Chapter One

Energy Density

By Ronald Stein

Summary

The energy available from deep-earth minerals/fuels is abundant, affordable, reliable, and, equally important, continuous and uninterruptable. Because of all these wondrous properties, this kind of energy has made it possible for us to reduce infant mortality, extend longevity, and "make products and move things" anywhere in the world via planes, trains, ships, and land vehicles. It is also thanks to the energy extracted from deep-earth minerals that we have been able virtually to eliminate deaths from diseases and extreme forms of weather.

Intermittent electricity from less-energy-dense renewables like wind and solar, on the other hand, requires huge land resources and the construction of unsightly wind and solar farms that destroy vegetation, trees, and wildlife while lowering home values.

The two prime movers that have done more than any other invention for the cause of globalization—the diesel engine and the jet turbine—both get their energy manufactured from the energy density of deep-earth minerals/fuels. Without these awesome engines, there would be no modern transportation. And without transportation, there is no commerce.

Energy Density

Given all the hype over renewable sources to generate intermittent electricity, the numbers I am about to cite, all readily available from the Energy Information Administration (EIA),[29] are remarkable in that they reveal a continuing bias toward nonrenewable sources. The energy-density sources of oil, natural gas, and coal still dominate the fuel mix of U.S. consumption. And yet, over the past six decades, tens of billions of dollars have been spent on renewable and alternative intermittent electrical generation schemes, such as wind energy, solar energy, corn and other biofuels, along with electric cars. The result of all this investment in all these renewables has been only a modest gain in market share in comparison to oil, natural gas, and coal.[30]

It may be easier to comprehend the U.S. Energy Information Administration projections[31] that dependency on energy from fossil fuels continues into the future when you understand that renewables are incapable of providing any of the thousands of products from fossil fuels that are part of all our lifestyles. Nor can renewables supply the fuels needed by the militaries, airlines, cruise ships, supertankers, container shipping, and trucking infrastructures, let alone the jet and diesel engines that are the basis of modern transportation. In addition, all the components of the EV (electronic vehicle) and renewable industries are manufactured from chemicals and by-products derived from the extraction and refining of fossil fuels.

In other words, despite these huge investments, renewables' share of the energy market has been shrinking.[32] What's happening? While conspiracy theorists may prefer to believe that Big Oil, Big Coal, and Big Nuclear are stifling the growth of renewables, the simple truth is that coal, oil, natural gas, and nuclear can satisfy the four energy imperatives: power density, energy density, cost and scale,[33] while renewables fall woefully short of meeting those imperatives.

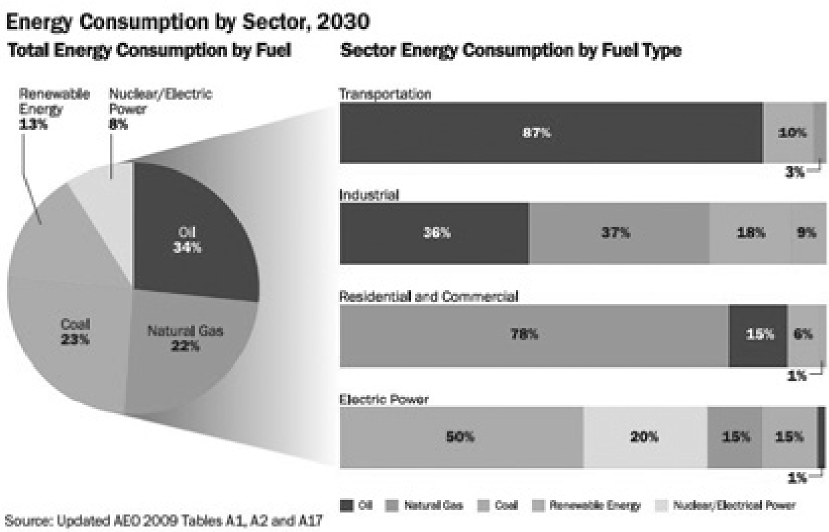
Back in 1949 nearly 91% of America's total primary energy came from oil, natural gas, and coal.[34] The balance came from renewables, with hydropower being a dominant contributor. By 2008 the market share for coal, oil, and natural gas, along with nuclear, had grown to

92.5% of total primary energy in the U.S. with the small remainder coming from renewables.

Per the U.S. Energy Information Administration Annual Energy Outlook of 2009, with projections of Energy Consumption by Sector to 2030,[35] the energy-density superiority of fossil fuels (that are abundant and readily available) to support the prosperity[36] we're enjoying from that energy supply source (that "makes thousands of products and moves things"), continues to be part of the world's energy mix.[37]

While wind and solar renewables are attempting to make significant and growing contributions to electrical generation, they are nowhere near supplanting oil, natural gas, coal, and nuclear. The reasons are many, beginning with their intermittent nature—meaning, of course, that when the wind doesn't blow or the sun doesn't shine, then wind turbines and solar panels are useless. They also have low-power-density generating capabilities that must always be backed up by fossil fuel or nuclear, and their land-consuming needs have prevented them from being a major player in supplying electricity. Until these technological constraints are overcome, renewables will continue being a media-friendly niche source of energy to electricity.[38]

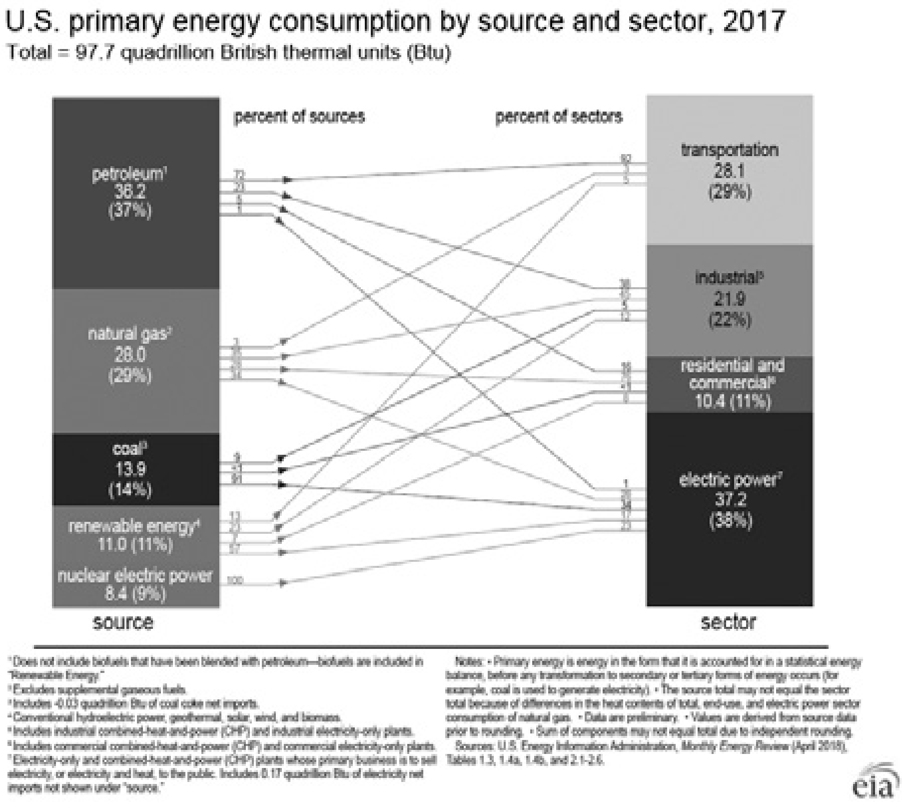
Figure 1-1



Observations of Figure 1-1

Fuel Source Supply projections to 2030 (shown on the left circle)	*Infrastructure Demand projections to 2030 (shown on the right-side bar charts)*
Oil 34%	Majority for the Transportation infrastructures and the Industrial infrastructure.
Natural Gas 22%	Primarily split among Residential and Commercial, Industrial, and continuously uninterruptable Electricity Generation, with some to Transportation.
Nuclear 8% and Coal 23%	100% is for continuously uninterruptable Electricity Generation and for the Industrial Sector.
Renewables Electricity 13%	Electricity Generation of *intermittent* electricity and for Sectors of Industrial, Transportation, and Residential and Commercial. However, electricity alone does not support the transportation infrastructures and, thus, commerce.

Figure 1-2



Observations of Figure 1-2

Energy consumption by SOURCE in 2017	*Energy consumption by SECTOR in 2017*
Petroleum	72% of petroleum goes to the Transportation Sector, but that represents 92 % of Transportation Sectors' demands, and 23% of Petroleum goes to the Industrial Sector to meet 38% of the demand in that sector.

Natural Gas	Almost equally split among Sectors of Industrial 35%, Residential and Commercial 28%, and continuously uninterruptable Electric Power 34%, with a small amount to the Transportation Sector.
Coal	91% of coal goes to the Electric Power Sector, but that represents only 34% of Electric Power Sector's demands.
Renewables Energy	The majority of 57% of Renewable Energy goes to *intermittent* Electric Power demands but is only 17% of the demand in that sector. Again, electricity alone does not support the transportation infrastructures.
Nuclear	100% of Nuclear goes to the Electric Power Sector, but that only represents 23% of continuously uninterruptible Electric Power demand with Natural Gas at 26%, Coal at 34%, and Renewable Energy at 17%.

In California, to meet 100% clean energy by 2045,[39] significant growth in renewables will be required to replace the electricity generation by nuclear and natural gas,[40] as the nuclear power plant at Diablo Canyon will be closing in 2025.

In comparing categories, bear in mind that the average amount of time that power is being produced varies among them, so that total energy obtained is not a simple function of power rating.

Recently, in California, the San Bernardino County Board of Supervisors slammed the brakes on big solar projects,[41] thereby highlighting a challenge California could face as it seeks to eliminate the use of fossil fuels and natural gas to generate electricity. San Bernardino locals soundly voiced their objections to those land-devouring, ecosystem-disrupting, unsightly monstrosities that lead to higher electricity prices and lower property values for nearby residents. The verdict, once again, was NIMBY (Not In My Back Yard)! So, with fewer and fewer places to locate these renewables farms, what's next?

In the increasingly likely event there will not be enough land permitted to build those huge intermittent electricity farms, and with continuously uninterruptible electricity generation now supplied by nuclear and natural gas rapidly vanishing from the grid, California's electricity will have to be imported from other states in order to make up the deficiencies of limited in-state generation. Such electricity imports will obviously come at a premium price for lower-income and blue-collar workers.

And what of the massive amount of electricity needed to charge the estimated 25 or 30 million electric vehicles in California? The utility companies have thus far had little to say about the alarming cost projections or how the state's residents would be impacted by the obviously higher rates authorized by California's Public Utilities Commission (PUC). And it's not just the total amount of electricity, but also the transmission and fast-charging capacity that will need to be built at current filling stations.

A Canadian engineer recently ran the numbers involved in the switchover to EVs and concluded that, in order to match the number of cars that a typical gasoline filling station today can service in a busy 12-hour period (2,000), an electric filling station would require 600 of the 50kw chargers. Even that conservative estimate would require a $24-million investment for each station just for the cheapest chargers. But there's more involved than expense.

For those 600 chargers, the station would need about 30 megawatts of power from the grid. If you think that seems like an incredible amount of electricity, you're right. Thirty megawatts are enough juice to power roughly 20,000 homes. In other words, powering these service stations of the future will require about the same amount of electricity as a city of 75,000 residents! Oh, and by the way, all that electricity, unlike off-hour home recharging, happens during peak-usage daylight hours. I see brownouts and blackouts in California's future. Carry a bag lunch. This could get ugly.

In addition to the huge investments at the electric service stations, utility companies will have to spend gazillions of dollars building a new grid, or merely billions to upgrade the current grid to prevent it from crashing. These mandated investments, naturally, will further drive up the cost of electricity for everyone just so a few elites can drive Teslas and the like.

Even at fast-charging stations, to fully charge an EV can take anywhere from 30 minutes to eight hours, depending on how much of a charge (empty to full or just topping off) the vehicle needs. The added cost of lounge areas that charging stations would need to install and maintain, or the holding areas for vehicles fully charged and waiting for customers to return from offsite dining, shopping or work, will be passed on to the consumer.

Since fossil fuels of oil, natural gas, and coal are energy-dense, portable and storable, with many useful by-products that create thousands of spinoff industries, there is no simple way to move from oil, coal, and natural gas to exclusive renewable electricity. Particularly, as has been pointed out, because the manufacture of all renewables also requires massive amounts of fossil fuels and other natural resources with proportionately little energy return. Some basic comparisons of energy density will help put things in perspective.

Aside from being an intermittent source of electricity, wind has very low energy density. In terms of manufacturing wind and solar devices, development may be constrained by the availability of materials, the cost of mining them, or the reclamation/decommissioning costs. An additional challenge is that even if unit prices of wind and solar devices drop, the costs of integrating wind and solar to the conventional grid and necessary build-out of new transmission lines runs into the billions.

There's no question that electric vehicles have some positive attributes: low refueling costs, no air pollutants at point of use, i.e., no tailpipes on the EVs, and quiet operation. But the crucial question remains, are they actually "clean and green"?[42]

EVs employ the marketing term "clean and green" because, after all, the vehicles have no tailpipes. But it has been pointed out, and accurately, that the EV exhaust outlets do exist, just many miles away. They exist at the mining operations for the lithium and cobalt used in the batteries, and at the power plants that produce the continuously uninterruptible power to charge those batteries. And the "tailpipes" also exist at the refineries that manufacture the chemicals and by-products that are the basis of all the products used in making each EV.

And, despite their promise, all-electric cars continue to be hampered by the same drawbacks that have haunted them for a century: high costs, limited range, slow recharge rates, lack of recharging stations, and a battery life of approximately ten years (as compared to conventional cars with their typical durability of 50-plus years).

Although modern lithium-ion batteries provide a fourfold improvement in energy density when compared with their older lead-acid cousins, they cannot hold a candle (no pun intended) to gasoline, as gasoline holds eighty times as much energy density than the lithium-ion battery. For today's EVs, the lithium-ion battery used in the Tesla weighs in excess of 1,000 pounds, while the iPhone battery is only 0.026kg.

As mentioned by the U.S. Energy Information Administration (EIA) in its Annual Energy Outlook of 2009, with projections of Energy Consumption by Sector to 2030,[43] and the EIA energy consumption projections to 2050 by fuel,[44] electricity by itself, especially intermittent electricity from renewables, cannot and will not power the world. Electricity alone cannot support the militaries, airlines, cruise ships, supertankers, container shipping, and trucking infrastructures. Nor can intermittent electricity from wind, solar, or batteries supply the many petroleum-sourced products that are demanded by every transportation and electricity generation infrastructure, products that are used in medications, cooling, heating, manufacturing, and agriculture and that, in so many ways, have become indispensable to our modern lives and lifestyles.