition” Delusion: A Reality Reset.*

This article will use quotations from Mark Mills’ articles to illustrate his views on the differences between hydrocarbons and renewable energy, in particular industrial wind turbines and solar energy.

THE ADVANTAGES OF HYDROCARBONS

Scientists have yet to discover, and entrepreneurs have yet to invest, anything as remarkable as hydrocarbons in terms of the combination of low-cost, high-energy density, stability, and portability. In practical terms, this means that spending $1 million on utility-scale wind turbines or solar panels will each, over 30 years of operation, produce about 50 million kilowatt-hours (kWh) – while an equivalent $1 million spent on a shale rig produces enough natural gas over 30 years to generate over 300 million kWh.

There are two core flaws with the thesis that the world can soon abandon hydrocarbons. The first: physics realities do not allow energy domains to undergo the kind of revolutionary change experienced on the digital frontiers. The second: no fundamentally new energy technology has been discovered or invented in nearly a century, nothing analogous to the invention of the internet.

To completely replace hydrocarbons over the next 20 years, global renewable energy production would have to increase by at least 90-fold. For context: it took a half-century for global oil and gas production to expand by 10-fold.

A transition to 100% non-hydrocarbon electricity by 2050 would require a U.S. grid construction program 14-fold bigger than the grid build-out rate that has taken place over the past half-century.


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THE COST REALITIES OF WIND AND SOLAR

For the cost to drill a single shale well, one can build two 500-foot high, 2-megawatt (MW) wind turbines. These two wind turbines produce a combined output averaging over the years to the energy equivalent of 0.7 barrels of oil per hour. The same money spent on a single shale rig produces 10 barrels of oil, per hour, or its energy equivalent in natural gas, averaged over the decades.

It costs less than $1 a barrel to store oil or natural gas (in energy-equivalent terms) for a couple of months. The U.S., on average, has about two months' worth of national demand in storage for each kind of hydrocarbon at any given point in time. Meanwhile, with batteries, it costs roughly $200 to store the energy equivalent to one barrel of oil. Thus, instead of months, barely two hours of national electricity demand can be stored in the combined total of all the utility-scale batteries on the grid plus all the batteries in the 1 million electric cars that exist today in America.

Consider Tesla, the world's best-known battery maker: $200,000 worth of Tesla batteries, which collectively weigh over 20,000 pounds, are needed to store the energy equivalent of one barrel of oil. A barrel of oil, meanwhile, weighs 300 pounds and can be stored in a $20 tank.

So, how many batteries would be needed to store, say, not two months but two days of the nation's electricity? The $5 billion Tesla "Gigafactory" in Nevada is currently the world's biggest battery manufacturing facility. Its total annual production could store three minutes' worth of annual U.S. electricity demand. Thus, in order to fabricate a quantity of batteries to store two days' worth of .S. electricity would require 1,000 years of Gigafactory production.

Grid-scale battery costs would have to drop at least 20-fold to match the reliability economics of conventional dispatchable power… At todays and likely future prices, building enough batteries to store 12 hours of electricity for the U.S. would cost about $1.5 trillion, and that scale of storage would still leave the nation regularly third-world dark. The alternative? Build about $100 billion worth of conventional hydrocarbon-based backup that can keep lights on for days and weeks when needed, not just hours.

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MATERIALS REQUIREMENTS AND COSTS

Replacing the energy output from a single 100-MW gas-fired turbine, itself the size of a residential house (producing enough electricity for 75,000 homes) requires at least 20 wind turbines, each one about the size of the Washington Monument, occupying some 10 square miles of land.

The largest share of the tonnage of materials in wind and solar farms is found in conventional materials like concrete, steel, and glass. Compared with a natural gas power plant, wind and solar require at least 10 times as many tons mined, moved, and converted into machines to deliver the same quantity of energy.

For example, building a single 100-MW wind farm requires some 30,000 tons of iron ore and 50,000 tons of concrete, as well as 900 tons of nonrecyclable plastics for the huge blades. With solar hardware, the tonnage in cement, steel and glass is 150% greater than for wind, for the same energy output.

50-100 pounds of various materials are mined, moved, and processed for one pound of battery produced. In an all-battery future, global mining would have to expand by more than 200% for copper, at least 500% for minerals like lithium, graphite, and rare earths, and far more than that for cobalt.

Meeting such unprecedented minerals demands will require opening far more mines than now exist, and far faster than in history. (The global average time from the qualification of a property to bringing a new mine into operation is 16 years). Meeting transition goals will require dozens of new mines for each of a dozen classes of minerals, each the scale of some of the biggest mines in the world today and each requiring tens of billions of dollars of investment. Even if it were feasible, there are still no plans to meet the scale of mineral demands in the time frames contemplated. This means, in short, that regardless of price, policies, and mandates, the world won't be able to build the machines to meet the transition aspirations.

EMBODIED ENERGY

Green machines mean mining more materials per unit of energy delivered to society. One needs to consider not just the physical mining realities by also the hidden energy costs of the underlying materials themselves, i.e. the "embodied" energy costs. Embodied energy arises from the fuel used to dig up and move earth, grind and chemically separate minerals from the ores, refine the ores to purity, and fabricate the final product.

Metal	Element	Total metal required produce one generation of technology units to phase out fossil fuels (tonnes)	Global Metal Production 2019 (tonnes)	Years to produce metal at 2019 rates of production (years)
Copper	Cu	4 575 523 674	24 200 000	189,1
Nickel	Ni	940 578 114	2 350 142	400,2
Lithium	Li	944 150 293	95 170 *	9920,7
Cobalt	Co	218 396 990	126 019	1733,0
Graphite (natural flake)	C	8 973 640 257	1 156 300 ◆	3287,9
Graphite (synthetic)	C		1 573 000 ◆	-
Silicon (Metallurgical)	Si	49 571 460	8 410 000	5,9
Vanadium	V	681 865 986	96 021 *	7101,2
Rare Earth Metals	-			
Neodymium	Nd	965 183	23 900	40,4
Germanium	Ge	4 163 162	143	29113,0
Lanthanum	La	5 970 738	35 800	166,8
Praseodymium	Pr	235 387	7 500	31,4
Dysprosium	Dy	196 207	1 000	196,2
Terbium	Tb	16 771	280	59,9

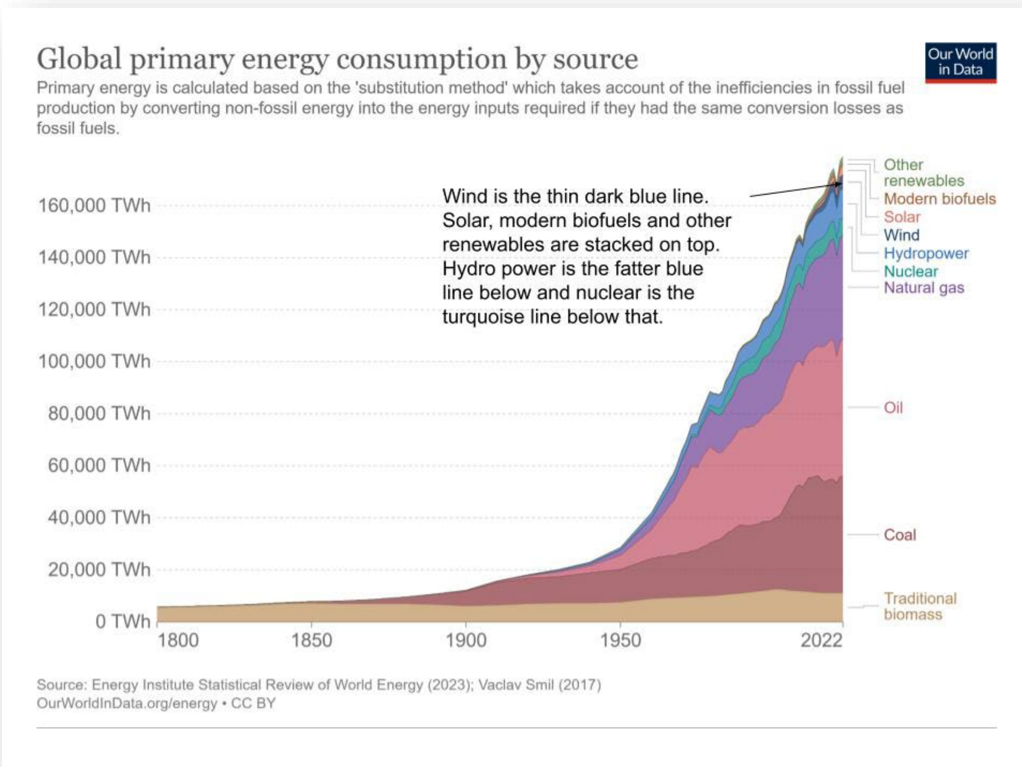
THE PURSUIT OF THE IMPOSSIBLE
Materials Constraints and Realities for the Net Zero Utopia
https://blog.friendsofscience.org/2022/11/28/the-pursuit-of-the-impossiblematerials-constraints-and-realities-for-the-net-zero-utopia/

Natural gas accounts for 70% of the energy used to fabricate glass. Glass accounts for some 20% of the tonnage needed to build solar arrays. For wind turbines, oil and natural gas are used to fabricate fiberglass blades, and coal is used to make steel and concrete. Some perspective: if wind turbines were to supply half the world's electricity, nearly 2 billion tons of coal would have to be consumed to produce the concrete and steel, along with 1.5 billion barrels of oil to make the composite blades.

More than 75% of all oil and 100% of natural gas are transported to markets via pipelines. Pipelines are the world's most energy-efficient means of moving a ton of material. However, nearly all the materials used to construct green machines are solids, and a very large share will be transported by truck. Using trucks instead of pipelines entails a 1000% increase per ton-mile in the embodied transportation of energy materials.

CONCLUSION

Hydrocarbons – oil, natural gas and coal – are the world's principal energy resource today and will continue to be so for the foreseeable future. Wind turbines, solar arrays, and batteries, meanwhile, constitute a small source of energy, and physics dictates that they will remain so. Meanwhile, there is simply no possibility that the world is undergoing – or can undergo -a near-term transition to a "new energy economy".



ABOUT THE AUTHOR

Robert Lyman is an economist with 27 years' experience as an analyst, policy advisor and manager in the Canadian federal government, primarily in the areas of energy, transportation, and environmental policy. He was also a diplomat for 10 years. Subsequently he has worked as a private consultant conducting policy research and analysis on energy and transportation issues as a principal for Entrans Policy Research Group. He is a frequent contributor of articles and reports for Friends of Science, a Calgary-based independent organization concerned about climate change-related issues. He resides in Ottawa, Canada. Full bio.

ABOUT FRIENDS OF SCIENCE SOCIETY

Friends of Science Society is an independent group of earth, atmospheric and solar scientists, engineers, and citizens that is celebrating its 22nd year of offering climate science insights. After a thorough review of a broad spectrum of literature on climate change, Friends of Science Society has concluded that the sun is the main driver of climate change, not carbon dioxide (CO_2).

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