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Beeville, TX 78102
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cc: marketing FEB 15 ANS'D

Dear Bryan,

First, let me say how much I enjoy C-Span and to state that you are the best interviewer of all television. My TV spends 80% of its time tuned to C-Span. For three yeras I lived out in the sticks and had a dish so could watch both stations. I recently moved to the city and unfortunately, my cable just provides C-Span I.

I write because of a discussion on electric cars you had earlier this week and wish to pass on a few facts that the laymen either don't know or haven't considered. This topic will come up again many times over the next few years so will "arm you with some facts" and some things to bring up in future discussions on this topic. My "expertise" comes via a degree in mechanical engineering received in 1966 and from working in the drilling and production sector of the oil industry since that time. I emphasize that I have no axe to grind on this subject, don't know all the facts, but do know enough to raise some pregnant points.

Everyone seems to think that electricity is "clean", i.e. they can charge their batteries from an outlet in the home with no visible signs of pollution. The only clean source of electricity comes from hydroelectric, nuclear (assuming one can properly dispose of the radioactive waste), wind generators, and solar. From the 1990 World Almanac come the 1988 preliminary figures for electricity production in the U.S. and its method of production. I also note the same figures for 1974 for contrast. Figures are in billion kilowatt hours.

	Coal	Oil	Gas	Nuc	Hydro	Other	Total
74	828	301	320	114	301	3	1867
88	1537	149	253	527	223	12	2701

Coal has gone from 44% of total to 57%, oil from 16% to 5.5%, gas from 17% to 9.4%, nuclear from 6.1% to 19.5%, and hydroelectric from 16% to 8%.

You will see where the above is pertinent to the discussion later. One of the bottom line's of all this is to relate the cost of driving an electric car to a gasoline car in equivalent price per gallon.

Back in the 1700's, Carnot established the equivalence between heat and work. He found one could convert heat to work by means of a heat engine but the conversion had an upper limit as to the efficiency of the process. When we burn gasoline in our car, that is what we are doing. The efficiency of a gasoline engine is around 50% with the diesel being slightly higher. The layman usually thinks of efficiency as miles per gallon. If your car gets 25 MPG and you put that same engine in a tank, it would probably get no more than 1-2 MPG. Obviously, the efficiency of the engine hasn't changed. But the efficiency of the overall system has changed due to the extra weight and drag.

When we compare a "normal" car to an electric car, let us first compare apples and apples. Let us consider cars of equal overall weight and aerodynamic design. A gallon of gasoline contains approximately 120,000 BTU's or British Thermal Units of energy when burned. The BTU is defined as the energy required to raise the temperature of one pound of water one degree Fahrenheit. It is also equal to 778 foot pounds of work. That is if one moved a weight of 1 pound a distance of 778 feet with no friction involved, then one would have expended one BTU of energy or work. If one expended 550 foot pounds of energy in a time period of one second, then one would be doing work at the rate of one horsepower. The electrical equivalent is that one horsepower is equal to .746 kilowatts or 746 watts. What you purchase in your house is measured in kilowatt hours. If you take the above equivalencies, you can calculate that to convert BTU's to kilowatt hours you multiply BTU's by .0002931. So if a gallon of gasoline has 120,000 BTU's, that is equivalent to 35.17 Kwh (kilowatt hours). Electricity rates in the US range from approximately 6 cents per Kwh near hydroelectric plants such as TVA to perhaps as high as 14 cents in NYC. So a "gallon" of juice in the batteries would cost from $2.11 per gallon to $4.92!! And this has no federal highway trust fund tax or state road tax included. However, it is not quite that bad as the gas engine had 50% efficiency and thus only usefully used 60000 of the 120000 BTU's in the gallon. There would be some small losses when moving the energy from your outlet into the batteries and additional small losses when withdrawing this energy to propel the car. We can probably neglect these and state that the equivalent cost is $1.05 to $2.46 sans taxes.

Now, let us address the pollution problem. From the above figures of power generation by source for 1988, we see that about 72% of all juice is generated via burning fossil fuels and 57% of the total (not 57% of the 72% but grand total) is from coal. What is the efficiency at the plant of converting these fuels into electricity? The majority of fossil fuel burning plants use the BTU's from the fuel to heat water and turn into steam and expand through nozzles to turn turbines which turn generators which produce electricity. From my days of thermodynamic studies, we used to calculate overall efficiences of this process on the order of 35%. To validate this approximation in case great advances have been made since the 60's or in case someone has figured out how to get around Carnot's observations of several hundred years ago, I again consulted the World Almanac. I could sift out the figures to arrive at the overall efficiency of coal fired plants which account for 56.9% of all power generated in 1988. US coal consumption for 1988 was 881.4 billion short tons and that for utilities was 756.8. Toatl energy from all sources consumed that year was 79.94 Quads. A quad is 1 followed by 15 zeros BTU's or a thousand trillion BTU's. When the national debt ends up being computed in Quad dollars, Congress will really be fouled up as they get confused now among millions. billions, and trillions!! Of this 79.94 Quads, 18.81 Quads were due to coal, and since coal utility usuage was 85.86% of total coal use, the coal consumption for power plants amounted to 16.15 Quads. If one multiplies this by the .0002931 mentioned above one arrives at an electrical equivalent of 4733.6 billion kilowatt hours. This would have been the amount of power generated for 100% efficiency on converting coal to electricity. The net amount generated, from above, was actually 1537 billion kilowatt hours for an

overall efficiency of 32.5%. This may or may not include line losses from source to consumer.

What is emitted at the generating plant as compared to what comes out your exhaust pipe? I would guess that the amount of carbon monoxide may not be much different on a BTU of fuel basis. The gasoline is going to emit far less sulphur than the coal plant but perhaps more nitrous oxide, etc. If the car burns 120000 BTU's per gallon and wastes 60000, then let us say that it gets 25 miles per 120000 BTU's. The same net 60000 BTU's to turn your wheels would require burning approx. 171000 BTU's at the plant.

All this doesn't seem to be the thing to do from a pollution viewpoint unless we ultimately end up with all nuclear facilities or in particular all fusion processes. But I support the R&D on electric cars or in small numbers.

Finally, consider this. Average daily usuage of gasoline is about 7.3 million barrels per day. Converting this to approximate Quads results in yearly Quad usuage of motor gasoline to be 13.4 Quads. The total electricity generated translates to 9.21 Quads for the year. Even if one assumes equal efficiencies, power plant capacity would nearly have to triple if electric cars were the standard. And, as they say, that ain't going to happen anytime soon.

Hope this is useful and informative. Keep up the good work at C-Span.

Sincerely,

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