Electricity, current generation/consumption and projections + Electric vehicle projection for electricity demand through 2040

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A summary report prepared for JLN Solar

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1. APPROACH AND METHODOLOGY

Two sets of data were requested to be found for this report; A) information on average yearly insolation in the USA to be used to calculate energy produced by the Electric Butterfly^{tm} to satisfy a given market (transportation) and B) projections of future electricity demand in the Plug-in Electric Vehicle (PEV) market.

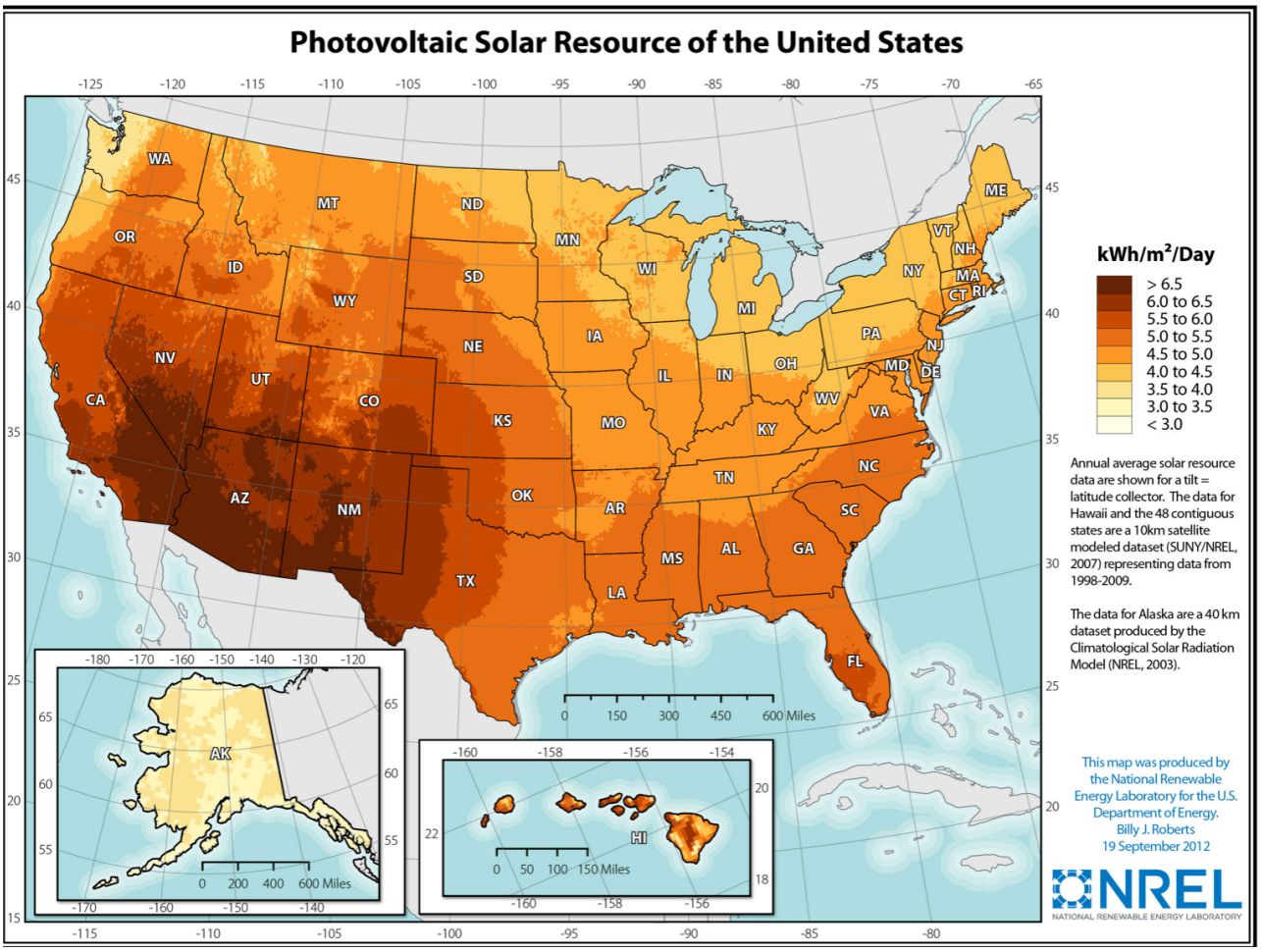
For the first item, the average insolation in the USA, there is more than one possibility to report, depending on the approach used to calculate the figure and the methodology. I will present two cases for this section; one is geographically based and the other an average of radiation measurements averaged accounting for all locations.

For the second part of the request, the projections of electricity demand from the transportation sector with a focus on the Plug-in Electric Vehicle market, I have investigated US government data (the US Energy Information Agency database) and other non-government sources.

The following sections include my findings that I hope capture the data needed by JLN Solar.

2. AVERAGE INSOLATION IN THE USA

A compilation done by NREL shows a map of the average annual insolation by region in the USA considering PV collectors mounted with a tilt angle equal to the latitude.



From this work, we can see that sunny areas of the South-West can have an average *daily* annual insolation of >6.5 kWh/m^2; the West, ~6.0 kWh/m^2, the Central region ~5.0 kWh/m^2; the Mid-West 4.5 kWh/m^2 and the North-East 3.5 kWh/m^2

A simple approach would be to average the annual daily *regional averages* to obtain a country-wide average insolation value, thus, we can estimate:

USA average daily insolation= (6.5+6.0+5.0+4.5+3.5)/5 kWh/m^2/day

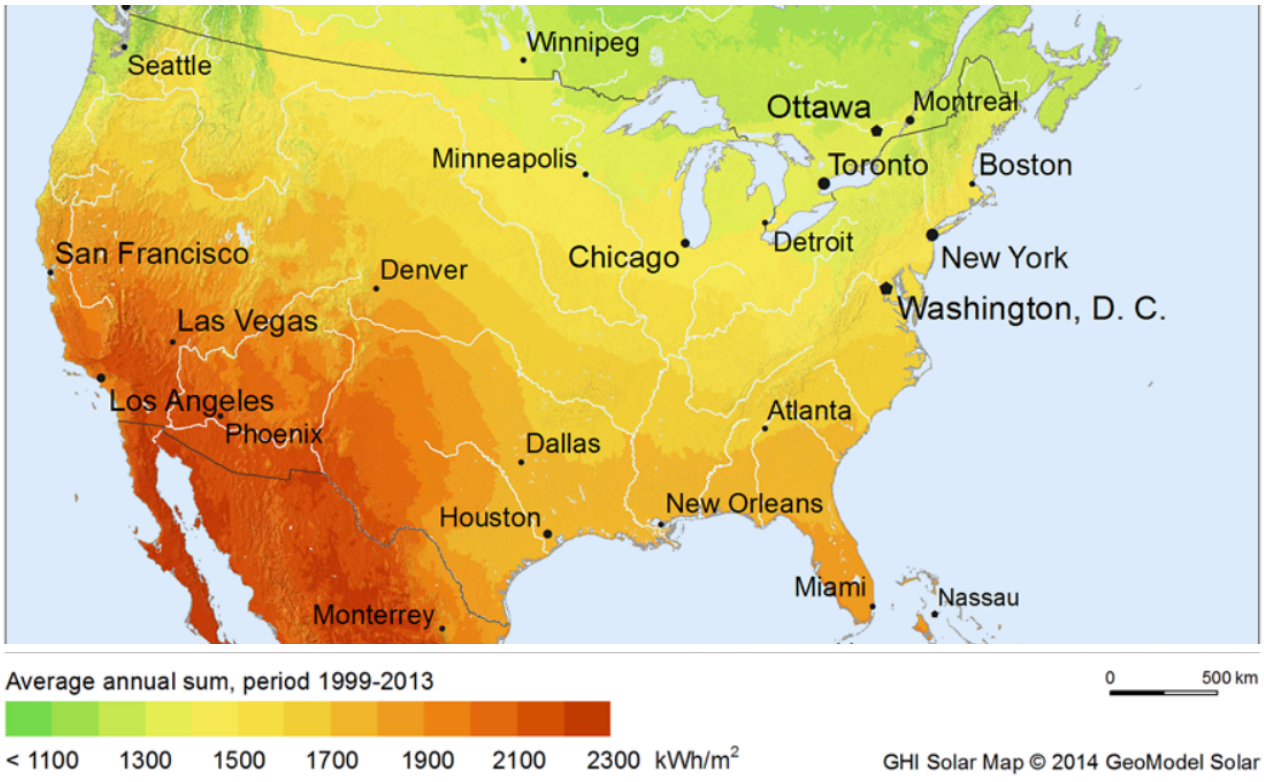
USA average daily insolation= 5.1 kWh/m^2/day

Or

Annual (average) potential nationwide can be estimated as:

364 days x 5.1 kWh/m^2/day = 1,856.4 kWh/m^2/year

An alternative approach is to consider annual averages



The Figure above shows on *an annual basis* that sunny areas of the SW USA, can provide approximately 2,300 kWh/m^2 of solar insolation, the Central continental USA about 1,700 kWh/m^2 and the NE approximately 1,400 kWh/m^2.

Thus, considering only 3 general geographical regions of the USA, we could estimate (by the same method) that the average insolation for the continental USA is:

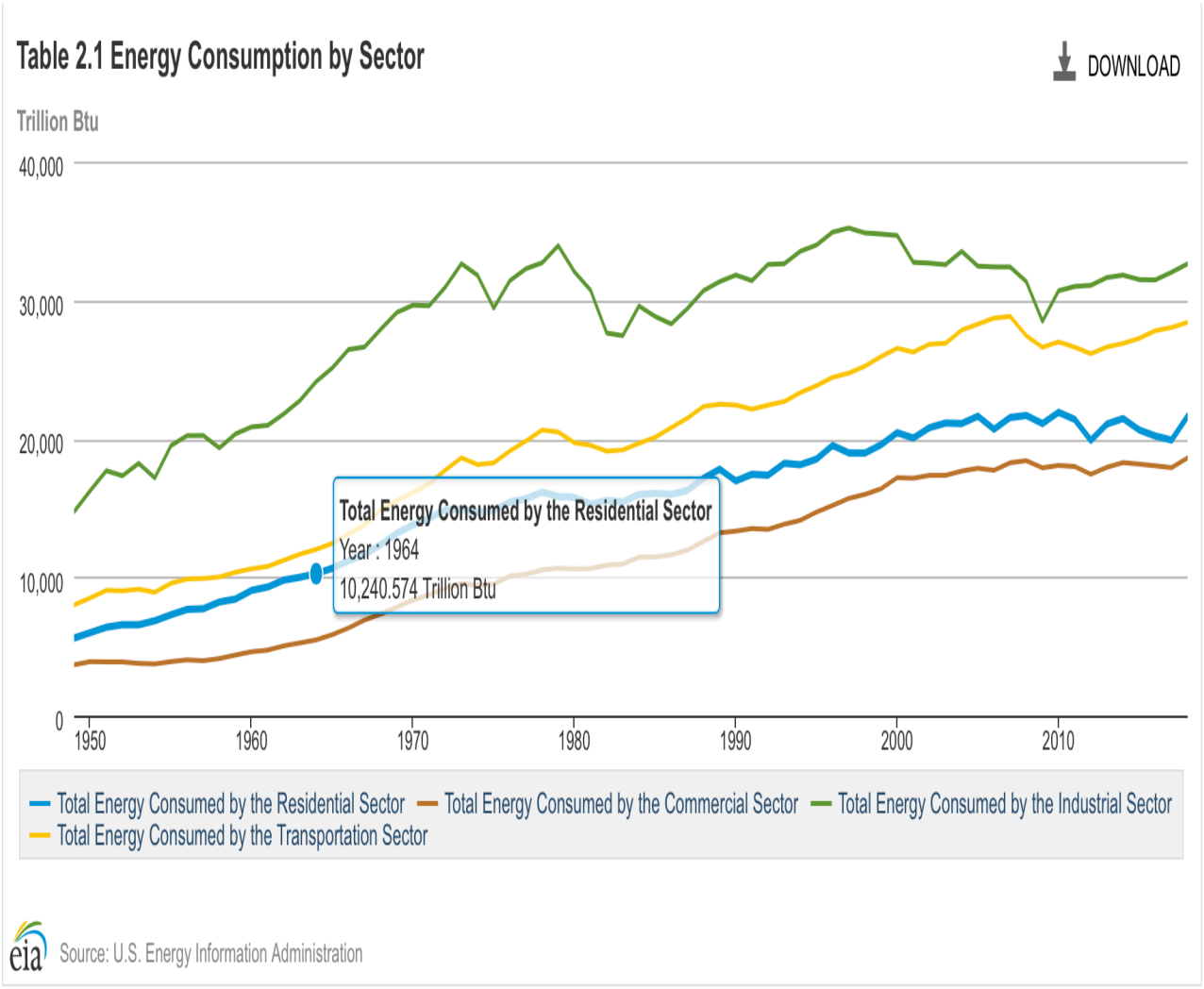
(2,300+1,700+1,400)/3 = **1,800 kWh/m^2/yr**

Then both calculations are in agreement (a small discrepancy of 56 kWh/yr is a small difference in this simplified approach) and thus, in my opinion, an estimate **of 1,800-1856 kWh/m^2/yr** for the *average annual insolation value* for the USA as a whole, is a good starting point for the JLN Solar's Electric Butterfly calculations .

Evidently, more accurate calculations can be performed using the regional averages for that specific region.

3. HISTORICAL ENERGY CONSUPTION IN USA BY SECTOR 1948-2018

As background information to projections of electricity demand for the specific market segment of transportation and projections based on the electric car future demand for electric power, I first present historical energy data which indicates the trends and give an idea of the market size contributions of solar electricity in the overall energy portfolio of the USA.

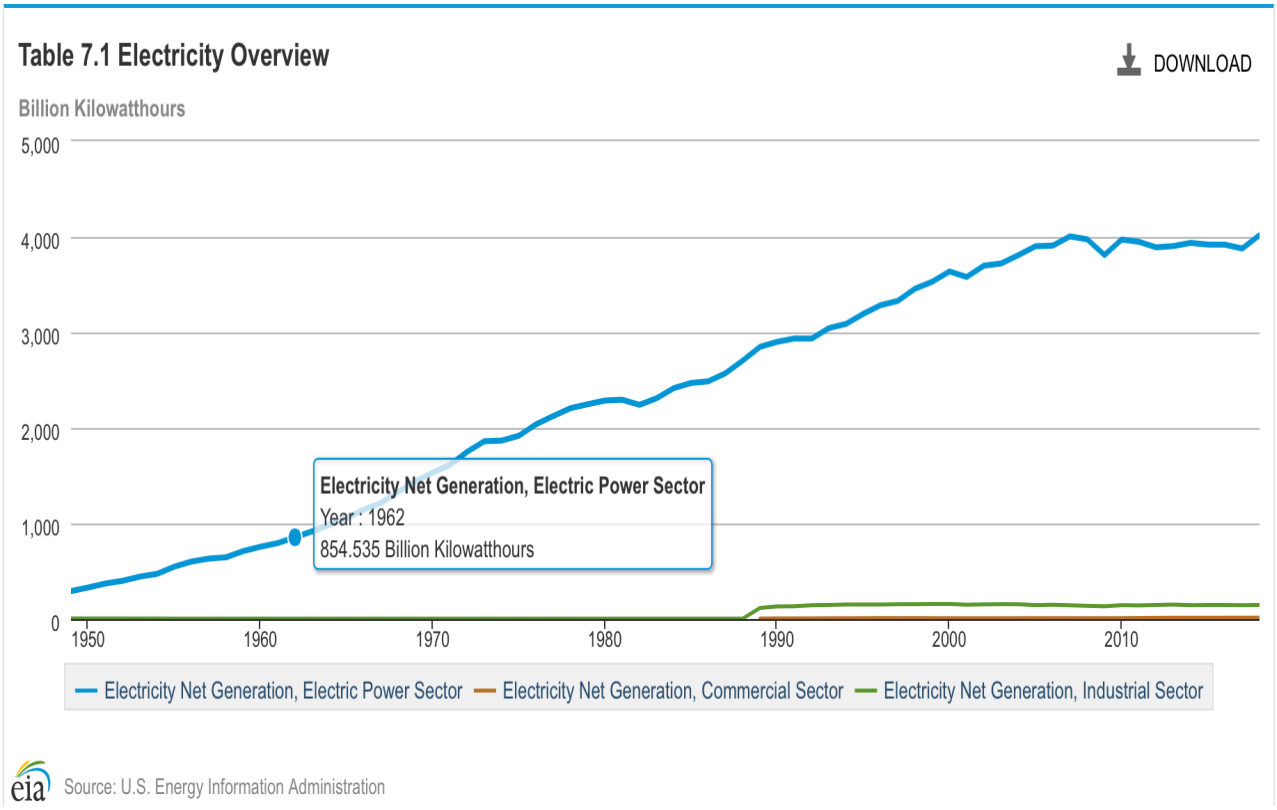


These data shows that the transportation sector as of 2018 was consuming some 28,000 trillion BTUs. Using 1 kWh ~ 3,412 BTUs to covert units, the

transportation consumption then is about 8.2 trillion kWh, of course, this figures account for all sources of energy used in transportation including electric power.

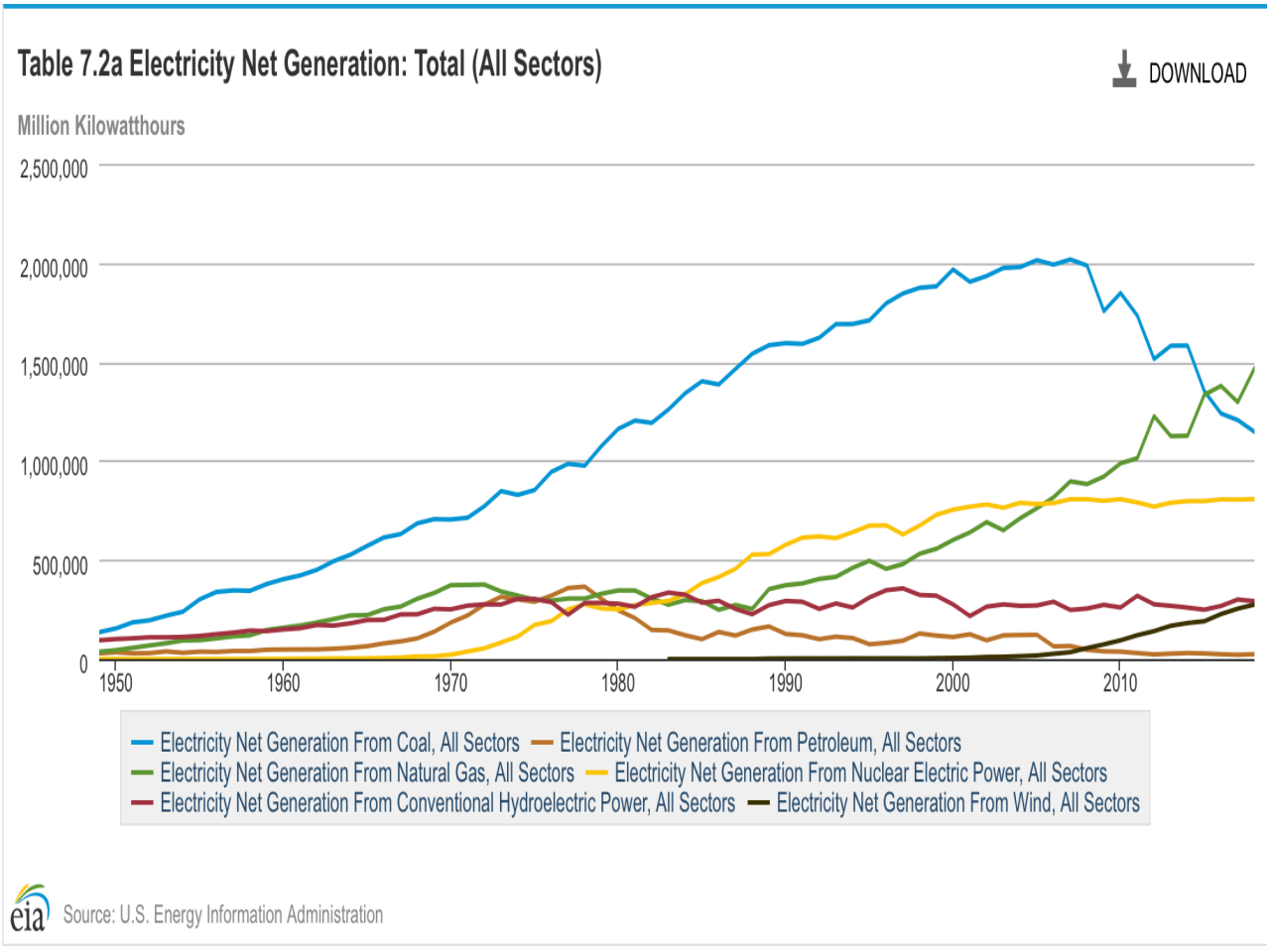
3.1 HISTORICAL ELECTRICITY GENERATION

Focusing now on the electricity market alone, the US Energy Information Agency estimates for 2018 the net electricity generation from the commercial, industrial and electric power sector and from all sources of energy was about 4,000 Billion kWh.



3.2 ELECTRICITY NET GENERATION ALL SECTORS

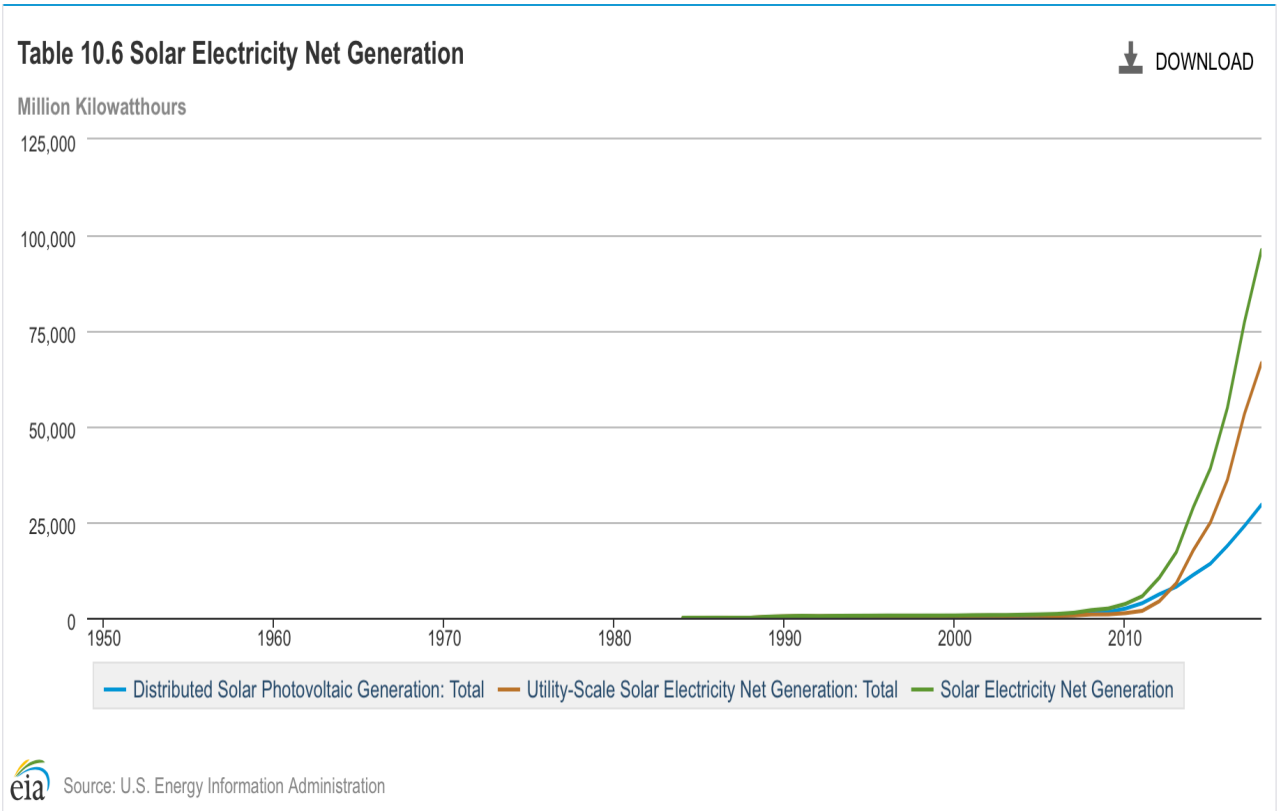
An interesting fact regarding solar electricity is that in the overall picture of the electricity landscape of the USA, solar electricity is still a very, very minor component of the energy portfolio. The only renewable energy sources with significant contribution to the electricity generation in the USA are hydroelectric power and wind power.



3.3 SOLAR ELECTRICITY NET GENERATION

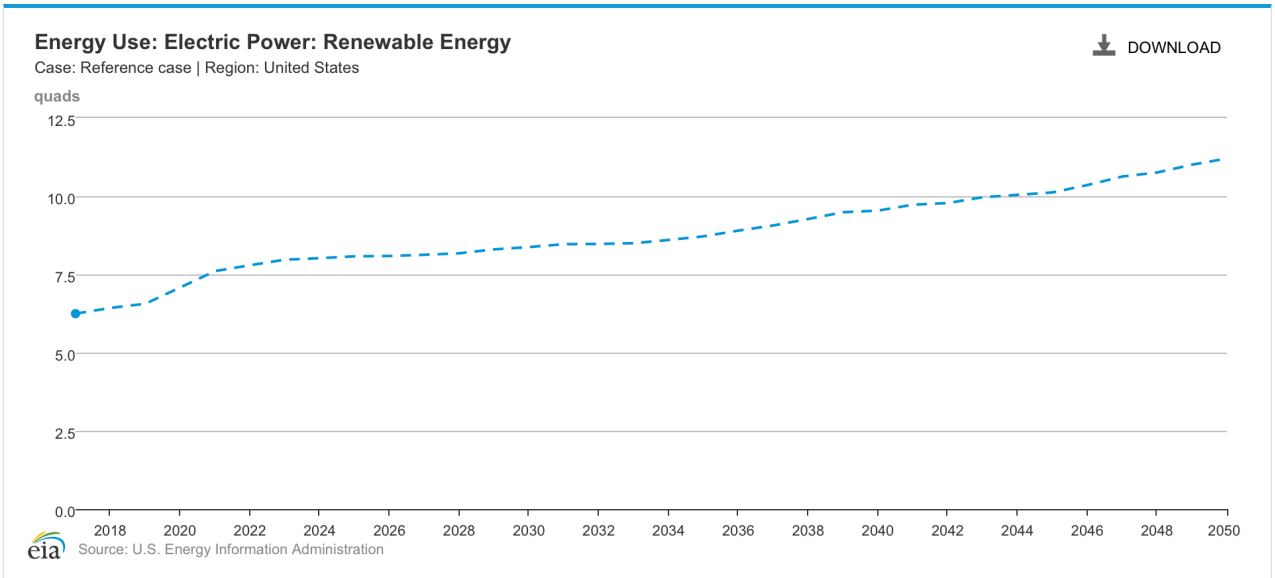
Although renewable energy and specifically solar PV are relatively new comers into the electricity market, these technologies are experiencing a nearly exponential growth in their penetration of the electricity market.

As of 2018 the total solar electricity produced in the USA was about 90,000 Million kWh coming from both the distributed grid power network and the utility scale applications.



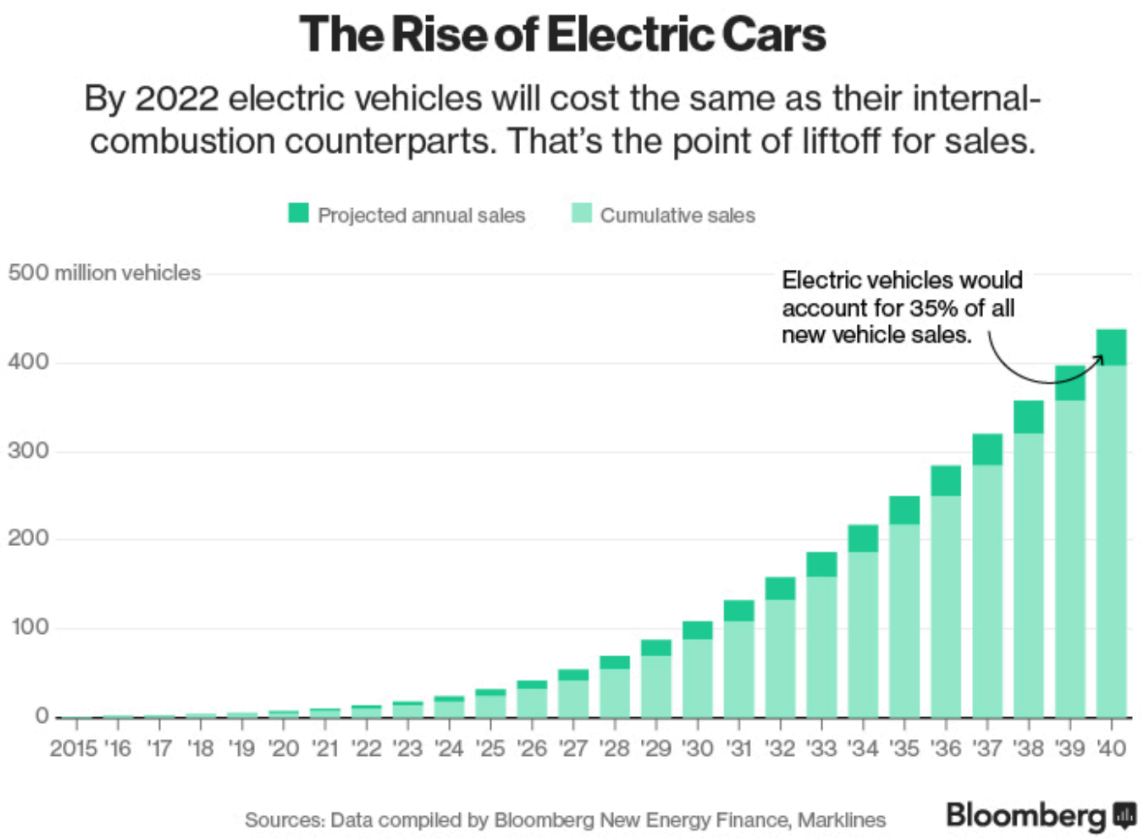
4. PROJECTION THROUGH 2050 FOR CONTRIBUTION OF RENEWABLE ENERGY TO ELECTRIC POWER GENERATION

It is estimated that the market for solar electricity and renewable energy in general will sustain steady growth through 2050.



5. PROJECTION THROUGH 2040 FOR ELECTRICITY DEMAND FROM THE ELECTRIC VEHICLE SECTOR

First of all, I present projections on the number of plug-in electric vehicles (PEV) to enter the market through 2040 (Bloomberg projections)



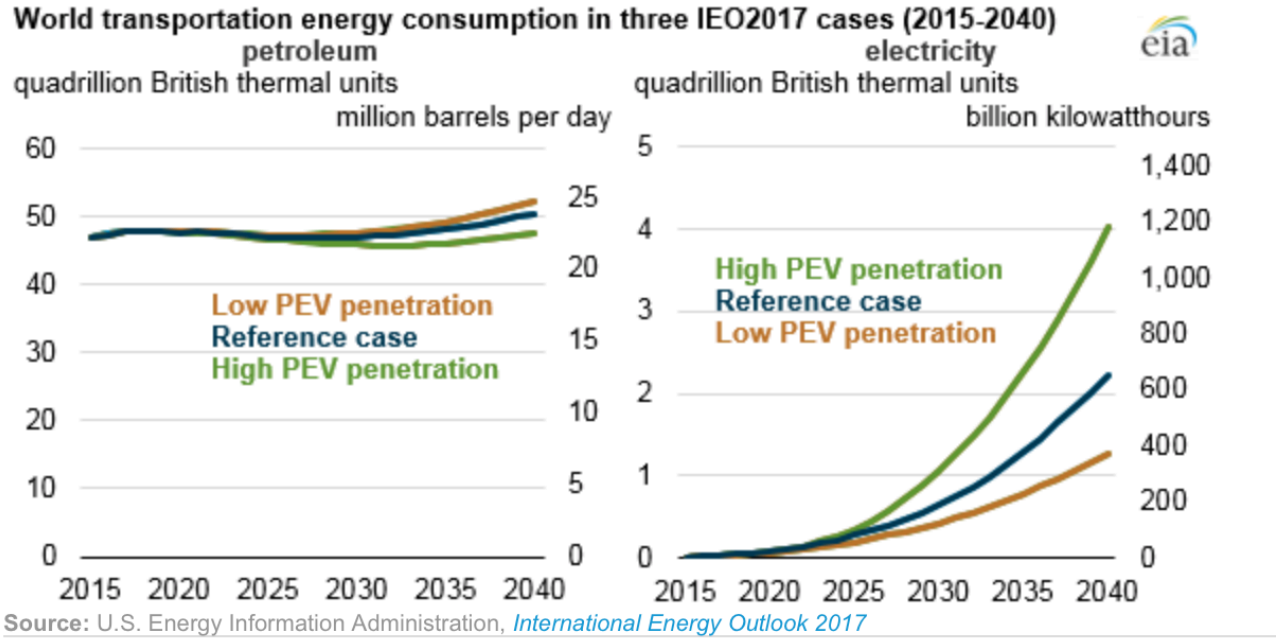
Clearly this PEV market is projected to substantially grow through 2040 and therefore, the impact on the demand for electricity arising from this new segment has been quantified (and projected) by the Energy Information Agency as well.

(From EIA site, sic)

Cumulative sales of plug-in electric vehicles (PEVs), including battery electric vehicles and plug-in hybrid electric vehicles, reached 1.2 million worldwide in 2015. Still, PEVs account for less than 1% of vehicles in use globally. Future developments in battery technology, policy, and consumer preference have important implications for future PEV adoption and serve as a great source of uncertainty in meeting future mobility demand.

An Issues in Focus analysis conducted for EIA's most recent *International Energy Outlook* (IEO2017) considers some of these uncertainties through different PEV penetration scenarios and considers the effect that differing rates of adoption have on worldwide energy consumption. EIA developed two IEO2017 side cases to determine the effect on worldwide energy use if PEV adoption were higher or lower than projected in the Reference case.

The Low PEV Penetration case reflects low consumer acceptance of PEV technology and projects a little less than half of the PEV stock as in the Reference case by 2040. The High PEV Penetration case reflects high consumer acceptance of PEV technology and projects almost double the PEV stock as in the Reference case by 2040.



Source: U.S. Energy Information Administration, *International Energy Outlook 2017*

Different levels of projected PEV penetration have noticeable effects on worldwide liquids fuel consumption. Liquids fuel consumption in the light-duty vehicle (LDV) sector is almost two quadrillion British thermal units (Btu) higher in 2040 in the IEO2017 Low PEV Penetration case than in the Reference case.

The High PEV Penetration case projects liquids fuel consumption to be 2.75 quadrillion Btu lower than in the Reference case in 2040.

Projected changes in light-duty vehicle electricity consumption is not one-to-one with the changes in light-duty vehicle petroleum fuel consumption. Higher adoption of PEVs results in less petroleum use, both because of the greater efficiency of the PEV powertrain and the switch from using petroleum to electricity. In the Low PEV Penetration case, LDVs consume almost one quadrillion Btu less electricity than in the Reference case. In the High PEV Penetration case LDVs consume 1.8 quadrillion Btu more electricity than in the Reference case in 2040. (End of EIA report)

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From the graph, in right side of the above Figure of this government report, we can see that by 2040 it is estimated that the demand for electricity to supply the PEV market sector is projected to reach between **400 billion kWh** for the lowest estimate (low penetration case of PEVs) and as high as **1200 billion kWh** for the high penetration case scenario.

6. REFERENCES

1) US ENERGY INFORMATION AGENCY

2) BLOOMBERG ENERGY