SOLAR ELECTRICITY GENERATION AND THE ELECTRIC BUTTERFLY™

AN EXPLORATORY STUDY FOR THE JLN SOLAR ELECTRIC BUTTERFLY™

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Table of Contents

1.- JLN SOLAR'S ELECTRIC BUTTERFLY™

1.1- INTRODUCTION TO THE ELECTRIC BUTTERFLY™

The Electric Butterfly™ is a stand-alone two-axis tracking solar array system that includes a total of 72 solar modules. It features a custom designed gearbox and is built to withstand 140 mph hurricane force winds, tidal surges, class 5 earthquakes, and sandstorms in the stowed position. It is built with American steel.

The unit is self-contained for security and is not dependent on the internet for operation. The units can be built on farmland or ranch land. Unlike single axis trackers, these units can be built on uneven terrain. Furthermore, The units can be built very near populated areas, unlike wind, coal, nuclear or natural gas energy. The units do not produce any noise pollution, greenhouse gas emissions, or catastrophic radiation danger.

1.2- THE POWER AND ENERGY OF THE ELECTRIC BUTTERFLY™

The PV Module to be used in the Electric Butterfly, is based on the American invented and developed CIGS ($CuInGaSe_2$) thin film PV technology. CIGS PV Modules are the most advanced and the most efficient among the thin film technologies. Today, the efficiency of a laboratory solar cell is 23.3%, the champion module efficiency is slightly in excess of 18.5%, and the shipped commercial module is between 14% and 16% efficient. JLN SOLAR,INC. projects its module efficiency resulting from the first pilot 125 MW plant to be between 15% - 16%, with potential continuous improvements towards >18% efficiency. The module is 1240mm x 630mm with a rating of about 120-130 W.

1.3- THE ELECTRIC BUTTERFLY™ ENERGY YIELD IN THREE DIFFERENT GEOGRAPHICAL LOCATIONS

To model the energy output of the Electric Butterfly, the following assumption are used as input in the NREL PV Watts simulation software:

1) Modules are rated at 125W each, thus, 125x72 =9kW for the system capacity
2) dual-axis tracking
3) Standard module efficiency of 15%
4) Thermal coefficient of power loss -0.47 %/˚C
5) 10% system losses

6) Inverter efficiency of 96%
7) DC to AC size ratio 1.2
8) Three states are modelled:
   TX cites of Austin, Fort Stockton, Kingsville
   CA, cities of Chico and Bakersfield
   WI, city of Madison

1.3.1- Austin, TX results

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

18,782 kWh/Year*

System output may range from 18,147 to 19,304 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	5.87	1,324	138
February	6.67	1,343	140
March	6.60	1,454	152
April	7.67	1,626	170
May	7.94	1,705	178
June	8.87	1,810	189
July	9.04	1,889	197
August	9.06	1,866	195
September	8.02	1,633	170
October	7.15	1,544	161
November	6.45	1,369	143
December	5.40	1,219	127
Annual	**7.40**	**18,782**	**$ 1,960**

Location and Station Identification

Requested Location	Ausitin ,tx
Weather Data Source	Lat, Lon: 30.25, -97.74 1.1 mi
Latitude	30.25° N
Longitude	97.74° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.104 $/kWh

1.3.2- Fort Stockton, TX

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESULTS

23,048 kWh/Year*

System output may range from 22,534 to 24,385 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	8.07	1,782	196
February	8.20	1,636	180
March	9.48	2,066	227
April	10.17	2,106	231
May	10.47	2,192	241
June	10.66	2,169	238
July	10.42	2,157	237
August	9.56	1,998	219
September	9.20	1,853	203
October	8.35	1,792	197
November	7.71	1,646	181
December	7.43	1,652	181
Annual	**9.14**	**23,049**	**$ 2,531**

Location and Station Identification

Requested Location	fort stokton, tx
Weather Data Source	Lat, Lon: 30.89, -102.9 1.0 mi
Latitude	30.89° N
Longitude	102.9° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.110 $/kWh

Performance Metrics

Capacity Factor	29.2%

1.3.3- Kingsville, TX

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

19,201 kWh/Year*

System output may range from 18,706 to 19,773 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	5.47	1,232	135
February	6.72	1,333	146
March	7.20	1,569	172
April	7.81	1,631	179
May	8.27	1,756	193
June	9.46	1,962	215
July	9.23	1,955	215
August	9.22	1,947	214
September	7.55	1,557	171
October	7.92	1,702	187
November	6.45	1,368	150
December	5.35	1,190	131
Annual	**7.55**	**19,202**	**$ 2,108**

Location and Station Identification

Requested Location	Kingsville, TX
Weather Data Source	Lat, Lon: 27.49, -97.86 1.2 mi
Latitude	27.49° N
Longitude	97.86° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.110 $/kWh

Performance Metrics

Capacity Factor	24.4%

1.3.4- Chico, CA results

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

20,697 kWh/Year*

System output may range from 19,975 to 21,300 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.52	1,021	159
February	5.11	1,045	163
March	7.01	1,588	248
April	8.66	1,868	291
May	10.28	2,206	344
June	11.70	2,335	364
July	12.08	2,453	382
August	11.29	2,309	360
September	9.88	1,970	307
October	7.95	1,698	265
November	5.57	1,193	186
December	4.46	1,011	158
Annual	**8.21**	**20,697**	**$ 3,227**

Location and Station Identification

Requested Location	Chico, CA
Weather Data Source	Lat, Lon: 39.73, -121.82 1.0 mi
Latitude	39.73° N
Longitude	121.82° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.156 $/kWh

1.3.5- Bakersfield, CA results

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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

22,421 kWh/Year*

System output may range from 21,149 to 23,244 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	5.22	1,161	181
February	6.42	1,313	205
March	8.30	1,830	285
April	9.34	1,982	309
May	10.82	2,342	365
June	12.08	2,501	390
July	11.67	2,439	380
August	11.23	2,320	362
September	10.19	2,058	321
October	8.17	1,743	272
November	6.81	1,446	225
December	5.59	1,284	200
Annual	**8.82**	**22,419**	**$ 3,495**

Location and Station Identification

Requested Location	bakersfield, ca
Weather Data Source	Lat, Lon: 35.37, -119.02 0.2 mi
Latitude	35.37° N
Longitude	119.02° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.156 $/kWh

Performance Metrics

Capacity Factor	28.4%

1.3.6- Madison, WI results

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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

17,239 kWh/Year*

System output may range from 15,980 to 18,627 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.94	974	154
February	5.08	1,107	175
March	6.24	1,484	234
April	6.79	1,530	242
May	7.74	1,746	276
June	8.64	1,872	296
July	8.89	1,918	303
August	8.11	1,790	283
September	7.34	1,594	252
October	5.61	1,302	206
November	4.33	1,018	161
December	3.65	905	143
Annual	**6.36**	**17,240**	**$ 2,725**

Location and Station Identification

Requested Location	Madison, WI
Weather Data Source	Lat, Lon: 43.09, -89.38 1.1 mi
Latitude	43.09° N
Longitude	89.38° W

PV System Specifications *(Residential)*

DC System Size	9 kW
Module Type	Standard
Array Type	2-Axis Tracking
Array Tilt	0°
Array Azimuth	180°
System Losses	10%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

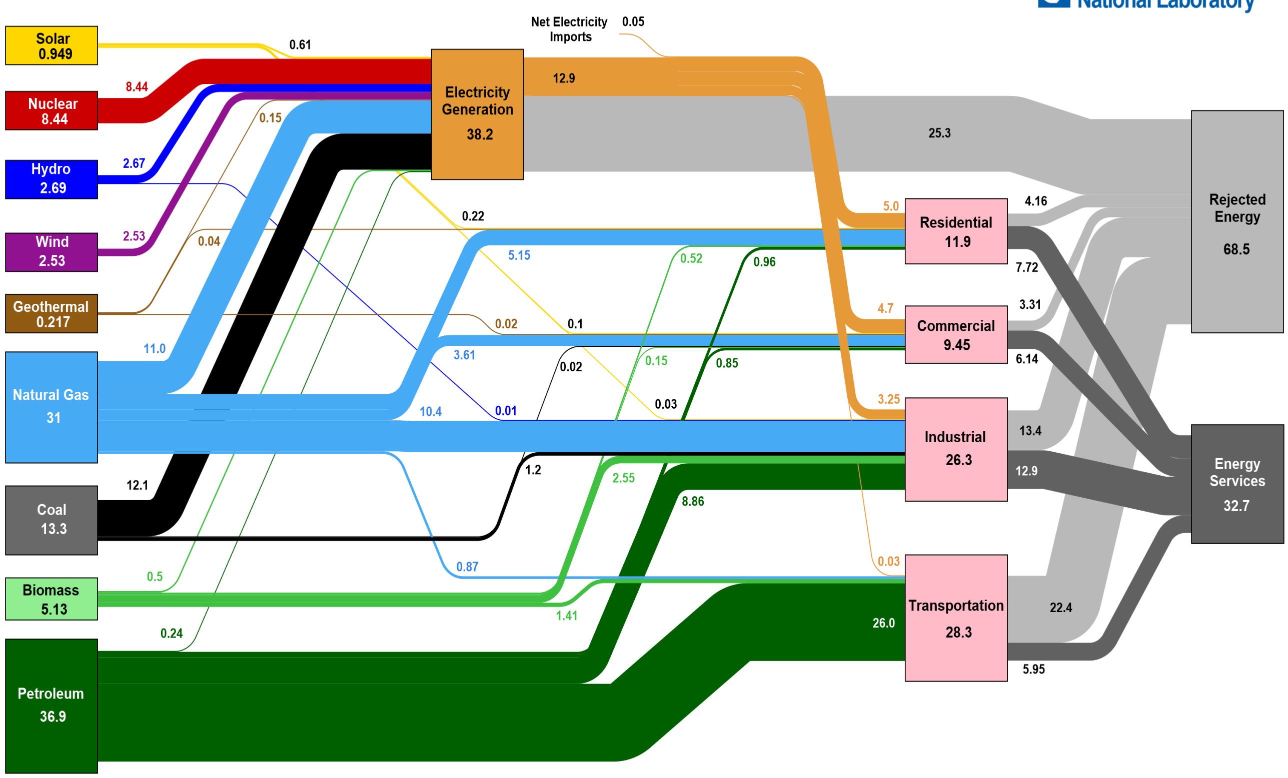
Average Retail Electricity Rate	0.158 $/kWh

2.- ESTIMATED U.S. ENERGY CONSUMPTION 2018

2.1- ALL SOURCES

Estimated U.S. Energy Consumption in 2018: 101.2 Quads

Lawrence Livermore National Laboratory



Source: LLNL March, 2019. Data is based on DOE/EIA MER (2018). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

As of 2018, the estimated U.S. energy consumption to generate electricity was 38.2 Quads.

A quad is a unit of energy equal to 10^{15} (a short-scale quadrillion) BTU, or 1.055×10^{18} joules in SI units.

3.- THE U.S. POWER GRID

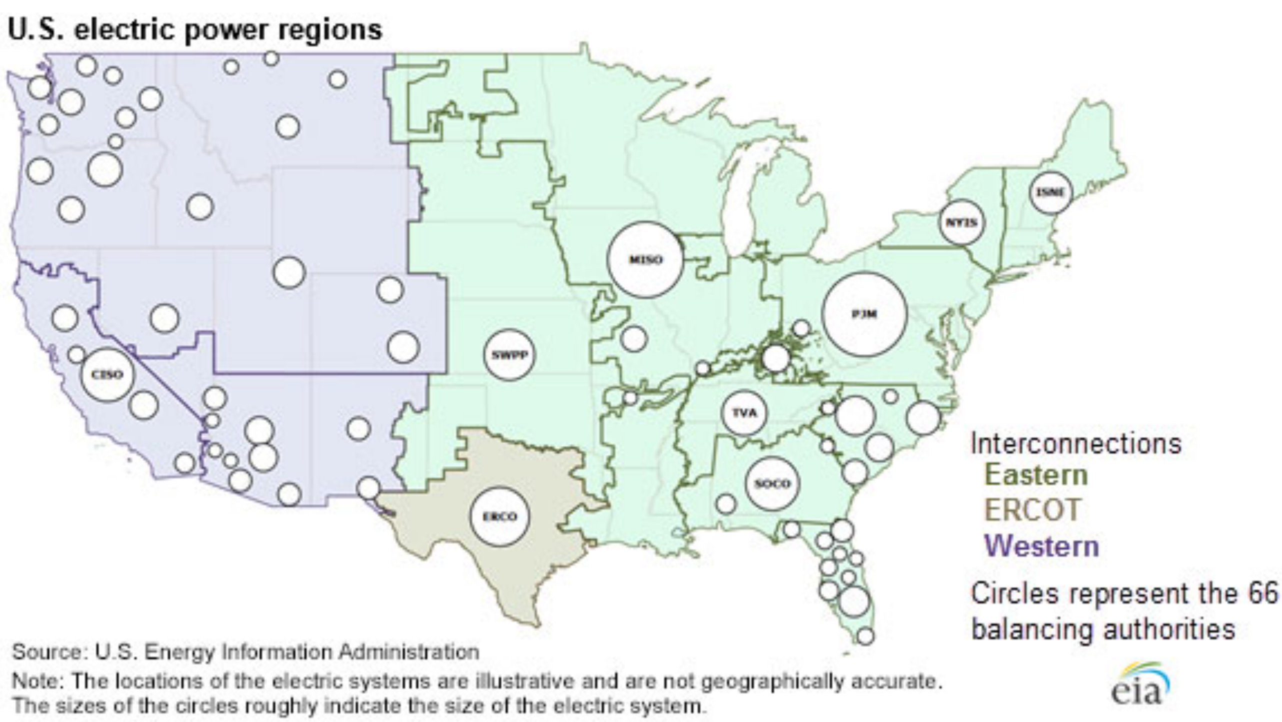
3.1- U.S.A GRID

In the U.S.A, smaller local electricity grids are interconnected to form larger networks for reliability and commercial purposes. At the highest level, the U.S. power system in the Lower 48 states is made up of three main interconnections, which operate largely independently from each other with limited transfers of electricity between them.

1) The Eastern Interconnection encompasses the area east of the Rocky Mountains and a portion of the Texas panhandle.

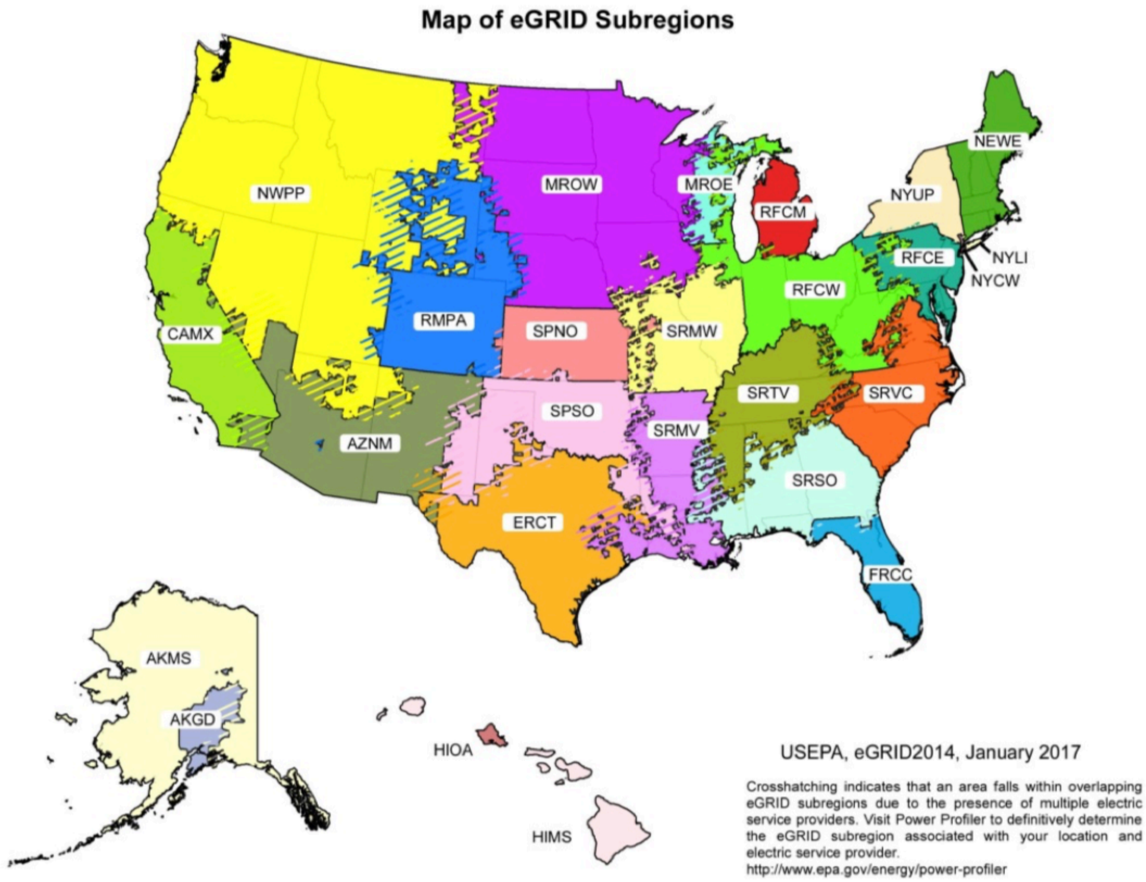
2) The Western Interconnection encompasses the area from the Rockies to the west.

3) The Electric Reliability Council of Texas (ERCOT) covers most of Texas.



3.2 SUB-GRIDS

The three main grids in the USA are fed from smaller grids (sub-region) grouped and depicted in the following Figure.



For these sub-regions, according to the EPA, and as of the most recent data available (2016), the output and energy mix is tabulated as follows:

2. Subregion Resource Mix (eGRID2016)														
eGRID subregion acronym	eGRID subregion name	Nameplate Capacity (MW)	Net Generation (MWh)	Generation Resource Mix (percent)*										
				Coal	Oil	Gas	Other Fossil	Nuclear	Hydro	Biomass	Wind	Solar	Geo-thermal	Other unknown/ purchased fuel
AKGD	ASCC Alaska Grid	2,406	4,705,316	12.6	9.2	61.9	0.0	0.0	12.6	0.9	2.9	0.0	0.0	0.0
AKMS	ASCC Miscellaneous	1,033	1,629,718	0.0	24.6	7.9	0.0	0.0	65.4	0.0	2.1	0.0	0.0	0.0
AZNM	WECC Southwest	63,308	166,327,576	29.5	0.1	39.8	0.0	19.5	3.5	0.4	1.2	2.8	3.2	0.0
CAMX	WECC California	110,656	200,602,485	4.3	0.1	48.4	0.7	9.4	12.1	2.9	7.0	10.6	4.1	0.2
ERCT	ERCOT All	159,336	389,939,062	25.9	0.0	48.2	0.5	10.8	0.3	0.3	13.7	0.2	0.0	0.2
FRCC	FRCC All	97,820	229,407,929	16.0	1.2	66.6	0.0	12.8	0.1	2.4	0.0	0.1	0.0	0.7
HIMS	HICC Miscellaneous	1,164	2,741,704	0.2	61.7	0.0	0.0	0.0	3.3	4.3	14.8	2.1	9.5	4.1
HIOA	HICC Oahu	2,338	7,207,141	20.7	68.7	0.0	0.9	0.0	0.0	6.1	3.2	0.4	0.0	0.0
MROE	MRO East	11,271	20,471,860	64.5	0.6	20.5	0.1	0.0	6.8	5.3	2.0	0.0	0.0	0.1
MROW	MRO West	74,698	218,204,106	52.7	0.2	6.7	0.0	12.8	5.0	1.3	21.1	0.0	0.0	0.2
NEWE	NPCC New England	44,890	107,729,043	2.4	0.6	49.8	0.1	30.4	5.3	8.2	2.5	0.7	0.0	0.1
NWPP	WECC Northwest	90,679	284,912,897	22.5	0.2	15.3	0.3	3.4	47.2	1.3	8.6	0.5	0.7	0.1
NYCW	NPCC NYC/Westchester	16,614	44,416,982	0.0	0.4	64.6	0.0	34.1	0.0	0.9	0.0	0.0	0.0	0.0
NYLI	NPCC Long Island	6,275	11,777,168	0.0	2.7	88.5	0.0	0.0	0.0	8.0	0.0	0.8	0.0	0.0
NYUP	NPCC Upstate NY	30,844	84,093,338	2.1	0.2	27.7	0.0	31.4	31.6	2.1	4.7	0.1	0.0	0.0
RFCE	RFC East	98,917	283,222,518	17.6	0.2	38.0	0.2	39.7	0.9	1.9	1.0	0.4	0.0	0.0
RFCM	RFC Michigan	32,930	92,326,063	41.5	0.9	31.4	1.9	17.5	0.0	2.0	4.8	0.0	0.0	0.0
RFCW	RFC West	185,858	533,500,666	49.8	0.4	16.7	0.7	27.6	0.9	0.6	3.2	0.1	0.0	0.1
RMPA	WECC Rockies	23,339	63,912,177	51.3	0.0	20.2	0.0	0.0	12.1	0.3	15.1	0.8	0.0	0.1
SPNO	SPP North	28,326	66,741,590	57.9	0.1	9.5	0.0	12.4	0.3	0.1	19.8	0.0	0.0	0.0
SPSO	SPP South	61,022	156,780,737	34.8	1.9	40.7	0.2	0.0	3.6	1.5	17.1	0.1	0.0	0.1
SRMV	SERC Mississippi Valley	58,822	172,359,088	14.0	1.1	58.7	1.4	21.2	1.4	1.8	0.0	0.0	0.0	0.4
SRMW	SERC Midwest	38,432	121,294,301	71.4	0.1	8.3	0.0	15.1	1.2	0.1	3.5	0.0	0.0	0.2
SRSO	SERC South	87,370	264,562,049	28.9	0.1	47.0	0.0	18.2	2.0	3.5	0.0	0.3	0.0	0.0
SRTV	SERC Tennessee Valley	73,446	222,211,053	43.7	0.6	23.4	0.0	25.1	6.4	0.8	0.0	0.1	0.0	0.0
SRVC	SERC Virginia/Carolina	113,211	324,246,074	24.9	0.2	29.5	0.1	39.6	1.5	2.8	0.2	1.1	0.0	0.1
U.S.		**1,515,007**	**4,075,322,641**	**30.4**	**0.6**	**33.8**	**0.3**	**19.8**	**6.4**	**1.7**	**5.6**	**0.9**	**0.4**	**0.1**
*percentages may not sum to 100 due to rounding														

Created: 2/15/2018

3.3- ELECTRICITY GENERATION BY STATE (2016 EPA DATA)

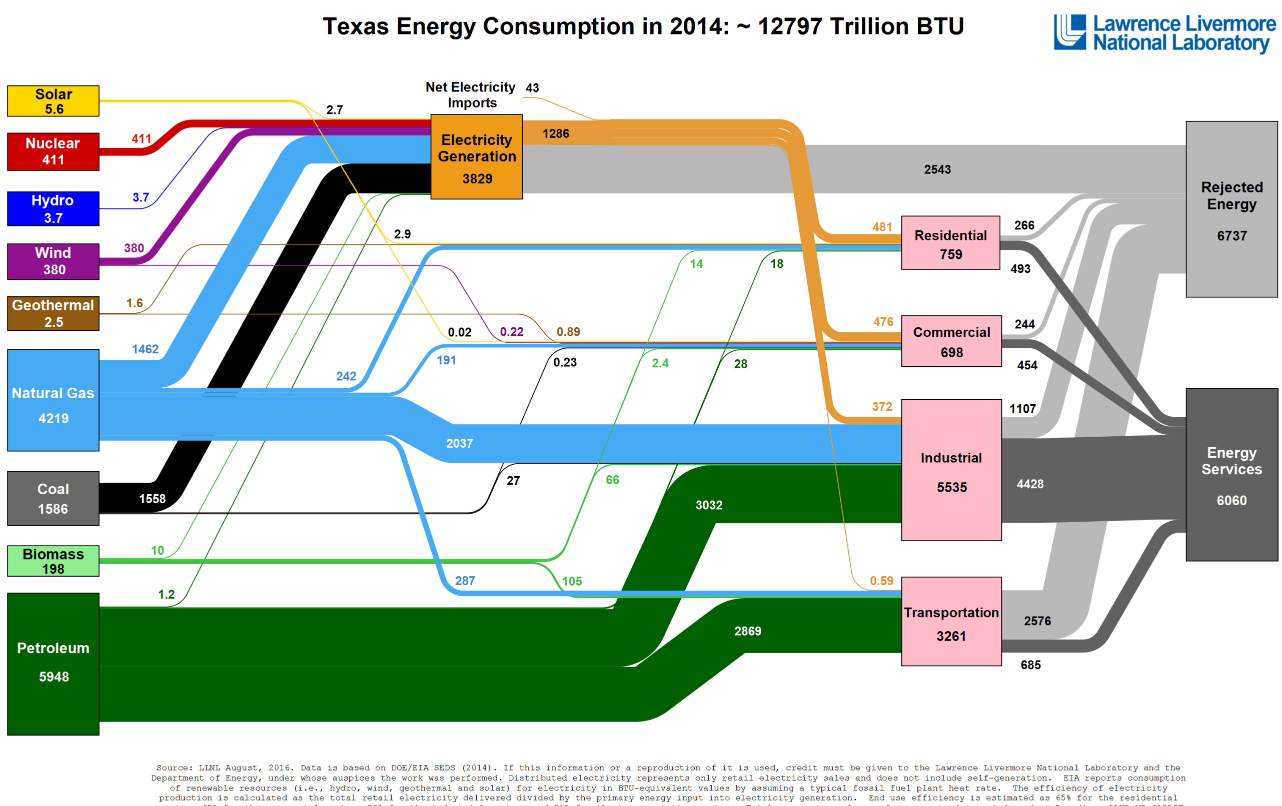
By estate, the EPA estimates the annual net generation shown in the table bellow.

State abbreviation	State annual net generation (MWh)
PSTATABB	**STNGENAN**
AK	6,335,034
AL	142,863,240
AR	60,445,059
AZ	108,734,631
CA	197,323,837
CO	54,418,480
CT	36,496,560
DC	76,474
DE	8,731,261
FL	238,226,428
GA	132,902,274
HI	9,948,845
IA	54,396,531
ID	15,660,938
IL	187,437,381
IN	101,397,209
KS	47,599,990
KY	80,273,501
LA	106,842,115

MA	31,951,671	OH	118,922,078
MD	37,166,747	OK	78,655,008
ME	11,514,427	OR	60,181,812
MI	112,121,790	PA	215,066,508
MN	60,036,476	RI	6,564,885
MO	78,611,513	SC	96,985,764
MS	62,881,295	SD	10,289,416
MT	27,783,530	TN	79,340,633
NC	130,768,153	TX	453,941,342
ND	37,856,452	UT	38,133,928
NE	37,197,843	VA	92,554,816
NH	19,282,493	VT	1,911,207
NJ	77,598,197	WA	114,086,583
NM	32,922,552	WI	64,966,611
NV	39,228,694	WV	75,942,968
NY	134,090,833	WY	46,656,630

4.- TEXAS ELECTRICITY GENERATION (ERCOT GRID)

4.1- TX ENERGY CONSUMPTION, BY SOURCE IN 2014



A snapshot of TX energy

 Texas is the leading U.S. producer of both crude oil and natural gas. In 2017, the state accounted for 37% of the nation's crude oil production and 24% of its marketed natural gas production.

 As of January 2018, the 29 petroleum refineries in Texas were able to process more than 5.7 million barrels of crude oil per day and accounted for 31% of the nation's refining capacity.

- Texas leads the nation in wind-powered generation and produced one-fourth of all the U.S. wind powered electricity in 2017. Texas wind turbines have produced more electricity than both of the state's nuclear power plants since 2014.

- Texas produces more electricity than any other state, generating almost twice as much as Florida, the second-highest electricity-producing state.

- Texas is the largest energy-producing state and the largest energy-consuming state in the nation. The industrial sector, including its refineries and petrochemical plants, accounts for half of the energy consumed in the state.

4.2- TX ELECTRICITY GENERATION (ALL SECTORS)

According to the government data above (EIA and EPA), Texas as of 2016 generated (approximately) between 390,000,000 and 453,941,342 MWh on an annual basis. And only 0.2% of this generation came from solar.

5.- THE ELECTRIC BUTTERFLY SOLUTION

5.1- TX, CA AND WI EXAMPLES

5.1.1- TEXAS

Considering the most recent data on the annual electricity generated in TX (453,941,342 MWh), we can estimate

453,941,342,000 kWh / 18,782 kWh = **24,169,000** Electric Butterflies would be needed in the Austin, TX area to supply <u>the entire state of TX</u> with its demand for electricity

453,941,342,000 kWh / 23,048 kWh =**19,695,477** Electric Butterflies would be needed in the Fort Stockton, TX area to supply <u>the entire state of TX</u> with its demand for electricity

453,941,342,000 kWh / 19,201 kWh =**23,641,547** Electric Butterflies would be needed in the Kingsville, TX area to supply <u>the entire state of TX</u> with its demand for electricity

5.1.2- CALIFORNIA

Similarly, for CA

197,323,837,000 kWh / 20,697 kWh = **9,533,934** Electric Butterflies would be needed in the Chico, CA area to supply the entire state of CA with its demand for electricity

197,323,837,000 kWh / 22,421 kWh = **8,800,849** Electric Butterflies would be needed in the Bakersfield, CA area to supply the entire state of CA with its demand for electricity

5.1.3- WISCONSIN

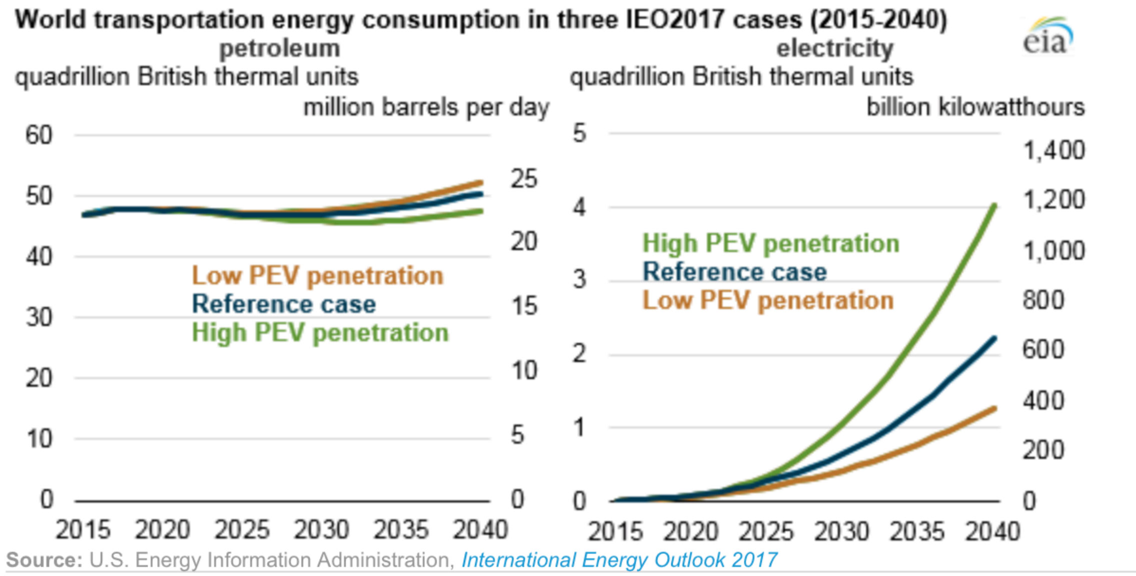
Similarly , for WI

46,656,630,000 kWh / 17,239 kWh = **2,706,458** Electric Butterflies would be needed in the Madison, WI area to supply the entire state of WI with its demand for electricity

All of the above figures consider a standard module efficiency of 15%. Higher efficiencies will reduce the number of electric Butterflies accordingly.

For instance, and to a first approximation, the number of Electric Butterflies needed to supply a given demand, would be reduced by 25% if PV modules with an efficiency of 20% are employed. Similarly, a projected module efficiency of 18% is used, the number of Electric Butterfly units can be reduced by approximately 17%.

5.2- ELECTRIC VEHICLE MARKET



It is projected that the plug-in electric vehicle market will have an electricity demand of 1,200 billion kWh by the year 2040.

Considering a sunny location like Chico, CA (or similar) where the Electric Butterfly can generate up to 20,497 kWh/year, we can estimate from

1,200 billion kWh / 20,497 kWh =0.0585 billion (or **58.5 million**) Electric Butterflies could supply that entire market segment.

REFERENCES

1) Energy Information Agency (www.eia.gov)

2) EPA (www.epa.gov)