To EV or not EV, that is the question

According to a table of general USA electrical consumption provided by EIA (next page), nearly 60% of electricity is still generated with fossil fuel, split almost evenly between coal and natural gas, with natural gas having an edge. This is for Y2021, in quadrillion BTUs (odd units, in my opinion). Since there are 2.931E8 MWh of energy in 1 quadrillion BTUs, I have done the conversion to tWh.

So, looking at the table, about 4115 tWh of electricity was produced in 2021, or an average power of 469 gW. Gasoline holds about 32,317 MJ/m^3, (33.98 kWh/gal) and we use about 143 billion gallons a year in the US, so that is 33.98 x 143 x 10^9 kWh worth of energy. The cars that burn it get at best 30% efficiency of that energy, say 25% , so is an equivalent mechanical work of 969,895 gWh. You can work backwards with an EV along the same line of reasoning, where EV efficiency is 90%, and line losses between 5% and 8%. So, the amount of electricity needed to be supplied is 969,895/(0.9 x 0.92) gWh, or about 1.2 tWh. This comes out to about 134 gW average power. We now do 469 gW, more or less, so 134 / 469 = 28%, which means we need to step up power by 28% to power EVs.[1]

Since about 60% of that power is now made from coal and natural gas, you can further go back up the efficiency chain all the way back to the combustor at the power plants. The table shows about 37% efficiency overall (some combined cycle fossil fuel plants can get as high as 60%). The other sources (nuclear, hydro, and alternative) presumably have higher efficiencies, but not shown here, so that would imply an optimistic fossil fuel plant efficiency for an EV of 37%. 0.9 x 0.92 x 0.37 = 0.31 efficiency, which is virtually the same as the ICE alternative. Since this EIA data shows 58.1% coming from fossil fuel sources, a better estimate might use a weighted average of 1 X (1 – 0.581) + 0.37 X (0.581), or 0.634. Using this factor times the EV estimated efficiency of 0.9 X 0.92 gives 52.5% efficiency. This is a 75% improvement, but does it justify a complete revamp of the transportation system?

Installed power of wind and solar would be considerably more than 28% (that is, 134 gW), because the utilization factor is low (solar can't ever be better than 0.5, for example). As a rough estimate, if a typical wind generator is 5 MW, that implies at least 134 gW/5 MW number of units required, or 26,800 of these things additionally, at a bare minimum. Assuming they're spaced about 3 or 4 acres per 5 MW machine, that's about 167 mi^2. That is about a 12 mi by 12 mi square, but of course they won't all be bunched up like that, and certainly this is a bare minimum number. Admittedly, this aspect certainly is in the same comparison sphere of what is currently done with land to extract oil and gas.

Two other things to consider is the astronomical number of batteries required (there is something on the order of 290 million cars registered in the US now), and the yet unsolved problem of energy storage and stability in an electric grid with no fossil fuel plants in it. Probably technically feasible, but does it achieve its goal, which seems to be to reduce CO_2 in the air? It's the classic action of coming up with a remedy for a specific problem, without considering all the other effects, some of which are not knowable beforehand.

It might be wise to consider EVs might be a good solution for a very specific locale, say population dense metropolitan areas, and leave it at that.

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[1] As details come out about ramifications of EVs, we could expect a huge backlash if everyone was told to cut back 28% on electricity use so they could power EVs instead. Especially if told to do so by 2030, 8 years from now.

U.S. electricity flow, 2021 https://www.eia.gov/totalenergy/data/flow-graphs/electricity.php

quadrillion Btu

Sources: U.S. Energy Information Administration (EIA), Monthly Energy Review (April 2021), Tables 7.1, 7.2a, 7.3a, 7.6, and A6; and EIA, Form EIA-923, "Power Plant Operations Report."

	10^{15} BTU									tW-hr			
consumption of coal for electricity generation, all sectors	9.483419		43.7%							2,779			
													$quad \cdot BTU = 293.071 \cdot tW \cdot hr$
consumption of natural gas for electricity generation, all sectors	11.93766		55.0%							3,499			
consumption of petroleum for electricity generation, all sectors	0.203038		0.9%							60			
consumption of other gases (1) for electricity generation, all sectors	0.066471		0.3%							19			
consumption of fossil fuels for electricity generation, all sectors		21.69059		21.69059		58.1%	<= fossil fuel portion				6,357		
consumption of nuclear electric power for electricity generation, all sectors	8.129062					21.8%				2,382			
consumption of renewable energy for electricity generation, all sectors	7.346143					19.7%				2,153			
consumption of other (2) energy for electricity generation, all sectors	0.180806					0.5%				53			
total consumption of energy for electricity generation, all sectors		37.3466		37.3466				37.6%	<= efficiency		10,945		
conversion losses from energy consumed for electricity generation	22.60287									6,624			
electricity gross generation, total, all sectors		14.74373		14.74373							4,321		
electricity plant use (3)	0.701502									206			
net generation of electricity, total, all sectors		14.04222		14.04222							4,115		
electricity transmission and distribution losses (4) and unaccounted for (5)	0.766371							5.5%	<= losses	225			
net imports of electricity	0.134178									39			
total electricity end use, all sectors		13.41003		13.41003							3,930		
electricity retail sales to the residential sector	5.038052									1,477			
electricity retail sales to the commercial sector	4.520155									1,325			
electricity retail sales to the industrial sector	3.366953									987			
electricity retail sales to the transportation sector	0.021808						tot losses			6			
electricity direct use (6)	0.463063				plant & losses			32.1%		136			
					90% car			28.9%				469.469	<= total average power generated (gW)