



## **Project Report**

# ***COAL VS RENEWABLE ENERGY***

Dashboard, Scorecard and Visualizations

MSIS 2629 – Spring 2017

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## Project Motivation

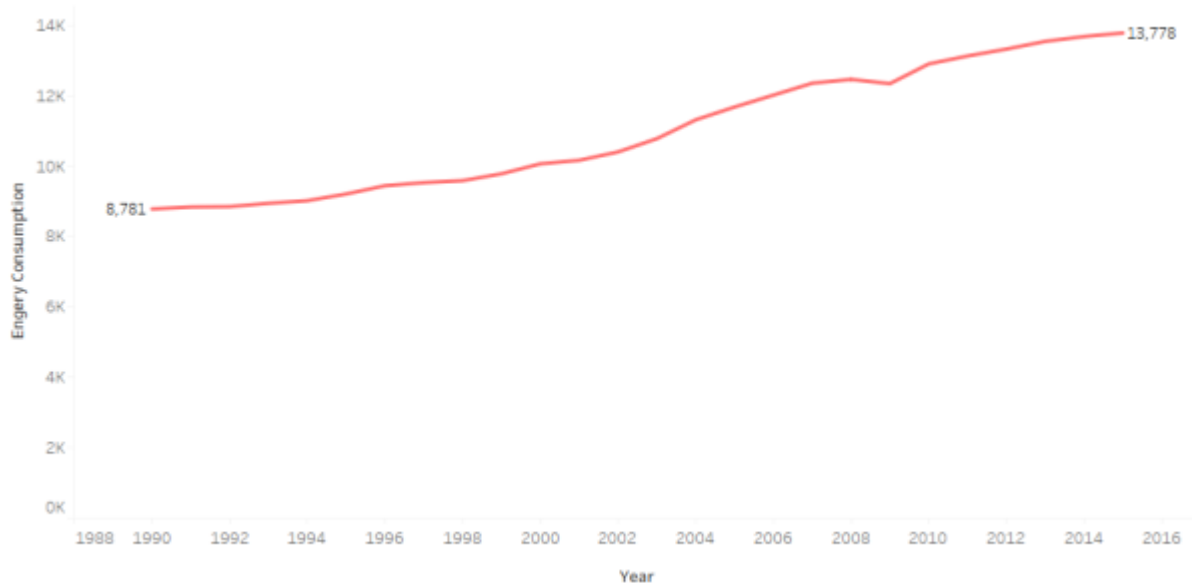
The newly formed White House administration recently pulled out of the Paris climate agreement. The president, Donald Trump stated that the agreement put the United States at an economic disadvantage and wanted to focus on bringing coal jobs back. As a consequence of this, climate action was abandoned, funds for clean energy were diverted, and, coal and oil – the dirty, non- renewable energy sources were embraced again. On the other hand, experts predict that the non-renewable energy industry cannot sustain the same job market as it once did, and that the Trump administration was trying to rejuvenate a dying industry. The US department of energy has a similar story to tell. According to them, while coal still produces much more energy in the US than renewable forms of energy, solar jobs now outnumber the number of jobs in coal by more than 2 to 1.

The rest of the world, China and India in particular, are increasingly focused on reducing consumption from coal plants, slashing jobs related to the coal industry, and heavily investing in renewable energy. While the US administration is turning a blind eye towards renewable energy, other countries in the world are focusing and heavily betting on renewable energy to not only help in climate change but also be the source of high-paying jobs in the future.

Our project aims to analyze the different parameters affecting the coal energy industry and the renewable energy industry and predict whether or not continuing to invest in the coal energy industry is a sustainable practice. We hope to answer whether the Trump administration is taking a reasonable path in order to restore coal jobs in the US economy.

# Increasing world energy consumption over the years

Increasing world energy consumption over the years



The trend of sum of Energy Consumption for Year. The view is filtered on Year, which ranges from 1990 to 2015.

**Figure 1: Increasing energy consumption the world**

The world energy consumption has been increasing over the years as per observed from the data gathered from the US Energy Information Administration. The EIA also predicts that consumption will increase by 56% by 2040.

JULY 25, 2013

**EIA projects world energy consumption will increase 56% by 2040**

Source: <https://www.eia.gov/todayinenergy/detail.php?id=12251>

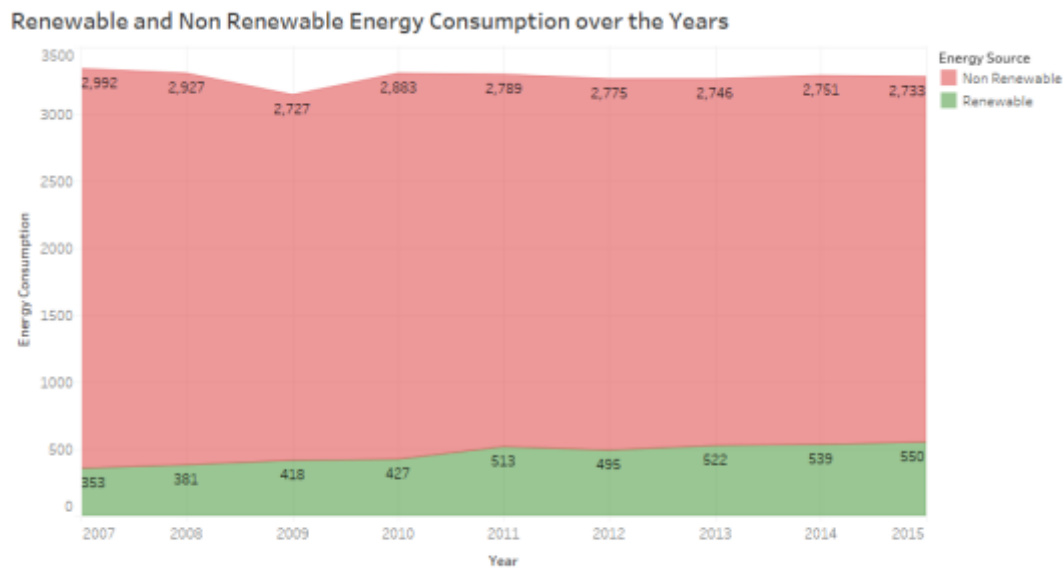
## Shift in Energy Consumption

**Claim:** Renewables would be the fastest growing source of electricity consumption

**Warrant:** The graph observes U.S. energy consumption from renewable sources has been steadily increasing from 2012. Whereas, its reducing with Non Renewables. A number of factors are associated to this change in energy consumption from the two types of sources. Each year US invests more of their economy into the development of renewable energy,

knowing how unsustainable fossil fuels are and the dependency they create. Fossil fuels like coal are seeing the dip as natural gas, solar and wind becomes cheaper and easily meets the demand while creating more jobs and having lesser impact on the environment.

<http://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WT3ApevyvIU>



The plot of sum of Energy Consumption for Year. Color shows details about Energy Source. The view is filtered on Energy Source and Year. The Energy Source filter keeps Non Renewable and Renewable. The Year filter ranges from 2007 to 2015.

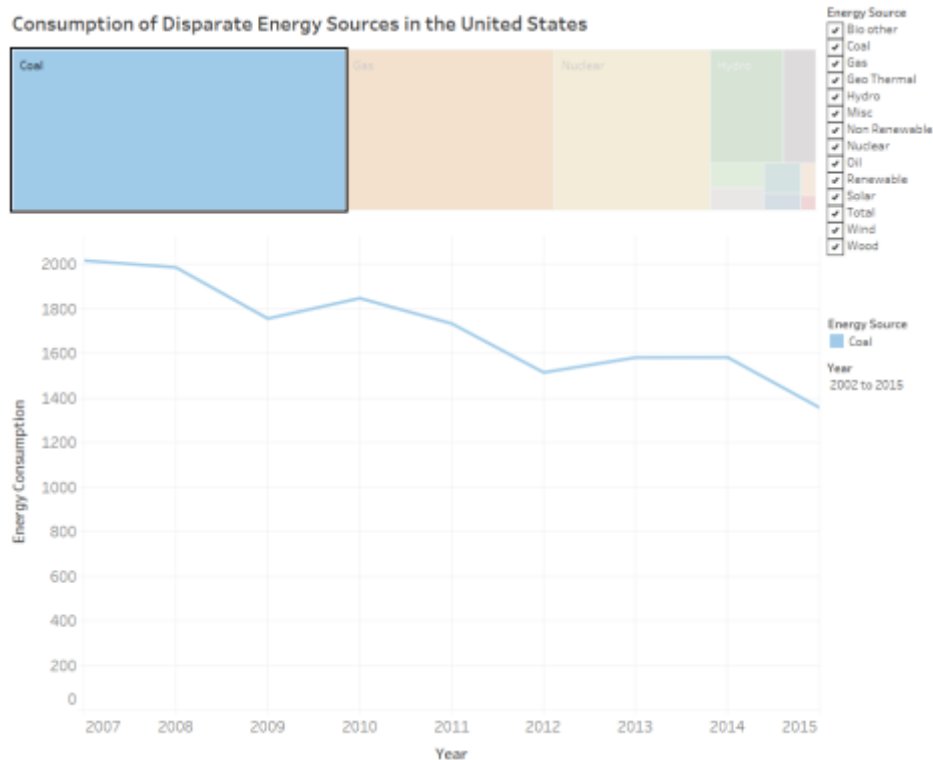
**Figure 2: Area graph showing a steady increase in energy consumption from renewables and reduction of non-renewable consumption**

**Claim:** Energy Consumption from Coal is reducing while consumption from solar energy sees rapid increase.

**Warrant:** The below graphs depict that coal one of the major energy consumption is gradually decreasing over the years. This could be potentially due to its effects on the environment, reduction in number of jobs, mining areas being shut down.

<http://www.greenpeace.org/international/en/campaigns/climate-change/Solutions/Renewable-energy/>

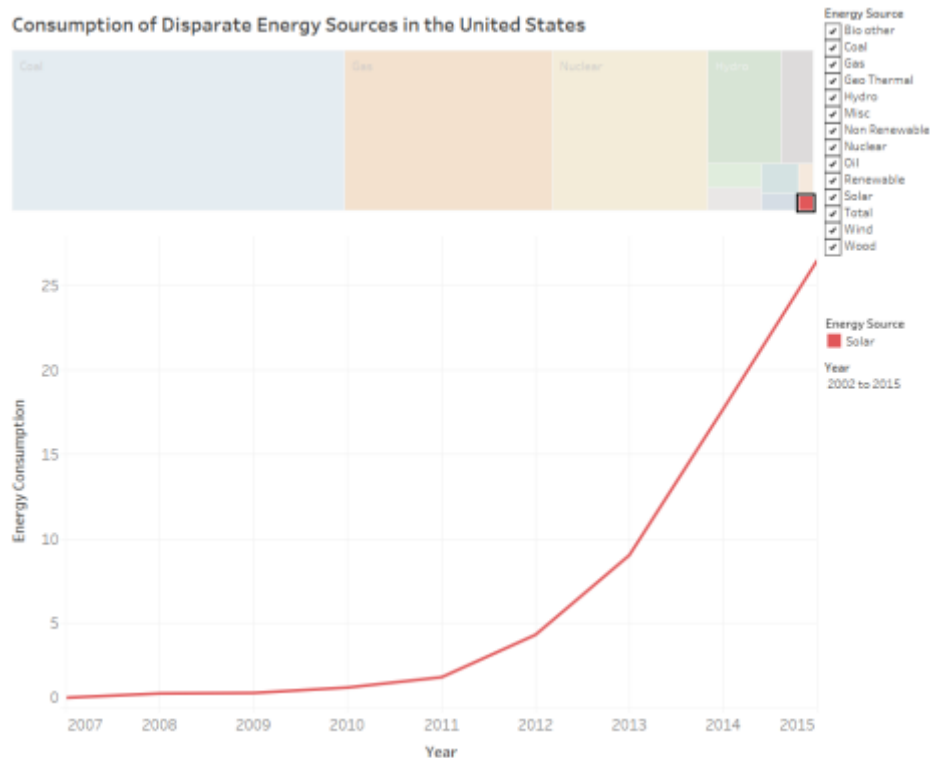
Mining is the first step in the dirty life cycle of coal. When coal mines move in, whole communities are forced off their land by expanding mines, coal fires, subsidence, and overused and contaminated water supplies. Mines are quick to dig up and destroy forests and soils. But once the coal is gone, the problems they leave behind, like acid mine drainage, can persist for decades. Around the world, Greenpeace campaigns to help communities stop coal mines, and speed up the shift to 100 percent clean, safe renewable energy.



**Figure 3 : Dashboard showing a steady decrease in coal energy consumption (in Thousand megawatts) over the years**

Consumption from solar energy on the other hand, sees rapid increase ever since 2011. Renewable energy is massive, mainstream and creating millions of jobs. Rapid renewable energy development is outpacing dirty and dangerous fossil fuel and nuclear power projects every year. Solar's expansion comes with a huge drop in costs, which makes it most favorable form of energy!

<https://cleantechnica.com/2014/02/06/technological-advancements-drove-solar-panel-prices/>



**Figure 4: Dashboard showing rapid increase in solar energy consumption (in thousand megawatts) from 2011**

Solar energy consumption reduce the electricity bills of homeowners. For example some of the major cities like San Francisco saved \$21,922, Los Angeles saved \$21,776 while population in east coast saved an average of \$30000 when they switched to solar in 2015.

<http://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/>

## How are the states doing w.r.t electricity generation?

The Trump administration has been saying that their focus is on restoring the long-struggling coal industry by tearing down the federal environmental regulations, governors and legislatures. But in some of the coal-producing, conservative states — are seen to have their inclinations set elsewhere.

# States Expected to Continue Course Toward Clean Energy Future

January 26, 2017 | By Jen Fifield

SHARE      

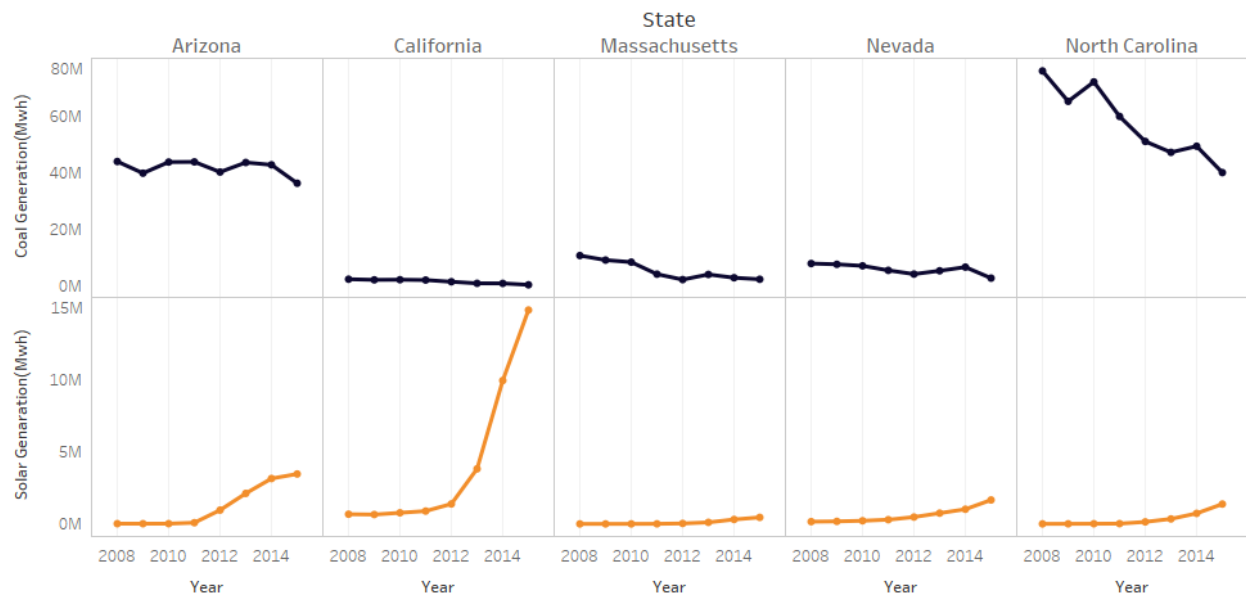
Source: <http://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2017/01/26/states-expected-to-continue-course-toward-clean-energy-future>

According to research conducted by Pew Research, the energy experts and analysts say they are expecting more states to advance initiatives which focus on reducing the country's dependence on fossil fuels. Many states will consider surging their requirements on how much electricity used in the state should come from renewable energy sources. The states will also begin to cut down the carbon emissions to fit their clean energy goals, as California and several states in the Northeast have done in recent years.

With these thoughts, we wanted to learn the state-wise solar and coal consumption of United States. Since, considering the time frame, it was practically not possible for us to evaluate all the 52 states in the country, we decide to pick 5 of them. Since California is state we all reside in, we were curious about how this state is doing on the energy consumption front. The other states we picked up were Arizona, Massachusetts, Nevada and North Carolina. These were the states which have been using both coal and solar for different purposes. When we tried to find the datasets, we found data relevant to the state-wise electricity generation through solar and coal.



## Electricity Generation through Coal &amp; Solar



The trends of sum of GENERATION (Megawatthours) and sum of GENERATION (Megawatthours) (StatewiseSolarData.csv) for Year broken down by State.

**Figure 5: More and more states shifting their focus towards solar energy for electricity generation.**

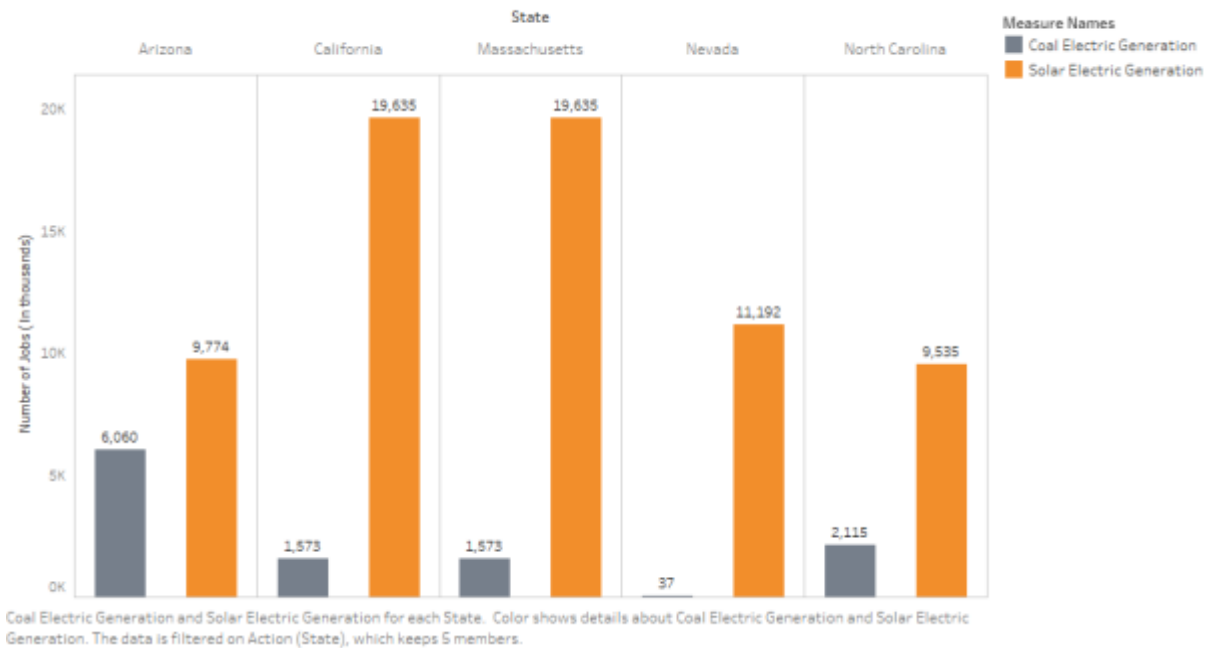
**Claim:** More and more states are adopting solar.

**Warrant:** After, plotting the consumption of coal in these 5 states from the year 2008 to 2014, interestingly we noticed that all these states show a gradual decrease in the coal use for the generation of electricity. While North Carolina shows an exponential decrease in coal utilization, Arizona, California, Massachusetts, Nevada are also gradually reducing their coal use. We then plotted the consumption of solar for the states over the same time span. While California showed an exponential growth in the solar acceptance, the solar use for electric generation in the other states has also been increasing steadily.

This is a fair indication that more and more states are adopting solar energy for relying on their utilities.

## How is the shift in solar affecting the electricity jobs?

State wise solar Jobs in 2017



**Figure 6: Solar Electricity generation is creating more jobs than coal**

It can be observed that for all the five states, solar electric generation created more jobs than that of coal. For California, Massachusetts and Nevada, there is significant gap between the two. Arizona and North California also show greater number jobs created by Solar than coal. This data pertains the current year 2017.

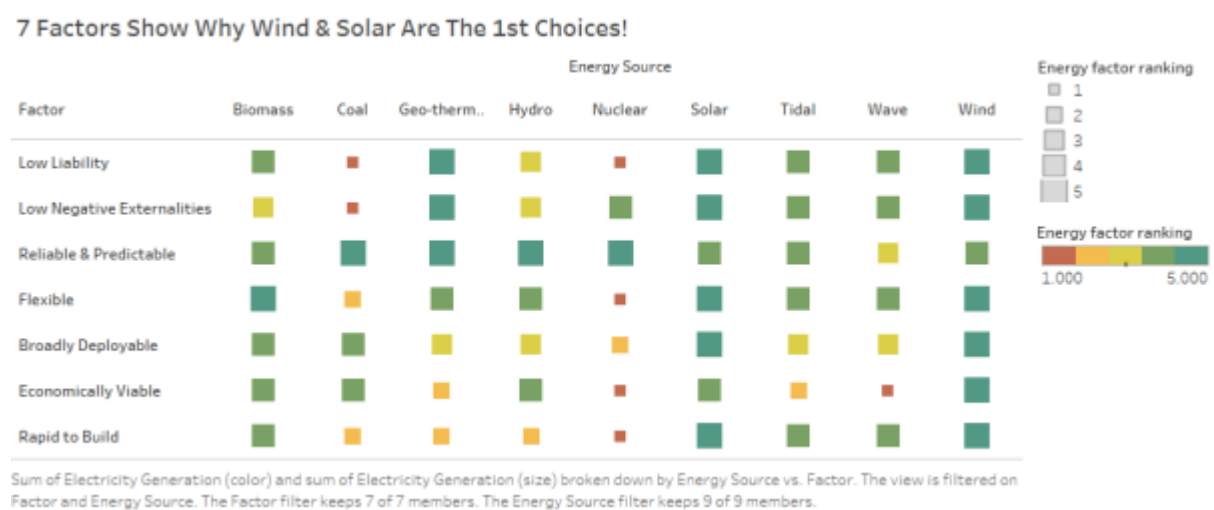
## Evaluating energy efficiencies based on the 7 factors

**Claim:** It's not favorable to bring coal back

**Warrant:** Based on the 7 factors, coal is evaluated with other renewable energy sources. It's not surprising to see coal ranks low in most of the categories. It challenges in terms of pollution, greenhouse gas emissions, not flexible to respond to changes in demand or supply, processing coal to produce energy takes time and liability issues causing economic

disruption or health challenges. Even though, Solar is in the lowest segment when it comes energy consumption in United States, it clearly ranks higher among the 7 factors because of which US witnesses rapid increase in solar energy consumption and this made us compare it with coal. Adopting and shifting our focus to solar energy and other forms of renewable energy has clearly many benefits on mankind and environment than trying to expand concentration in bringing coal back.

<https://cleantechnica.com/2016/07/11/7-factors-show-wind-solar-1st-choices/>



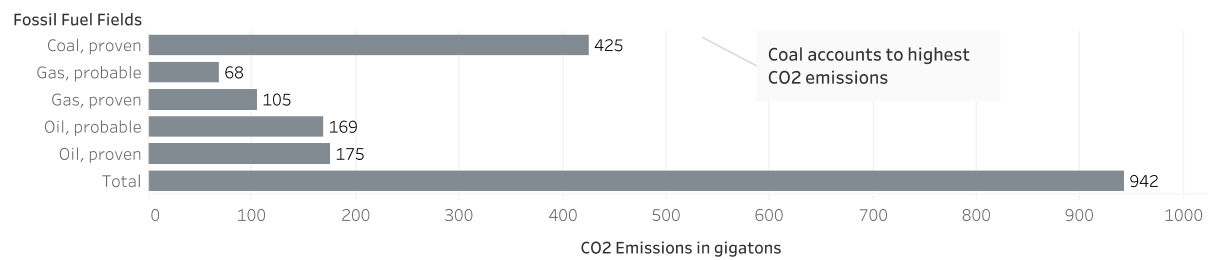
**Figure 7: Energy efficiency for electricity generation based on 7 factors (Coal vs Solar)**

## Analysis of CO2 Emissions from Coal Industry

**Claim:** Coal Industry's contribution to the CO2 emissions are significant and is very detrimental to the environment

**Warrant:** The graph below displays the CO2 emissions from existing, under-construction oil/gas fields, and existing coal mines, globally in just the year 2016. Close to 425 gigatons of CO2 was emitted by just coal reserves alone.

## Carbon dioxide Emissions from Fossil Fuel Mines globally in 2016



**Figure 8: CO2 Emissions from Fossil Fuel Mines in 2016**

From looking at the above graph, we can see that coal plants are the world's top source of CO2 emissions, the primary cause of global warming. According to (Source : <http://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/coal-air-pollution#.WTzpIRPyv6Y>), in 2012, utility coal plants in the United States emitted a total of 1.7 billion tons of CO2 and a typical coal plant generates 3.5 million tons of CO2 per year. The imminent death of the coal industry is good for the world because it'll greatly reduce the amount of CO2 pumped into the atmosphere each year. This has a direct impact on global warming, making coal the single greatest threat to our climate. Other than CO2, coal mining is also a source of methane, a very potent global warming gas.

In addition to this,

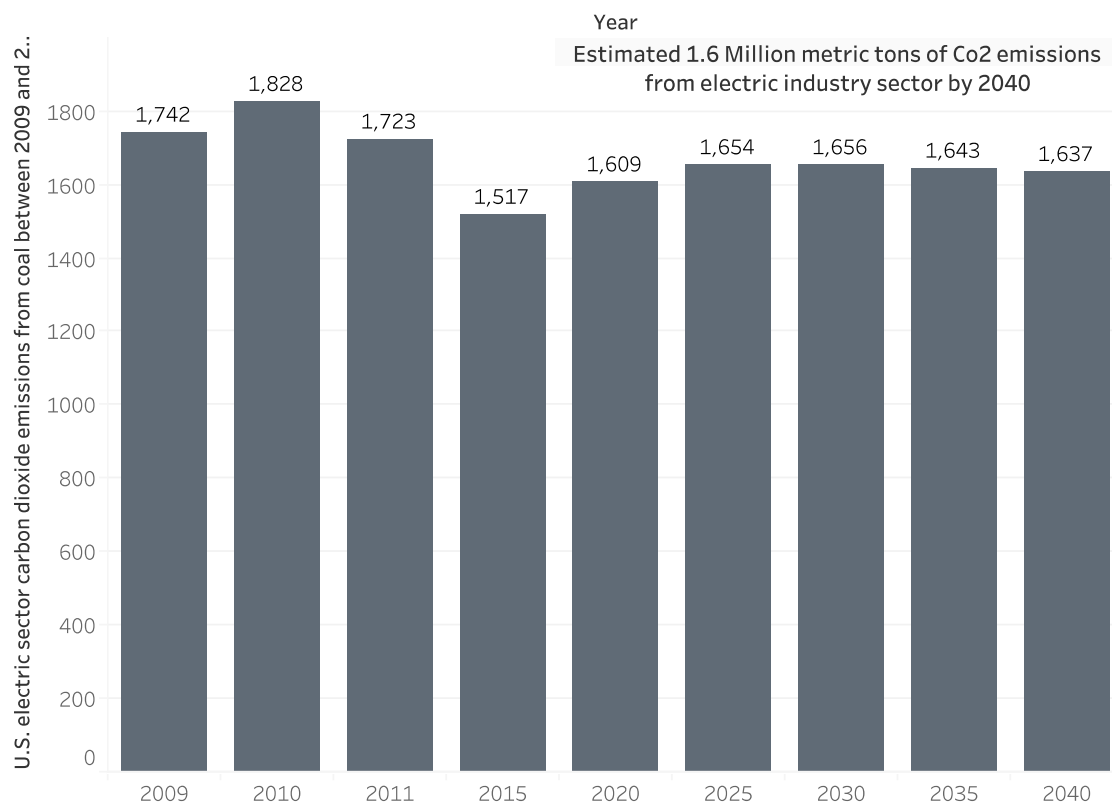
- The air pollution caused by coal mines adversely affects the health of the surrounding population.
- Causes water pollution by contaminating ground water sources
- Open – cut coal mining disturbs landscapes.

Coal power in the United states accounted for around 30.4% of the country's electricity production in 2016. With coal being one of the primary sources for energy production, it poses a serious threat to the environment

The graph below estimates around 1.6 million metric tons of CO<sub>2</sub> emissions from electric sector.

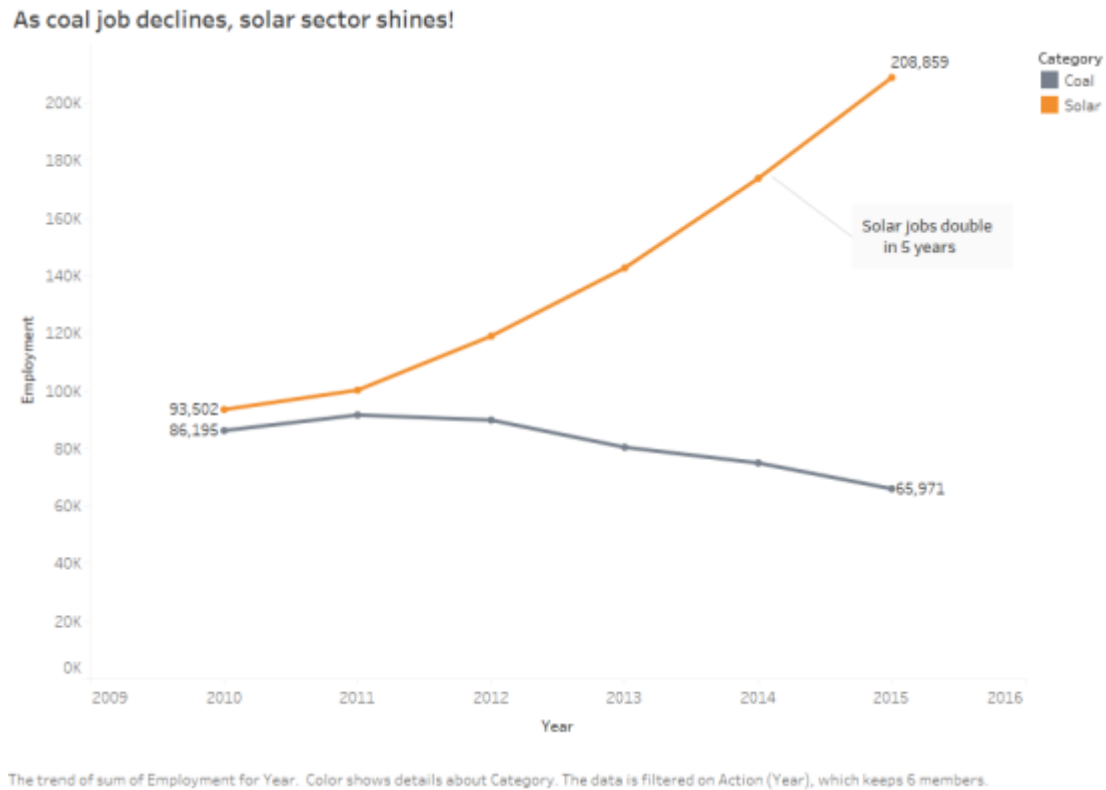
If the United States and the rest of the world continues its use of coal at the same rate, the world is looking at a critical 2 degree rise in temperature in as little as two decades. This change will be drastic for the environment, with all forms of life being severely affected. It is imperative that the world including the United States, being one of the countries with the highest emissions, take serious measures to curtail the emission of green house gases into the atmosphere.

### U.S. Electric Sector Carbon dioxide Emissions



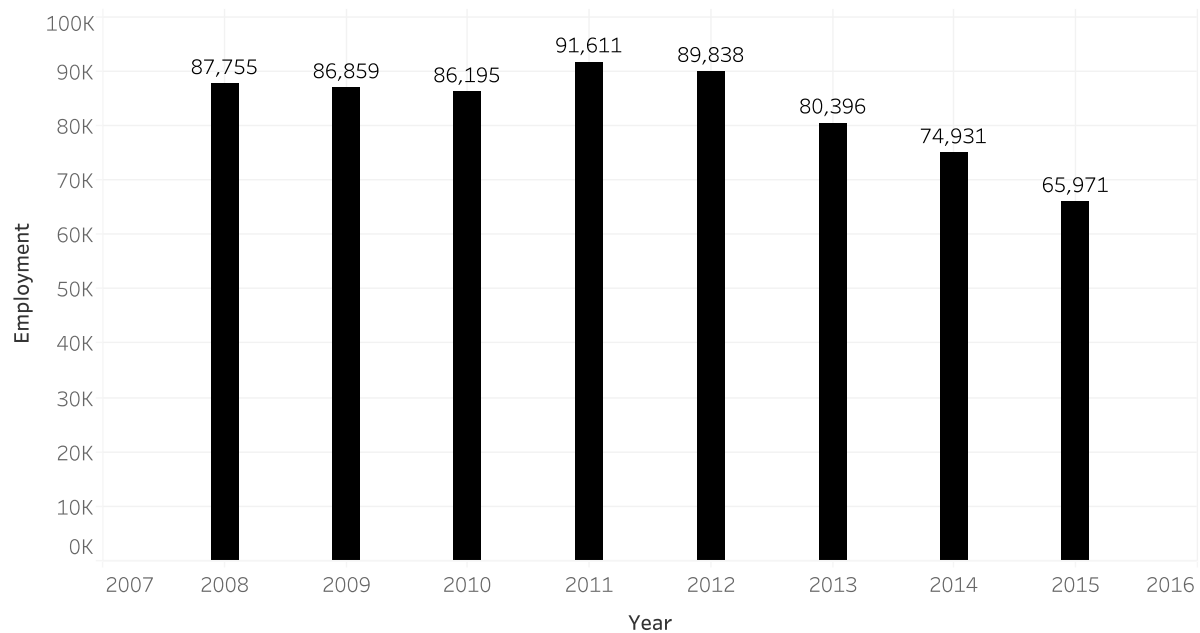
**Figure 9 : U.S. electric sector CO<sub>2</sub> emissions from coal**

## Analysis On the Job Industry



**Figure 10: Comparison of solar and coal**

Coal Jobs decreasing over Years



**Figure 11:** A Bar graph showing a gradual decline in coal jobs year after year

## How likely is it that President Trump will bring back coal jobs?

**Claim :** President Trump cannot bring back coal jobs

**Warrant:** Observe from the above figure that the number of coal jobs in the United States has gradually declined starting from 2011. A number of factors can be attributed towards this decline. Coal has historically competed with oil and gas as a source of energy. These competitors have gained ground against coal in the last decade. In addition, an increased global demand for coal from newly industrializing countries such as China had led to the US exporting increasing amounts of coal thus reducing local jobs in the coal energy sector. The period of 2000 to 2008 saw the most demand for coal internationally. Finally, renewable energy has gotten less expensive in that time and has gained more focus. Many coal plants in the US and the West came up for retirement just as *natural gas, wind, and solar* were getting cheap and thus missed out on a market share opportunity. It is often suggested that

employment in America's coal industry collapsed not five years ago, but fifty years ago. From the establishment of the EPA by President Nixon, to the steady market share gains of natural gas and other renewable energies in the US, and the shift to machine-based, open pit coal extraction, these have all contributed towards keeping growth in the coal industry negligible for a really long time.

From the previously mentioned graph, the 2015 coal mining employment was seen at *65,971 jobs*. On a much longer timeline, the US coal employment has literally been *decimated*, falling from a high of over 800,000 jobs in the 1920's to less than 100,000 today. Taking this decline into consideration, the Trump Administration promising a second resurrection of America's coal industry demonstrates ignorance of the state of the industry. The administration appears to be ignoring natural demand in other sectors and skewing focus towards a dying industry. US Coal industry is affected by the Markets and Technologies and not policy. And in today's global market, solar, wind, and natural gas are destroying coal for new, marginal additions in power generation in most domains.

## **Energy experts give Trump the hard truth: You can't bring coal back**

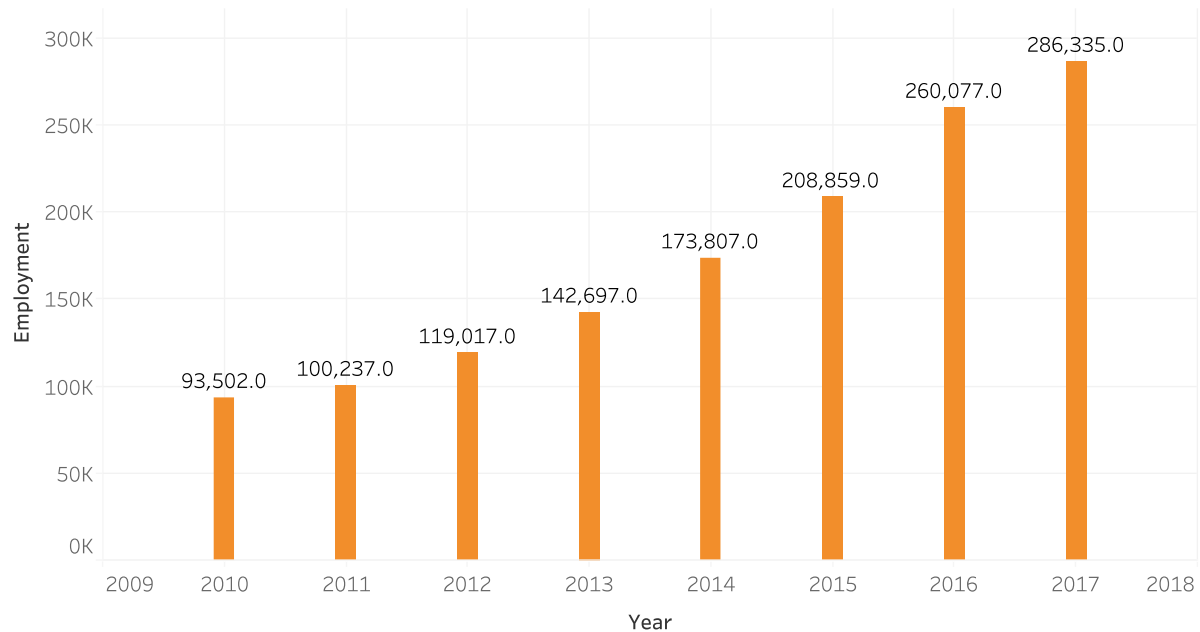
Coal wasn't killed by a political "war"—cheap renewables and fracked gas were the culprits.

Source: <https://thinkprogress.org/coal-wont-rebound-whatever-president-trump-does-energy-experts-say-e30a78745b77>



Lets take a closer look on the trend in solar industry :

#### Gradually rising Solar Jobs



**Figure 12: A bar graph showing a rise in solar jobs over years**

People often underestimate the number of jobs provided by the solar industry. The industry employs a large number of American workers and is on a steady growth path as seen from the graph above. Solar panels are increasingly visible on home rooftops across the country and the industry is only poised to grow further. The solar industry, *according to this year's census is adding workers **seventeen times faster** than all other sectors in the economy.* It is known to be contribution to 2% of all new jobs created in the United States in the last year alone. According to long term research conducted by the solar foundation, since 2010, the industry has contributed to 166000 new jobs and expects to increase to a total of 286000 jobs by the end of 2017.

## Today's Energy Jobs Are in Solar, Not Coal

By NADJA POPOVICH APRIL 25, 2017

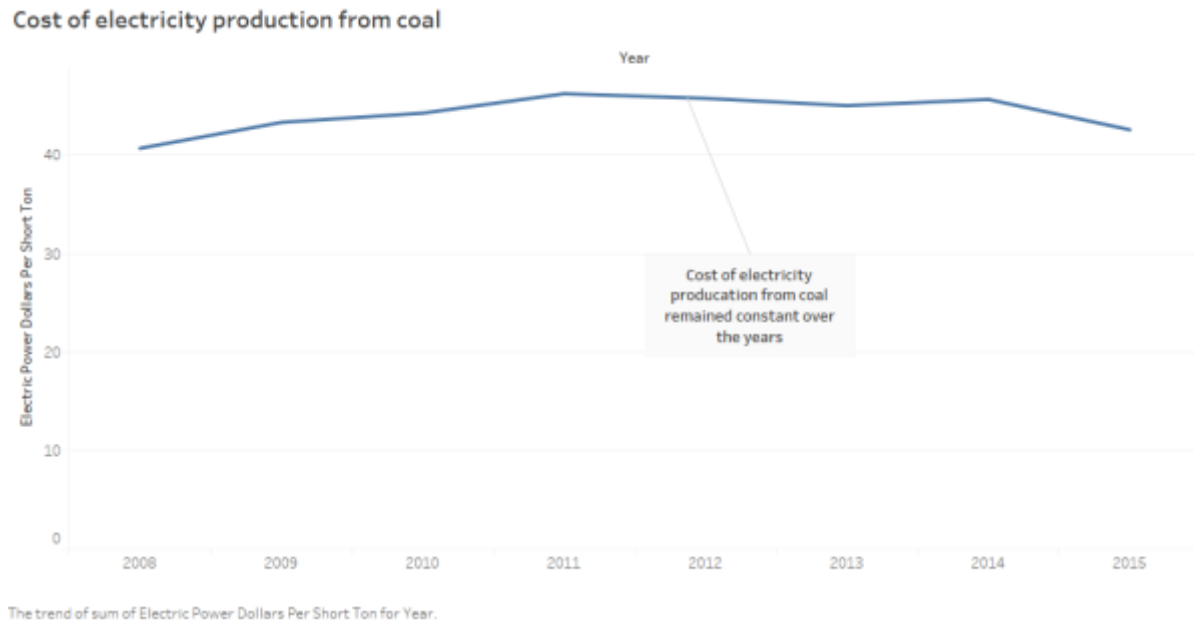
Source: <https://www.nytimes.com/interactive/2017/04/25/climate/todays-energy-jobs-are-in-solar-not-coal.html>

According to US Department of energy,( <http://www.nrel.gov/docs/fy14osti/60197.pdf>) the solar industry has added 51000 new jobs since end of 2015. Of these jobs, 80% were positions that never existed before, and the remaining 20% were added solar responsibilities to existing positions. An important point to note from the statement released by US department of energy is that inspite of solar jobs being about 1.3% of overall energy generated by the entire industry, it ranks second in employment among all the all the sectors. It beats natural gas by a small difference, coal by a factor of two, and wind energy by a factor of three, and nuclear energy by a factor of five and is only beaten by the oil industry which sits at about 38% more than solar.

## How much it costs to produce electricity?

**Claim:** Solar costs cheaper than Coal

**Warrant:** The graph below displays the cost of producing electricity from coal has statistically neither increased nor decreased, remaining constant over the past years. Whereas the cost of solar installations is drastically decreasing over the years making it a better choice of energy.



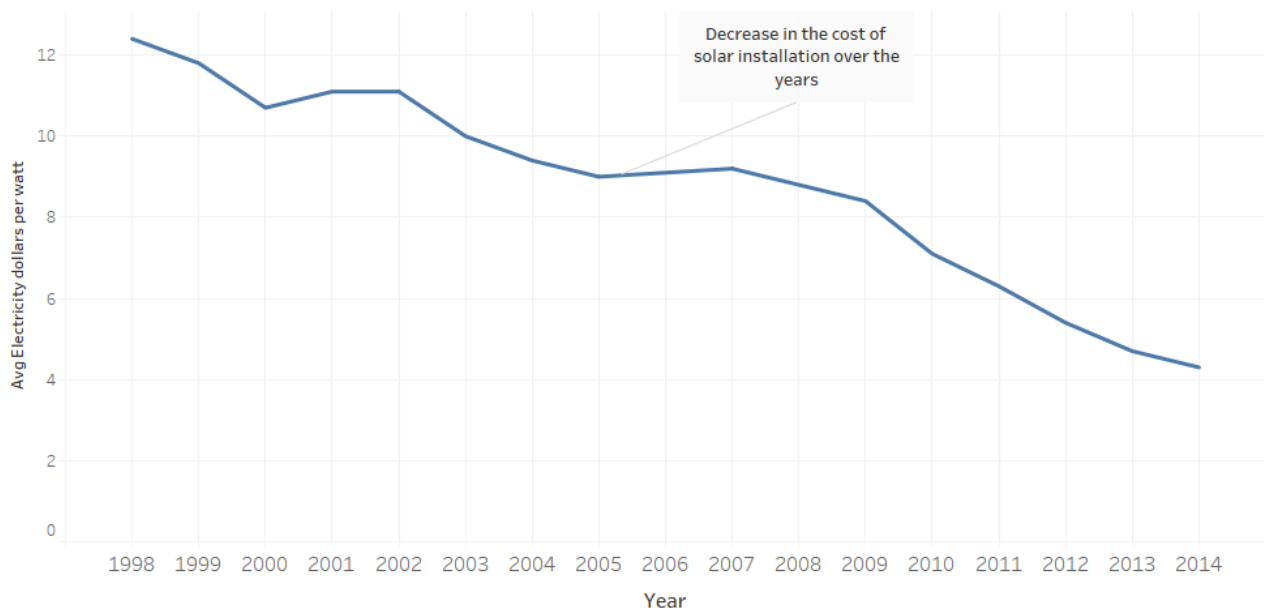
**Figure 13 : Line graph showing the cost of electricity production from coal over the years.**

Cost of coal-fired electricity in the United States can be decomposed in terms of the price of coal, transportation cost, energy density, thermal efficiency, plant construction cost, interest rate, capacity factor, and operations and maintenance cost. The dominant determinants of cost have been the price of coal and plant construction cost.

The generation cost consists of three main components—fuel, capital, and operation and maintenance. The first two are further decomposed; the fuel component into the coal price, transportation cost, coal energy density, and thermal efficiency; the capital component into plant construction costs, capacity factor, and interest rate.

Coal prices, in contrast, are statistically neither decreasing nor increasing, and so provide a statistically fluctuating floor on the overall generation cost, with no clear long-term trend.

Solar installation price over the years



The trend of sum of Avg Electricity dollars per watt for Year.

**Figure 14 : Line graph showing the decrease in the solar installation cost over the years.**

Solar panel technology has been around in some form for a long time now. However, it's only in the last ten years or so that solar has really taken off as a renewable energy source. There are two major factors influencing the technology's growth: the steady improvement of both solar panel cost and solar panel efficiency over time.

Less than 10 years ago, in 2008, the cost of a solar panel installation was \$8.82 per watt. The solar industry today looks very different: in addition to solar panel efficiency increasing dramatically, solar panel producers have significantly improved their manufacturing processes. Solar installers, too, can deploy solar PV across the United States more efficiently now than they could ten years ago. The result: the price of solar has fallen by over 60 percent, to just \$3.36/watt.

The price decreases over the past ten years are a major reason why homeowners are increasingly interested in installing solar panels. For a standard 6 kW home solar system, the

average gross cost has fallen from \$52,920 to just \$20,160 in the past decade. Subtract the 30 percent federal tax credit for solar, and you're looking at \$14,110 for a home solar PV system that can cover most, if not all, of your electricity needs.

## **Cost of solar energy vs Coal**

Winner: Solar

The winner probably comes as no surprise to most people.

Just 17 years ago, coal made up 56% of all electricity generation in US. In the last 15 years the electricity industry has been a huge shift towards renewable energy, with solar and wind accounting to 52% of all new electricity generation in 2014 and 69% in 2015. During the same years, coal accounted for 1% and 0% respectively of new generation. Once the power house of electricity generation coal is in retreat, thanks mostly to the cheap availability of natural gas and increasing popularity of renewables.

Solar energy's lack of emission, continually falling price and free fuel source move it into the winning slot. And considering our current extremely high emission levels and the climate issue we created and now need to address, the winner isn't a choice but a necessity.

## Data Analysis

In this section, we describe our approach, the data source and the process in which we reached the graph in the tableau sheet mentioned.

**Figure 1:** The energy consumption data at the world level was taken from Wikipedia. It represents the energy in Twh.

(Data link: [https://en.wikipedia.org/wiki/World\\_energy\\_consumption](https://en.wikipedia.org/wiki/World_energy_consumption))

Refer: Sheet "World\_energy\_consumption"

**Figure 2,3,4:** The world data pertaining to energy consumption from renewable and non-renewable energy was taken from the US Energy Information Administration website (Data link: <https://www.eia.gov/electricity/>). The renewable vs non-renewable energy consumption was plotted using an area graph. The data was then showed in detail by bifurcating the energy sources in the form of a Dashboard. In Figure 3, Coal energy was selected. In Figure 4, solar was selected.

Refer: Sheets: "renewable and nonrenewable energy consumption in usa", "Energy wise consumption in US"

**Figure 5:** The data pertaining to the state-wise electricity generation through coal and solar was taken from the EIA site. (Data link: <https://www.eia.gov/electricity/data/state/>) The data was filtered for solar and coal and then plotted in a line graph. The data spanned from 2008 through 2014.

Refer: "State wise Solar and Coal Generation"

**Figure 6:** The dataset for jobs generated by solar and coal for each state was obtained the government site for energy resources. (Data link:

[https://energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report%20State%20Charts%202\\_0.pdf](https://energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report%20State%20Charts%202_0.pdf))

Refer: "State wise solar Jobs in 2017"

**Figure 7:** This chart was created using the data provided in an article (Data link: <https://cleantechnica.com/2016/07/11/7-factors-show-wind-solar-1st-choices/>). We used the text table to represent how each energy source fairs for each of the 7 factors.

Refer: "Factor\_for\_energy"

**Figure 8:** The data related to CO2 Emissions from Fossil Fuel Mines was taken from the PriceofOil website. (Data link: Page 19:

[http://priceofoil.org/content/uploads/2016/09/OCI\\_the\\_skys\\_limit\\_2016\\_FINAL\\_2.pdf](http://priceofoil.org/content/uploads/2016/09/OCI_the_skys_limit_2016_FINAL_2.pdf))

Refer: "Co2 Emission From Coal – 2"

**Figure 9:** The data for the U.S. electric sector CO2 emissions from coal was taken from the EIA website. (Data link: [https://www.eia.gov/outlooks/aeo/pdf/0383\(2014\).pdf](https://www.eia.gov/outlooks/aeo/pdf/0383(2014).pdf))

Refer: "Co2 Emission From Coal"

**Figure 10:** Derived from Figure 8 and 9

Refer: "Solar and Coal Jobs"

**Figure 11:** The data for the jobs generated by Coal was taken from a report published by the Solar Foundation. (Data link: <https://www.eia.gov/coal/annual/pdf/acr.pdf> - Page 27)

The data ranged from 2008 to 2015.

Refer: "Coal\_Jobs"

**Figure 12:** The data for the jobs generated by Solar energy was taken from a report published by the Solar Foundation. (Data link: <http://www.thesolarfoundation.org/wp-content/uploads/2016/10/2015-Census-Factsheet-FINAL.pdf>) The data ranged from 2010 to 2017.

Refer: "solar\_Jobs"

**Figure 13:** The data related to the cost of electricity production from coal over the years is represented in Electricity dollars per short ton and spans from 2001 to 2015. (Data link: <https://www.eia.gov/coal/annual/>)

Refer: Sheet "Cost of electricity production from coal"

**Figure 14:** The data related to the solar installation costs is represented average electricity dollars per watt and it spans from 1998 to 2014. (Data link: <http://www.nrel.gov/news/press/2016/37745>)

Refer: "Solar installation price over the years"

## Rebuttals



Energy South (Follow)

Information updates on energy-related projects and activities---with an emphasis on the Southern United S...  
Aug 25, 2015 · 2 min read

### Smart Coal Could Reduce CO2 Emissions as Much as Nuclear Energy

Source: <https://medium.com/@EnergySouth/smart-coal-could-reduce-co2-emissions-as-much-as-nuclear-energy-617ec52dda13>

**FORTUNE** | Energy

COMMENTARY COAL

### Look for Coal and Mining Jobs to Come Back This Year

John Kemp, Reuters  
Apr 07, 2017



Source: <http://fortune.com/2017/04/07/coal-mining-jobs/>



## Project Critique

Since the solar energy industry has shown a boom since around 2012, we found limited data on the same.

While analyzing certain factors e.g jobs, we could not obtain the data for solar and coal jobs for the same time frame. Hence, we had to filter the two datasets and only consider the common time frame. With respect to the state wise job creation, we could only find the recent data i.e 2017 dataset.

Because of limited time constraint, we could not analyze the trends in other renewable energy resources as well e.g wind and hydro power.

If we had more time, we would have also explored the impact of state and federal policies on the solar and coal generation and consumption.

## Conclusion

In summarizing our results, we attempt to convey the movement away from coal and towards renewable source such as solar is inevitable and will continue to accelerate. While in the long run this will be good for both the environment and overall economy. When we pay for solar we pay for the human labor which often help create or support jobs. Solar energy's increase in job opportunities, continually falling price, lack of emissions and free fuel source move it to the winning slot.

Trump needs to reflect back on his promise of coal jobs and think deep in the area about whether its wise to bring back the coal jobs.

- Github Link: <https://github.com/ektaratanpara/dataviz-group5>
- Tableau Public Link: [https://public.tableau.com/profile/ektaratanpara#!/vizhome/Coal\\_Vs\\_Solar\\_Group5/RenewableandNonRenewableenergy2?publish=yes](https://public.tableau.com/profile/ektaratanpara#!/vizhome/Coal_Vs_Solar_Group5/RenewableandNonRenewableenergy2?publish=yes)

- Note: The raw files that did not require any cleaning/processing are placed under “processed\_files” folder in github repo.

## Project Structure

Team Members	Contribution	Data Collection	Data Wrangling	Tableau	Documentation and Presentation
<b>Apurva Hooli</b>	7 factors and Energy Generation by source	Yes	Yes	Yes	Yes
<b>Ekta Ratanpara</b>	Energy consumption across United States	Yes	Yes	Yes	Yes
<b>Krithika Narayanswamy Subramanyam</b>	Jobs and Emissions	Yes	Yes	Yes	Yes
<b>Sapthami Shetty</b>	Electricity Costs	Yes	Yes	Yes	Yes
<b>Shreya Prabhu</b>	State-wise Electricity Generation through Coal & Solar	Yes	Yes	Yes	Yes