Energy Production Analysis

Southern States

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Summary

Our goal

The goal of this analysis is to create Energy models analyzing the change in production and consumption of total and renewable energy for each of the states California, Arizona, New Mexico, and Texas. We will pick the state with the cleanest, renewable energy outlook in 2009 and using a forecasting tool to projecting from to 2050. Using the data provided we were able to organize and selectively choose which data points would best answer this question. Our most useful tool in this process was R programming a statistical software capable of making things neat as well as forecasting our data. By using R we have included all of our graphs displaying the data by sector, state, year, and there respective data values. Such graph's have aided us in the decision making process of which state had the best energy profile in 2009 as well as making predictions for 2025 and 2050.

Tasks

As a team we were challenged with how to clean and organize our data so that it can be easy to read. We kept our illustrations simple and labeled clearly as possible without disrupting data accuracy. Through the process of organizing data we removed some sectors from our data because we felt as if they were irrelevant to the data projection process. We narrowed the Sectors down in each state as Transportation, industrial, commercial, and residential. These sectors where most important in terms of consumption because it allows us to look further into where we are wasting energy.

From this we can look at the renewable production for each state and how much of that goes into the consumption. Going through this process will allow us to deem the state feasible or not in terms of most efficient. Allowing us to see what areas need improvement and how it could be solved.

How we will conclude

We will list all energy profiles for each of the states, listing how each state performed in 2009 and what energy sectors consumed the most. Evaluating each state in terms of efficiency over the 50 years. Then comparing there predicted performances with each other to gauge how much they are producing versus consuming. From this we can then make evaluations on each states performance and which one had the best profile in 2009 and prediction on wards to 2025 and 2050.

Memo

Capitol Building
AZ, CA, NM, & TX

Dear Governors,

Arizona performs well in terms of renewable energy in 2009. The majority of its production comes from hydroelectricity and biomass, the rest being non renewable energy. Overall Arizona's production and ability to incorporate renewable energy into it's production and consumption habits are good. California had the best energy profile by far in 2009. California incorporated a diverse amount of energy sectors into its production and consumption, generating more renewable energy than any other state. The reason for California's sizeable consumption is it's large population. New Mexico is home for solar and wind energy. New Mexico did well in the evaluation and is starting to use more renewable energy. Texas is more dependent on non-renewable energy. In the 2000's Texas began to build more wind farms to increase renewable energy.

The forecast for the state of Arizona is promising the total consumption and production is expected to increase. Arizona has recently just began building wind plants which is a promising factor for growth.The forecast for the State of California is continued growth in the renewable energy structure. This is due to the already well established renewable energy infrastructure. The forecast for the state of New Mexico is an increase in total consumption which may be influenced by an increasing population. Similar to Arizona, New Mexico has untapped renewable energy sources in geothermal and wind.The forecast for the state of Texas is an increase in renewable energy production mainly powered by wind energy. Total energy production is not expected to grow much.

From the analysis there is untapped potential for each state to increase renewable technologies in their sectors. Arizona has a prime landscape with dry regions and great sun exposure for solar energy. California's coastline has the ability to harness a ton of energy from tides. This implementation would increase hydroelectricity. New Mexico has vast resources available in the southwestern region to increase their geothermal production. There solar production can be increased by the use of residents homes and the wide-open plains. Lastly, due to its geography placement and high wind speeds, Texas has a large opportunity to increase their solar and wind energy production. This would help to reduce their reliance on oil and gas.

Sincerely,

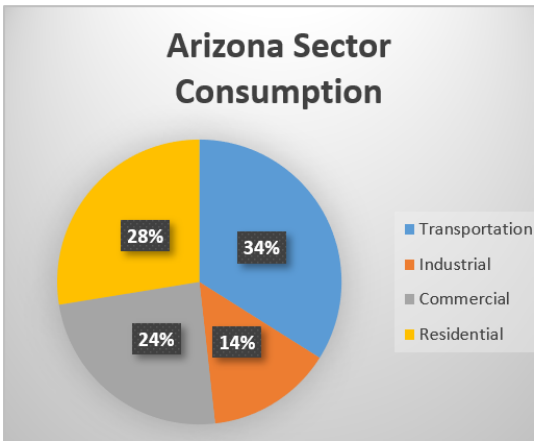
Tyler Church, Connor Hankamer, Dylan Russell, Emmanuel Hall

Math 435, Colorado State University

Energy Profiles

Arizona Profile

The state of Arizona has a opportunistic geography that allows for a ton of sun exposure and renewable resource adaptations. Over half the state is made up of deserts, a good portion consisting of dry grass-lands, and the Colorado river. Arizona has a prime spot for solar, wind, and hydroelectricity generation. However it lacks in production of fossil fuels with little to no natural gas reserves across the state. All values discussed in the following is gathered from data in 2009. [2]

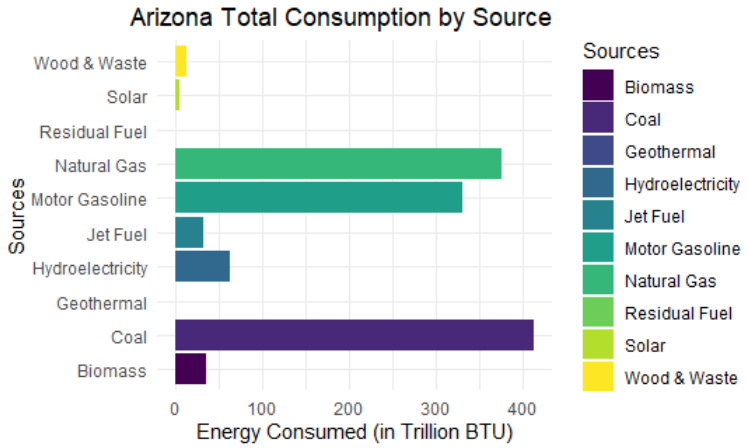


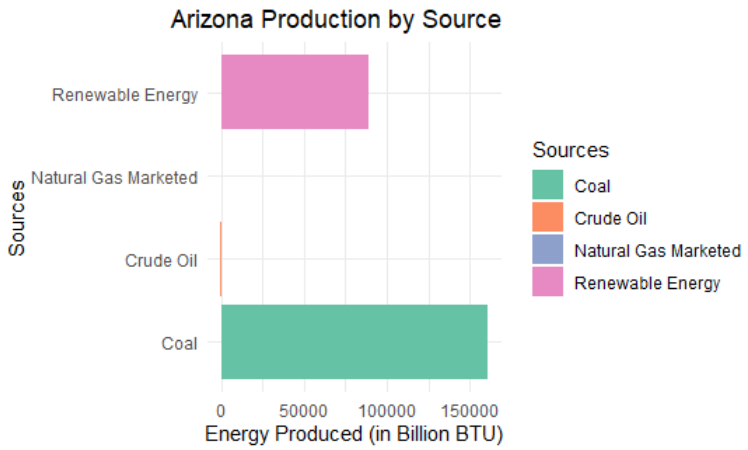
Arizona

Sector	Expenditures (Millions)	1 Year Change (%)
Total	17539.31	-25.28%
Industrial	1643.84	-36.69%
Transportation	8333.45	-41.00%
Residential	4314.61	0.09%
Commercial	3247.41	-2.97%

The sector consumption chart overviews the sector make up of total energy consumption in the state. The transportation sector consumes over 1/3 of the total consumption. The industrial sector takes on a little larger share than the commercial sector, while the residential sector consumes around 10+% less. Consumption in the residential sector is in the lower 20% compared to the rest of the US.

The table represents the total expenditures in millions of dollars for each sector and the one year % change from 2008 to 2009. The market crash in 2007-2008 caused more than a 35% decrease in both the Industrial and Transportation sectors. Noticeably Arizona is putting most of their focus and money towards the transportation sector which accounts for a little less than half of the total expenditures in 2009. The residential and commercial sector held stable in expenditures with less than a 3% decrease for both.





Referencing the Total Consumption and Production by Source plots we can view the main sources that establish Arizona's profile. The main sources consumed are Coal, Natural Gas, and, Motor Gasoline. The state produces over 170,000 Billion BTU's of coal. This is due to the abundance of coal from the Black Mesa and Pinedale coal fields. Arizona also homes the Hoover and Glen Canyon dam that contributes a massive amount to the hydroelectricity generation for the state. [2] Solar and wind energy is at a smaller level compared to the rest in 2009, however both have great potential.

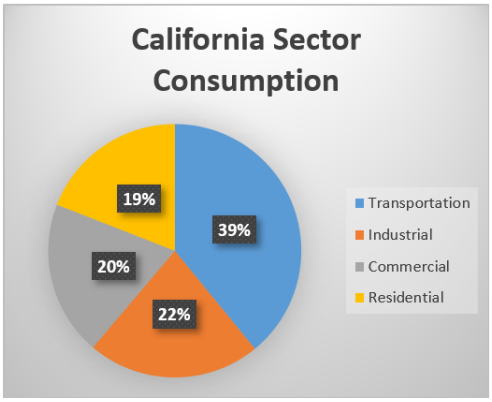
Arizona

Total Energy	Billion BTU
Production	570994.05
Consumption	1454313.46
Total Renewable Energy	
Production	88571.38
Consumption	103493.29

The table above exhibits the amounts of production and consumption of energy in billion BTU's for both Total Energy and Renewable Energy.

California Profile

The golden state of California is one of the largest states in the United States and home to almost 37 million residents and armed forces (as of 2009). California runs a $1.74 trillion economy with 53 Fortune 500 companies and tons of energy-demanding industries throughout the state. While maintaining this economic efficiency and population, California is just ahead of Hawaii for the lowest per capita residential energy consumption in all of the country. California has shown it's leadership in the new age of energy-efficiency and has made impactful decisions in their generation of Renewable energy. All values discussed in the following is gathered from data in 2009. [4]

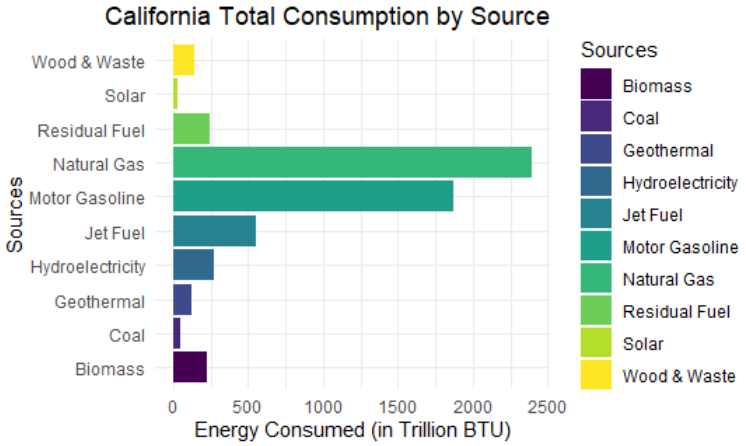


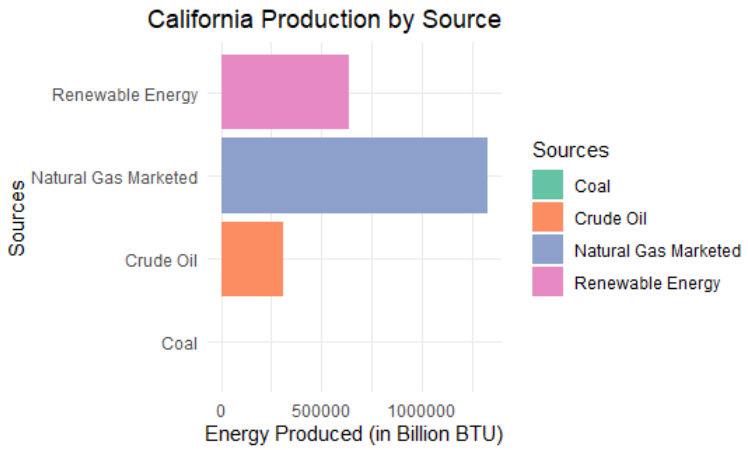
California

Sector	Expenditures (Millions)	1 Year Change (%)
Total	104711.69	-25.61%
Industrial	11655.82	-31.57%
Transportation	55601.63	-36.25%
Residential	18737.72	-6.81%
Commercial	18716.52	-3.25%

The sector consumption chart outlines total energy consumed by each of the main sectors in California. The transportation sector consumes the most energy at 39% of total consumption. The main drivers of this are the amount of vehicles registered in the state and the long travel distances for the population. With a heavy mix of economic activity and technological development taking place, the industrial sector makes up 22% of the total consumption in the state. This includes energy/non-energy intensive manufacturing and non-manufacturing as the main drivers. Despite the large demand from transportation we see that the residential sector contributes 19% of total consumption. This relatively low amount and can be explained from the low house-hold energy use and dry, hot summers and mild, wet winters where heat is not required throughout the year.

The table represents the total expenditures in millions of dollars for each sector and the one year % change from 2008 to 2009. First off, lets notice the defining decrease in the amount of expenditures compared to 2008. This is due to the collapse of the market in 2007-2008 ultimately causing more than a 30% decrease in both the Industrial and Transportation sectors. California is putting most of their focus and money towards the transportation sector which accounts for over half of the total expenditures in 2009.





Referencing the Total Consumption and Production by Source plots we can view the main sources that establish California. The drivers for Total Consumption are Natural Gas and Motor Gasoline where both account for almost 4300 trillion BTU. Natural Gas is the main power for home heating and the provider for electricity generation for utilities. The main geological basins for gas fields lie in the San Francisco and some along the coastal regions. [4] California also consumes a great amount of of Jet Fuel coming in at number one in the nation. The three main total producers that are available for sale and distribution within the state are Renewable Energy, Marketed Natural Gas, and Crude oil – with Coal being noticeably phased out.

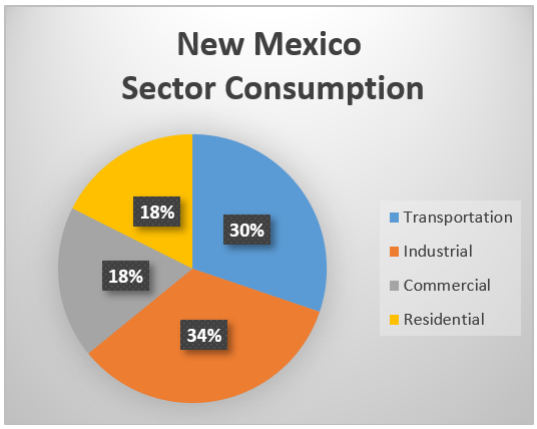
California

Total Energy	Billion BTU
Production	2605311.84
Consumption	8005515.05
Total Renewable Energy	
Production	635062.37
Consumption	712704.46

The table above exhibits the amounts of production and consumption of energy in billion BTU's for both Total Energy and Renewable Energy.

New Mexico Profile

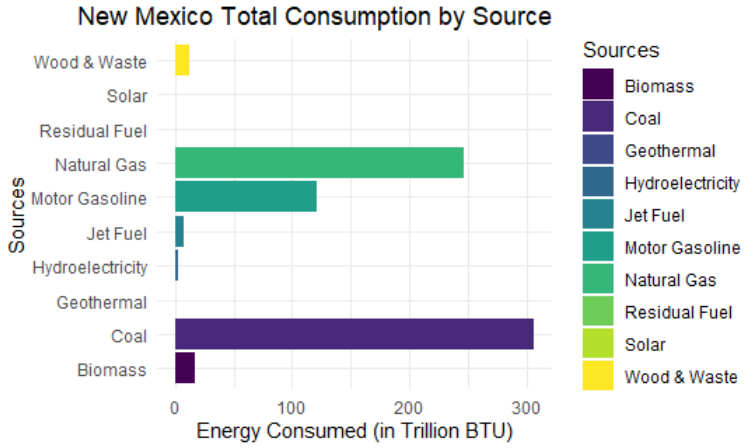
The state of New Mexico has a very diverse landscape consisting of mountains, plains, and deserts. It's this landscape that has given New Mexico abundant resources and options for producing energy. As one of the top 10 states for energy production, New Mexico's main sources for this are coal, oil, and natural gas. All values discussed in the following is gathered from data in 2009. [3]

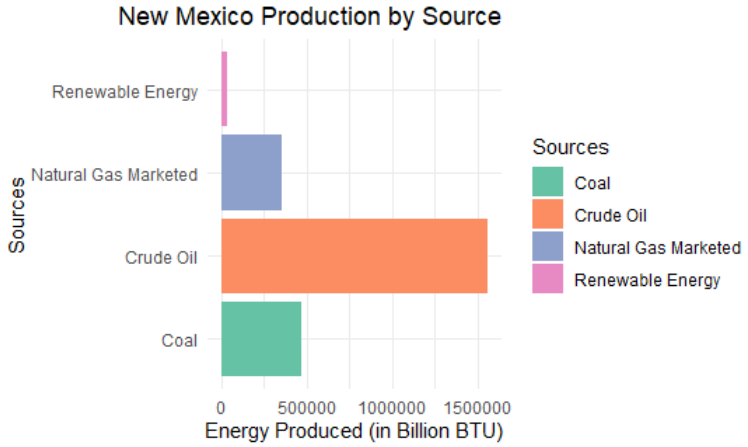


New Mexico

Sector	Expenditures (Millions)	1 Year Change (%)
Total	6454.27	-31.71%
Industrial	776.93	-47.29%
Transportation	3535.76	-37.50%
Residential	1165.50	-110.98%
Commercial	976.08	-17.56%

The industrial sector is New Mexico's biggest consumer of energy, consuming 34% of all energy consumed in the state, as the mining industry is a major consumer. The transportation sector is a close second at 30% and this is because transportation is the state's biggest consumer of oil. The residential sector is tied at 18% as the sector with the lowest energy consumption, and this is partially due to the fact that only 1 out of 5 houses use electricity to heat their house. The commercial sector makes up the last 18%.





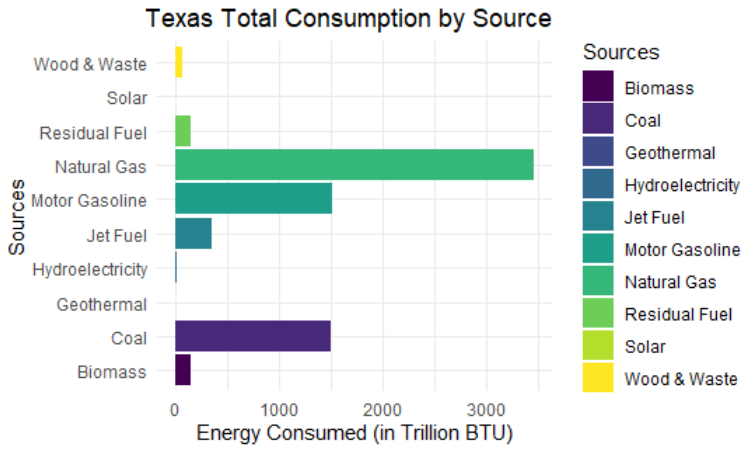
New Mexico

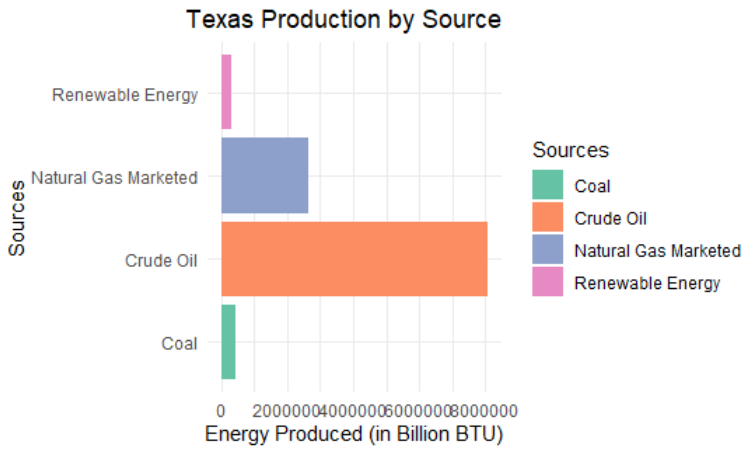
Total Energy	Billion BTU
Production	2412219.05
Consumption	670094.51
Total Renewable Energy	
Production	33785.17
Consumption	35635.38

Based on the graphs showing consumption and production by source you can see that power produced by coal is the main source of energy throughout the state. This is because the state is primarily powered by coal fired power plants. [3] Almost 550 trillion BTU of energy consumed came from coal and natural gas, but less than 50 trillion BTU came from renewable sources. Even as recently as 1990, 90% of the state's energy came from coal. This number however has been decreasing and we hope to see more energy produced by renewable sources in the near future.

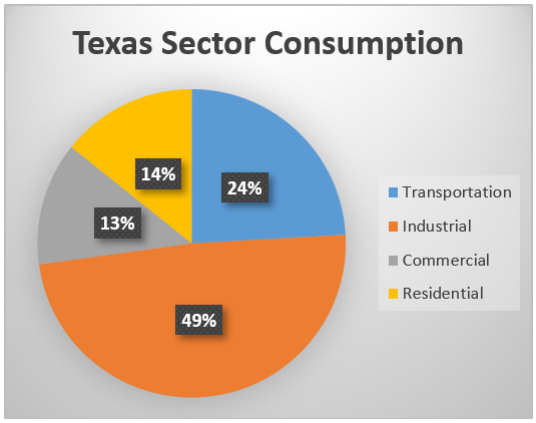
Texas Profile

The Lone Star State of Texas, is a oil and gas powerhouse producing more than 800,000 billion BTU in 2009. Texas is well renowned for its bountiful oil supply as well as abundant natural gas production. It is clear here that among the four states being analyzed Texas comes out on top for producing the most oil and gas.





Of all of the energy sectors in Texas' energy production coal and renewable energy were the only ones to put up numbers. Both nearly neck and neck on the production scale in 2009, producing about 50,000 billion BTU. When compared to its oil and gas production this is relatively smaller.



Texas

Sector	Expenditures (Millions)	1 Year Change (%)
Total	115217.04	-38.94%
Industrial	776.93	-47.29%
Transportation	43123.09	-43.39%
Residential	18783.70	-83.11%
Commercial	13269.46	-10.02%

Our main observation is the production vs consumption and how well Texas produces renewable energy. Renewable energy contributes to about one fifth of the net electricity produced in Texas, which is the lowest of all other sectors.

Texas

Total Energy	Billion BTU
Production	11914996.72
Consumption	11297410.59
Total Renewable Energy	
Production	303697.06
Consumption	356634.82

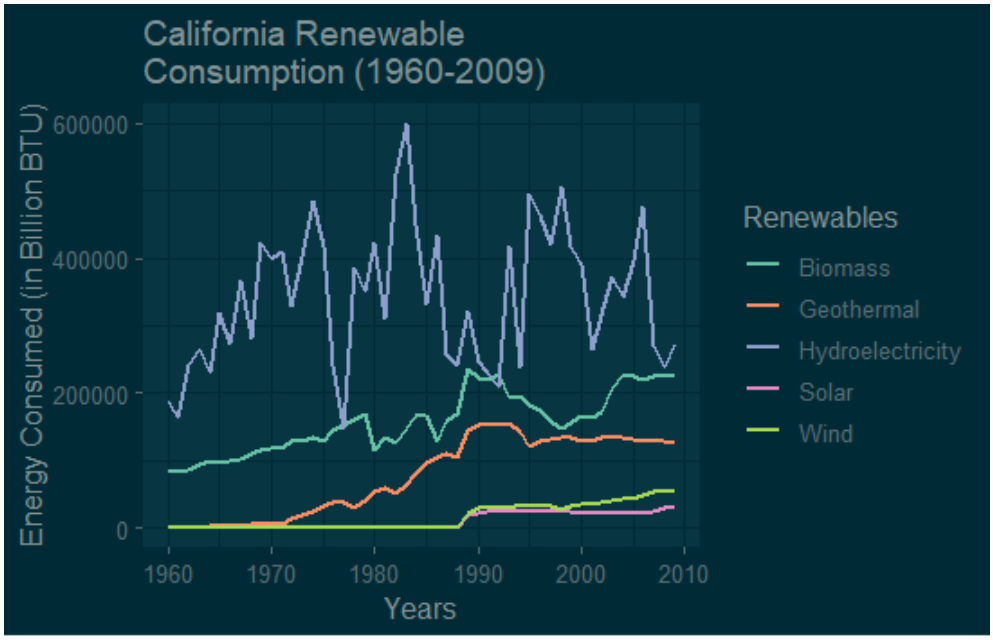
Texas has the second largest population and economy behind California. Texas uses more energy than any other state and accounts for one seventh of total US consumption. The state is sixth in the nation in per-capita energy consumption and is the third-largest net energy supplier despite its high energy use. The industrial sector being the petroleum powerhouse is the largest energy consuming end-use sector and accounts for half the states end-use energy consumption. Texas consumes 2.2 trillion BTU more than they produce in the oil and gas sectors. Which is the highest gap from consumption to production of all the states. Transportation being second highest because of the large amount of registered motor vehicles, the great distances people travel across the state, and the high number of vehicle miles traveled annually. [1]

The options that Texas has as a state are to install more renewable energy systems like solar panels,wind turbines, and even nuclear energy. In order to increase their production of green energy they must reduce their carbon emissions as well as create more of an incentive for people to want renewable energy.

Evolution of States from 1960 to 2009

When looking at the data we were given for the project there were some difficulties finding a model that would work well with time series data. The first step we took was use a simple linear regression to determine the increase or decrease year over year for the four states. We choose to focus on four MSN codes that would provide the best overview of each state's energy profile. The codes we choose are TEPRB, TETCB, RETCB, and REPRB. TEPRB stands for total energy production, TETCB stands for total energy consumption, RETCB stands for total renewable consumption, and REPRB stands for total energy production. These are all measured in billion BTU.

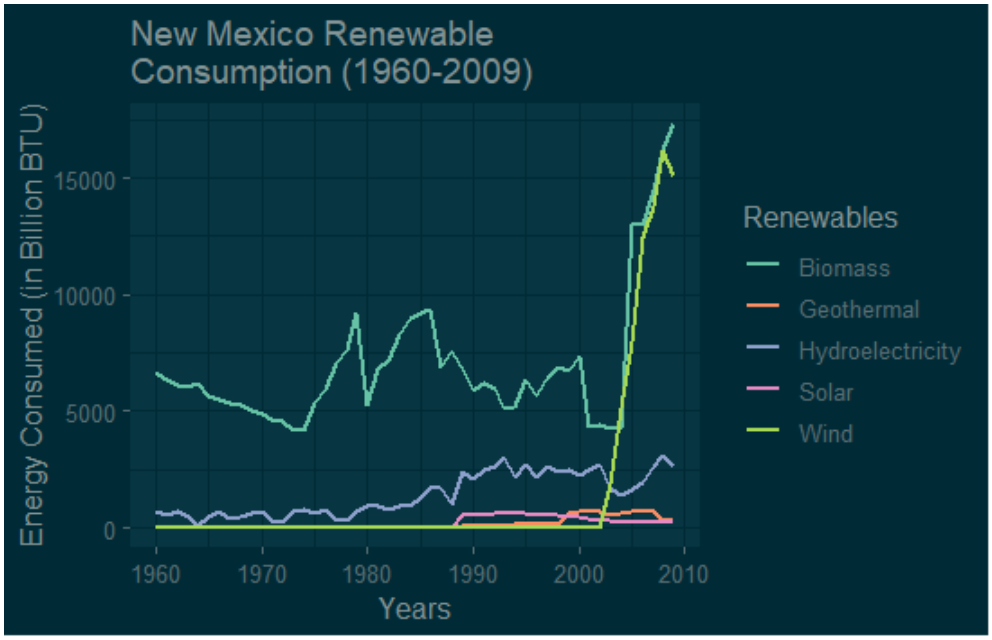
California



California is one of the top states in the nation in terms of renewable energy. It happens to be the number 1 producer of solar power in the country. California is a very sunny state and has lots of land, such as the deserts in the southeast, that is being used to generate solar power. There isn't very much room for California to improve its solar production as it already produces 40% of the country's solar power. The Folsom and Shasta dams are major contributors to California's hydro electrical resources. Most of California's hydro electrical plants are located in the mountains in the eastern part of the state. The massive climbs and dips in hydro production can partially be attributed to droughts and periods of increased rainfall. California also produces a lot of wind energy. Across the state of California there are many locations that are ideal for wind farms. The mountains and coastal areas are great for producing wind power. Further development of wind farms across the state would greatly increase California's renewable energy production. California is also the nation's top geothermal energy producer. There are geothermal plants located throughout the state, but the biggest source in the state is the Geysers in the Mayacamas Mountains. California has had a pretty steady use of biomass over the years, and is currently the top producer of electricity from biomass in the nation. This is because they have some power plants that are fueled by wood. California also makes wood pellets which can be used to generate electricity. California has taken major steps to increase their production of and reliance on renewable energy. [4]

- California's total energy consumption had a yearly increase of 91,950 billion BTU on average. This yearly rate of change is statistically significant and explains 92.54% of the data points.
- California's total energy production had a yearly increase of 2,705 billion BTU on average. This yearly rate of change is not statistically significant and explains 1.36% of the data points.
- California's total renewable energy consumption had a yearly increase of 9,565 billion BTU on average. This yearly rate of change is statistically significant and explains 69.76% of the data points.
- California's total renewable energy production had a yearly increase of 8,441 billion BTU on average. This yearly rate of change is statistically significant and explains 61.17% of the data points.

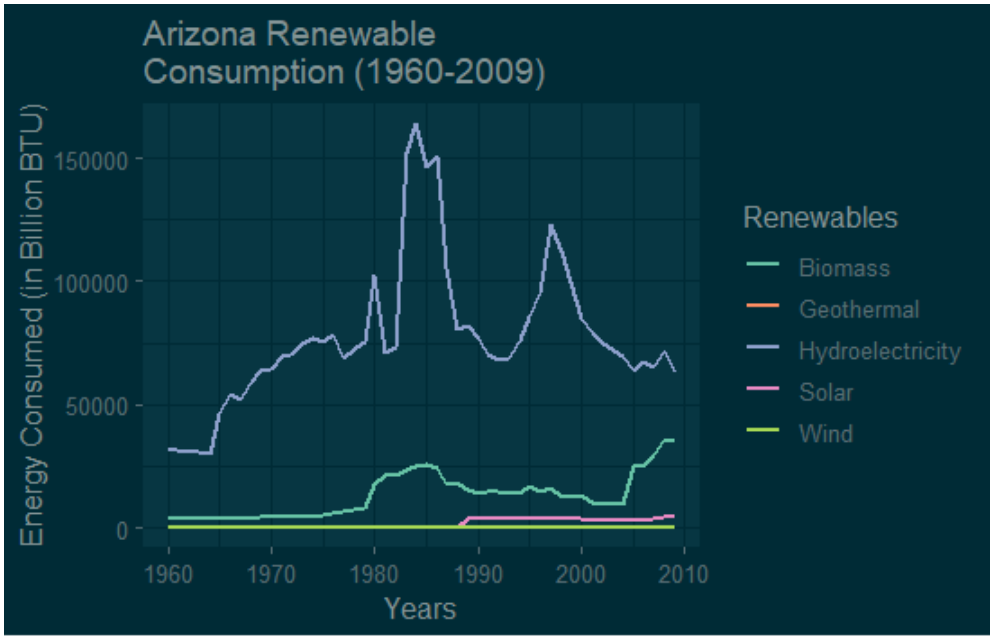
New Mexico



New Mexico's primary renewable sources are biomass and wind. Production of energy from biomass and wind sources has increased a lot within the past decade. New Mexico recently saw a big rise is their energy produced by biomass consumption and this is because businesses and residents use it very often. A lot of houses in the state use wood for heat. New Mexico had a huge jump in wind power recently. There are plains in the eastern part of the state that are an ideal location for wind farms. This location and many others like it around the state could lead to even more production of wind power. New Mexico doesn't produce a lot of hydro power. There are dams located in the San Juan basin that produce power, but the state overall does not have a lot of opportunities to generate hydro power. New Mexico has a lot of potential to produce geothermal energy. The southwestern part of the state is the area with the largest potential, so there might be developments there in the future. New Mexico is also a very sunny state, so there are a lot of opportunities for solar power production that aren't currently being used. It actually ranks among the top three states in terms of solar power potential. This is a state that could improve a lot in some sectors, but that is going to take a lot of work [3]

- New Mexico's total energy consumption had a yearly increase of 7,265 billion BTU on average. This yearly rate of change is statistically significant and explains 92.16% of the data points.
- New Mexico's total energy production had a yearly increase of 19,223 billion BTU on average. This yearly rate of change is statistically significant and explains 59.42% of the data points.
- New Mexico's total renewable energy consumption had a yearly increase of 331.66 billion BTU on average. This yearly rate of change is statistically significant and explains 42.78% of the data points.
- New Mexico's total renewable energy production had a yearly increase of 327.08 billion BTU on average. This yearly rate of change is statistically significant and explains 41.82% of the data points.

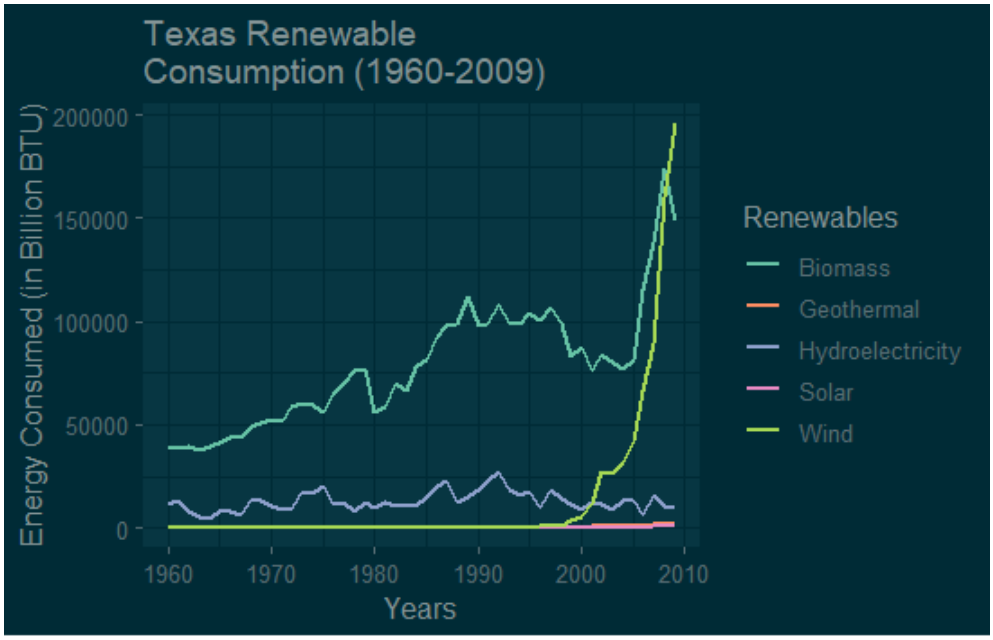
Arizona



Arizona relies heavily on hydro electrical power for its renewable power. The Glen Canyon Dam and the Hoover Dam are both located in Arizona, so it follows that hydro electrical power is the state's biggest renewable energy producer. Both of these power plants can be found on the Colorado River and rank among the largest in the state in terms of energy production. Arizona has the potential to produce a lot of solar energy. Due to its geography Arizona could produce a lot more solar energy. Arizona built its first large wind farm in 2009, so there isn't a lot of data available on how their production of wind power has changed over time. But this is promising because it shows that they are trying to produce more renewable energy. As of right now Arizona has no large scale geothermal power plants. There are hot springs and other areas that have potential to generate power but so far those areas aren't being used. Arizona hasn't relied heavily on biomass to produce their energy because there are other sources that provide them with more energy, but there is a large wood fueled power plant in the state. If Arizona wants to produce more renewable energy, solar power is the best source to look into. [2]

- Arizona's total energy consumption had a yearly increase of 25,540 billion BTU on average. This yearly rate of change is statistically significant and explains 97.9% of the data points.
- Arizona's total energy production had a yearly increase of 15,320 billion BTU on average. This yearly rate of change is statistically significant and explains 86.6% of the data points.
- Arizona's total renewable energy consumption had a yearly increase of 1,288 billion BTU on average. This yearly rate of change is statistically significant and explains 28.01% of the data points.
- Arizona's total renewable energy production had a yearly increase of 1,109.4 billion BTU on average. This yearly rate of change is statistically significant and explains 21.05% of the data points.

Texas



Over the past 50 years the state of Texas has increased its production of renewable energy drastically with the largest increase coming in the early 2000s. Wind power is the states main source of renewable energy. This is probably due to the fact that there aren't a lot of geothermal opportunities or hydro electrical in the state. Texas has recently seen a massive increase in the amount of wind power it's producing. These increases have led Texas to be one of the the top states for producing wind power. There is still of lot of potential for growth in this area due to Texas' geography, so we could see even more wind energy produced in the near future. Solar power is a great way to produce electricity, and this is an area where Texas can improve dramatically. While currently the state isn't producing solar power, there is great potential for solar farms in the west. Texas does not produce very much hydro electrical energy despite it having a few hydro plants. Texas doesn't get a lot of rain and its pretty flat and that makes it hard to generate hydro power. So there isn't really any room for further development in this area. Texas doesn't use any large scale geothermal resources to produce energy. Texas has produced a lot of energy from biomass for a while and that is because of all of the resources that the state has. A big improvement that Texas could make is to start producing solar power. [1]

- Texas's total energy consumption had a yearly increase of 162,075 billion BTU on average. This yearly rate of change is statistically significant and explains 94.67% of the data points.
- Texas's total energy production had a yearly decrease of 83,982 billion BTU on average. This yearly rate of change is statistically significant and explains 44.35% of the data points.
- Texas's total renewable energy consumption had a yearly increase of 3,281.6 billion BTU on average. This yearly rate of change is statistically significant and explains 56.83% of the data points.
- Texas's total renewable energy production had a yearly increase of 2,790.8 billion BTU on average. This yearly rate of change is statistically significant and explains 60.89% of the data points.

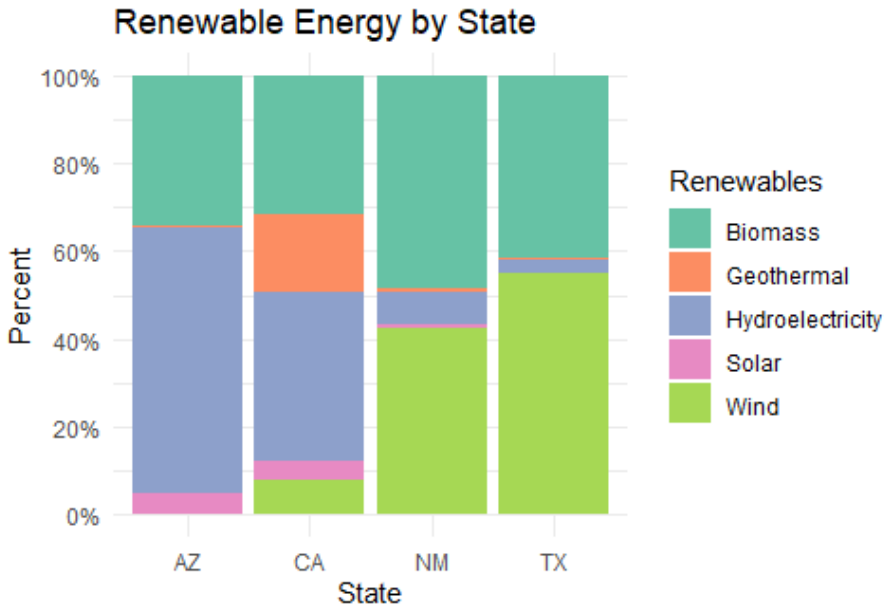
Most Energy Efficient State

Based on the analysis of all of the data from each state (Arizona/California/New Mexico/Texas) we determined who has the best profile for clean, renewable energy in 2009. We used the following criteria and

guidelines to determine the best profile.

- Renewable Consumption vs. Production
- Location
- How diverse each state is on forms of energy production
- Total Energy Consumption vs. Production

Renewable Consumption vs. Production



1 California- California's renewable energy consumption is outnumbered by how much non-renewable is consumed. Looking forward oil and gas is still a main consumer of all energy which is something to consider when evaluating this state. Production on the other hand is the highest in renewable energy for California making it number one. [4]

2 Arizona- Arizona's renewable production mainly comes from hydroelectric which is used to power cities. On the other hand renewable energy is outnumbered by non renewable energy consumed by a long shot. Natural gas and gasoline are the two non renewable resources consumed, outnumbering hydroelectric. [2]

3 New Mexico- New Mexico's reported consumption and production of renewable energy is very small compared to non renewable energy. However they plan on creating more solar farms for the future to help domestic homes and increase their renewable energy production. [3]

4 Texas- Texas mostly gets its energy from non-renewable energy and is just now starting to produce more renewable energy in the years to come. Thus we see an over consumption of renewable energy versus the amount they produce. [1]

Location

1 California- California is one of the largest states in the US containing different terrain that is befitting for energy production. Being on the west coast, there is enough sun year round in some of its terrain to support solar panels, wind turbines, hydroelectric, biomass, and geothermal. [4]

2 Arizona- Arizona is a hot climate state year round receiving more than enough sun for solar energy. The majority of their energy comes from the Hoover Dam and Glen Canyon Dam, both hydroelectric plants running year round. [2]

3 New Mexico- New Mexico is consistent of mountains and dessert terrain, which seems to be a good location for wind turbines and solar. When actually New Mexico produces the majority of energy from wind turbines rather than solar. The wind coming over the mountains provide enough wind to power these turbines year round. [3]

4 Texas- Texas having the Gulf of Mexico, with miles and miles of oil refineries provides a prime time spot for oil and gas business'. Being the big state that it is, the majority of its land is dirt and brush, but with an abundance of oil and gas. This open terrain also provides good location for Texas' renewable wind energy, the rest of renewable energy Texas produces comes from biomass. [1]

Diversity of Renewable Energy Sources

1 California- California Has probably the most diverse renewable energy sectors of the four states. It contains steady production of renewable energy year round. California intends on reducing its carbon emissions by half of what it is now by 2030. Completely diversifying their energy production to account for all the consumption. [4]

2 Arizona- Arizona is mostly composed of coal and renewable energy. Of that renewable energy more than two thirds comes from hydroelectric and the rest from biomass and solar. [2]

3 New Mexico- Containing oil and gas, coal, and then renewable energy. New Mexico is mostly biomass and wind, and does not make it super diversified. [3]

4 Texas- Texas is not a big renewable energy state, it is mostly known for oil and gas. When we talk about what renewable benefits it has as a state it has very few. Texas contains all of two major renewable industries, biomass, and wind. Given it geological features these are the best performing renewable sectors. [1]

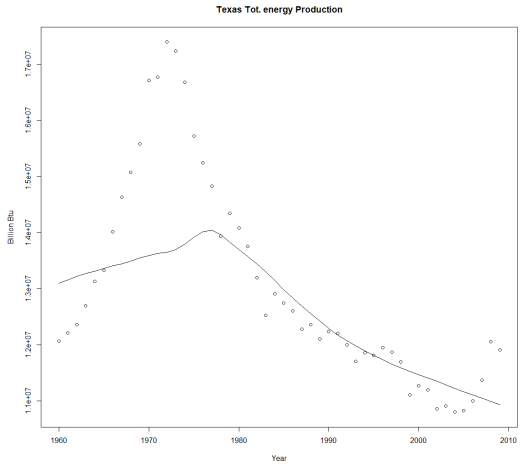
Total Energy Consumption vs. Production

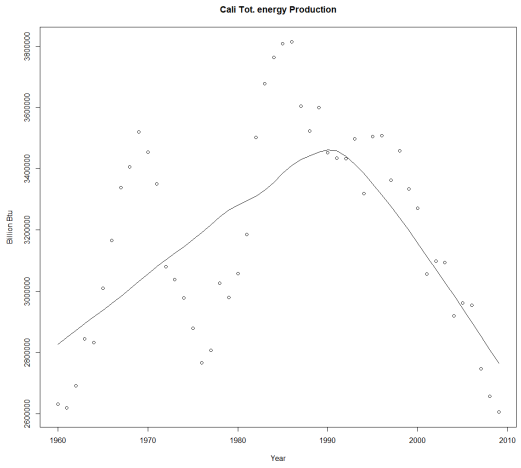
1 California- As a whole California is a large state with large consumption habits and produces enough to sustain its cities and citizens. In the larger spectrum of things is not totally energy efficient. Their consumption is slightly over that of production [4]

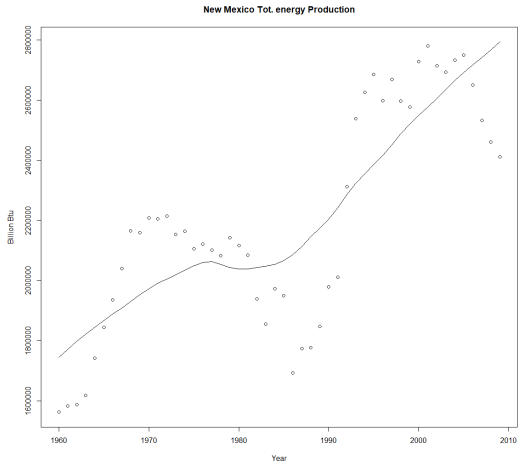
2 Arizona- Arizona from the 1960's onward has a steady upward trend of energy production but then plateaus off after 2009. Our forecast though for total energy production indicates a continuation of upward production through the future. [2]

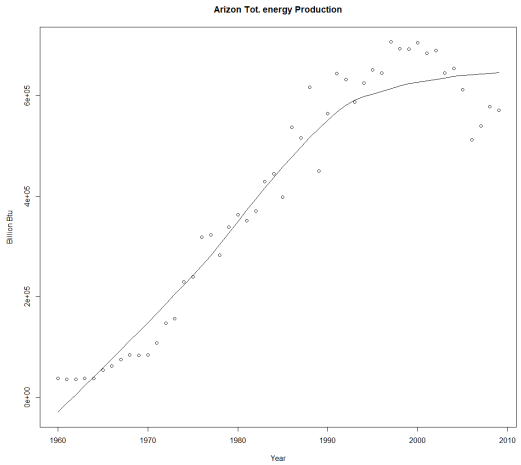
3 New Mexico- New Mexico, is heading toward better solar energy production in the future which could reduce their overall consumption. Thus becoming more energy efficient in the long run. While most of New Mexico's production comes from non renewable energy as does their consumption, they are consuming twice as much as they are producing. Which is not energy efficient. [3]

4 Texas- Texas is among the biggest states in the US ad contains nearly one fifth of our total consumption. Which consumes nearly twice as much as it produces. Making Texas a over consumptive state. [1]









Future Progression

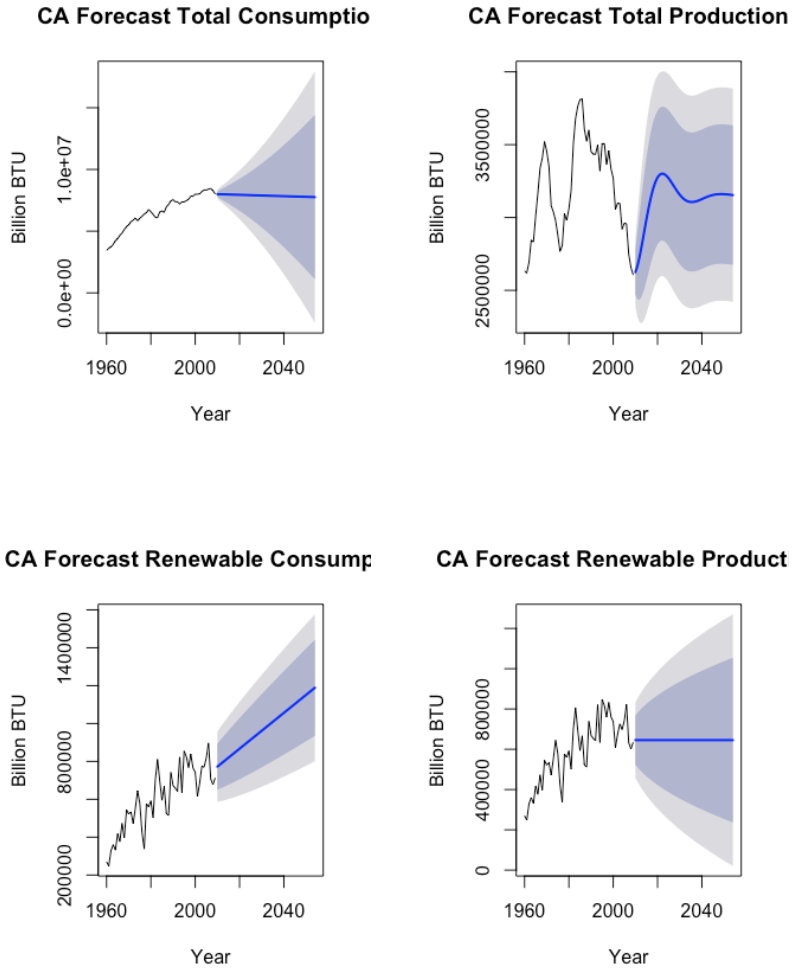
When forecasting for the states energy profiles, we came to the conclusion that the linear models used to describe the historical data would not provide the most accurate forecasting. When looking through the different types of forecasting models within R. We came to the conclusion that the ARIMA model would work best.

ARIMA stands for AutoRegressive Integrated Moving Average. To better explain this we will break down each part. First, we have AutoRegression which is regressing a variable on its past value. This applies a weight to each of the past terms and the weights vary based on how recent they are. Second, the Integrated part of ARIMA is used to reduce the seasonality of a time series. Lastly, Moving Average removes random movements of a time series. [6]

The following outputs in each states table is from running the auto.arima function in R. All of the models had a MAPE (mean absolute percentage error) less than 0.1 and using the function box.test all models are statistically significant. [6]

In the tables numerical values are in Billion BTU. TC is total energy consumption, TP is total energy production, TRC is total renewable energy consumption, and TRP is total renewable total renewable energy production. Also for the upper and lower 95% confidence bounds when a value is represented as 0

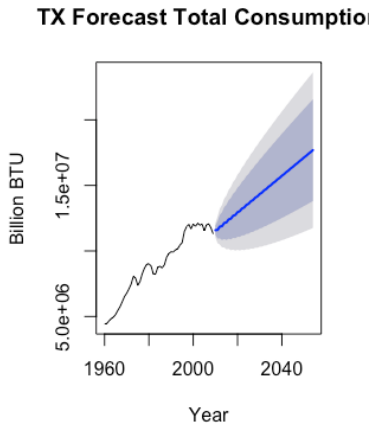
the projected value was negative whin in reality holds no weight.

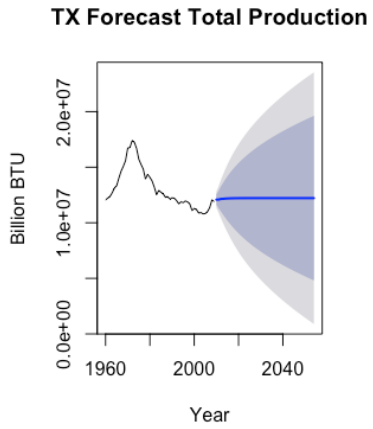


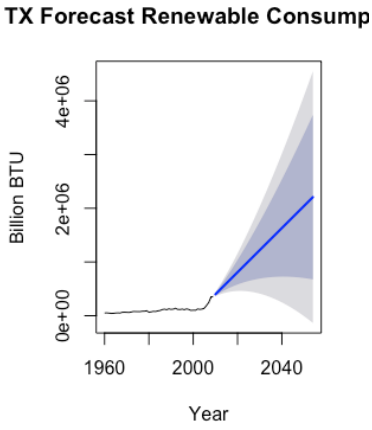
California 2025 & 2050 Projection

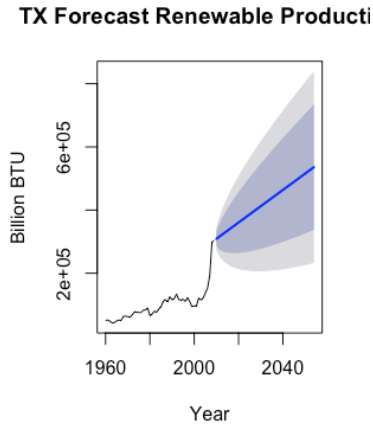
Code	2025 Est	Low 95%	Up 95%	2050 Est	Low 95%	Up 95%
TC	7,917,563	5,000,501	10,834,626	7,780,139	0	16,807,336
TP	3,269,389	2,556,200	3,982,577	3,160,390	2,428,551	3,892,228
TRC	914,245	642,235	1,186,255	1,150,901	777,137	1,524,665
TRP	645,388	250,729	1,040,497	645,388	47,162	1,243,614

California is established in the renewable energy sector. We feel that since California is widely established in the renewable energy market the models produce a well rounded forecast for the state. We feel that the model for renewable production will be close to 80% confidence interval and increasing through the years because of California's persistent transition to renewable energy.





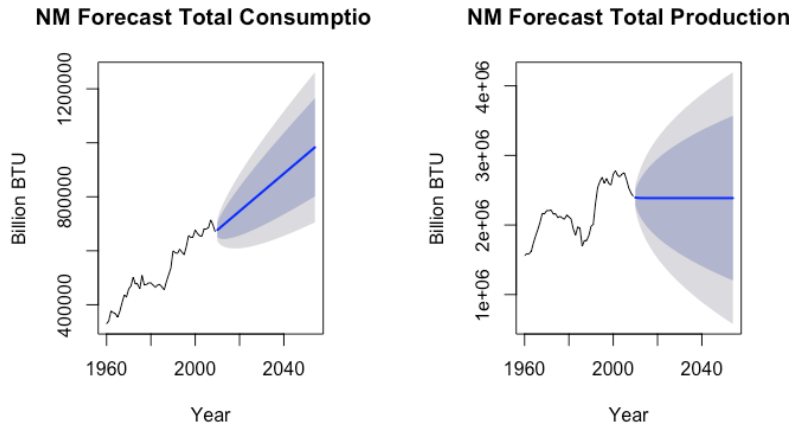


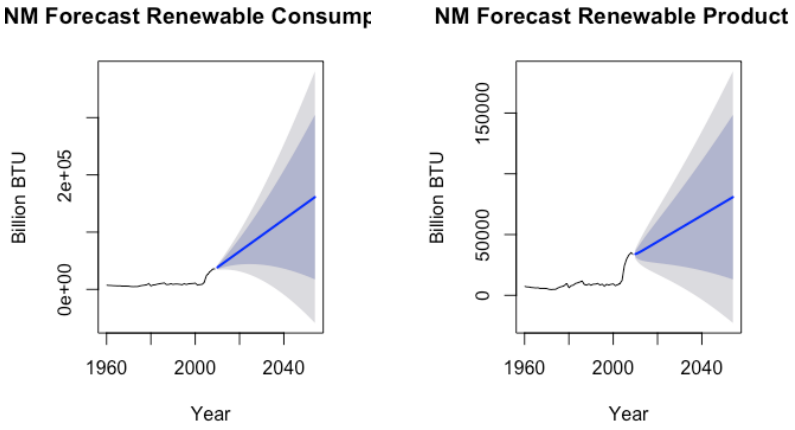


Texas 2025 & 2050 Projection

Code	2025 Est	Low 95%	Up 95%	2050 Est	Low 95%	Up 95%
TC	13,598,090	5,000,501	10,834,625	17,134,346	11,474,149	22,794,542
TP	12,216,600	2,556,200	3,982,577	12,217,568	1,458,224	22,976,911
TRC	1,014,690	451,859	1,577,521	2,042,902	0	4,094,264
TRP	386,309	207,401	565,216	515,224	225,814	804,634

Texas is expected to increase in renewable energy production and consumption this is inline with the Texas's profile in the previous section. When looking at Texas's total production this may be due to the price of oil. For example, Russia and OPEC are currently in a price war for oil driving the cost down. This leads to a decrease in oil production because the refinery process of the majority of oil available in Texas does not provide a profit at the current price. [1]

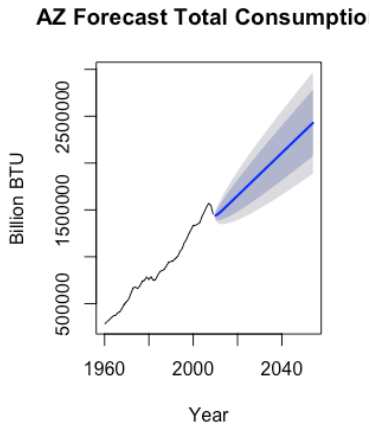


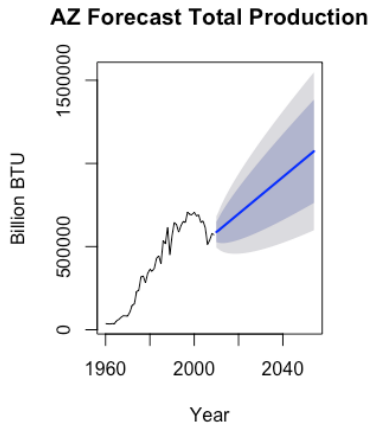


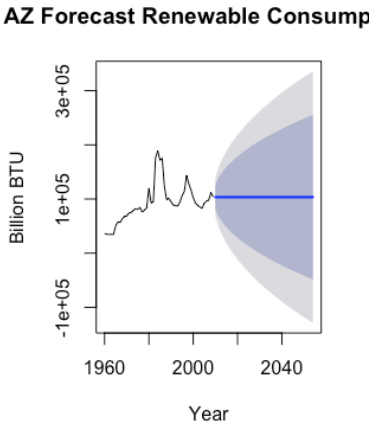
New Mexico 2025 & 2050 Projection

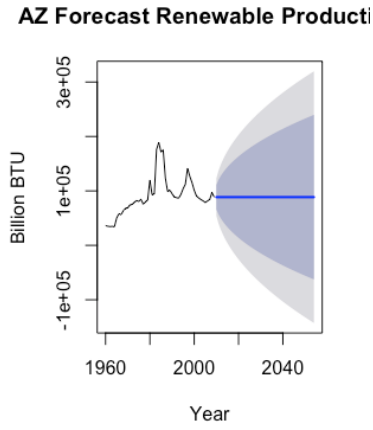
Code	2025 Est	Low 95%	Up 95%	2050 Est	Low 95%	Up 95%
TC	781,465	615,819	947,112	955,483	690,319	1,220,647
TP	2,386,080	1,328,707	3,443,451	2,386,080	662,072	4110086
TRC	80,257	25,184	135,331	149,980	0	342,911
TRP	49,257	12,667	86,387	76,495	0	169,830

New Mexico has some untapped resources in the renewable energy sector, such as wind power and geothermal. As New Mexico begins to utilize these resources their renewable energy production and consumption will increase. Also in future years New Mexico may see a growth in population that will lead to an increase in total energy consumption which encompasses total renewable energy consumption. [3]









Arizona 2025 & 2050 Projection

Code	2025 Est	Low 95%	Up 95%	2050 Est	Low 95%	Up 95%
TC	1,766,567	1,449,842	2,083,292	955,483	1,821,682	2,852,210
TP	752,413	465,856	1,038,969	1,028,866	575,507	1,482,225
TRC	103,493	0	241,998	103,493	0	325,210
TRP	88,571	0	226,369	88,571	0	309,156

Since the forecast for Arizona only include historical data this does not include the first wind plant built in 2009. With the increase of wind plants in the future years this will lead to an increase in in Renewable energy production. Also Arizona could further expand their use of solar energy with the prices of thin-film (material used in solar panels) decreasing and solar energy becoming more economically viable. [2]

Best Future Profile

After carefully weighing all qualitative and quantitative data that we compiled. We have determined that New Mexico has the most to gain in the coming years specifically 2025 and 2050. When looking at auto.arima function the projections for renewable consumption and renewable production are extremely favorable. New Mexico already utilizes wind and biomass but there are other sectors in renewable energy that New Mexico may start exploring in future years. The most obvious choice would be geothermal, which is prevalent in the southwestern part of the state. The other sector we feel that could push New Mexico is the use of solar power which is comparatively low. The state of New Mexico is a dry and sunny environment with large tracts of open land. Also while New Mexico has seen an increase in the Wind sector they can still push as the total renewable energy produced is comparatively low.

Energy Compact Goals

For the states to meet their energy compact goals they need to look at the three main things: renewable resources available, cost efficiency of renewable sources, and conduct research on other renewable technologies.

Each state has renewable resources that they use extensively, but there are some that aren't used. Texas for example has a lot of growth potential in their solar production, and if they actually started taking advantage of that potential their reliance on fossil fuels could be decreased. New Mexico and Arizona also have a lot of solar potential that can still be tapped into. If the states started using these really abundant resources that they already have available to them.

One of the limiting factors of implementing new renewable energy in a state is the start-up cost. A lot of renewable energy plants require large amounts of cost, time, and personnel. One example of this is one of the largest construction projects in the U.S., the construction of the Hoover Dam. When Governments are deciding on the amount of funds to allocate to renewable energy. We feel that there should be extra consideration given to positive aspects that are not immediate, for example factoring the reduction of carbon emissions. Also, the amount of jobs that such projects will create and the boost to the state economy.

The sometimes high cost of renewable energy can be mitigated in certain ways. We believe that government funding for research into renewable energy would be a great two-way street for the scientist as well as the government. Also, we believe that the state governments should partner with higher education institution to put on competitions with real world problems for students to solve. This would help the governments tackle some of the problems they are facing and provide valuable experience to college students.

Appendix

Code

```
    load the dataset from MCM website
>download.file("http://www.mathmodels.org/Problems/2018/MCM-C/ProblemCData.xlsx", "temp.xlsx")
>Energy_Data <- read_excel("temp.xlsx")
    Filter DATA for specific MSN Code and State
> ca_total <- Energy_Data %>% filter(str_detect(MSN, "TETCB" )) %>% filter(str_detect(StateCode, "CA"))
    create a scatter plot with a smoothed line
> scatter.smooth(x=ca_total$Year, y=ca_total$Data, main="CA total energy consumption")
    use ts() function to place in time series format
> CAT <- ts(ca_total$Data,frequency = 1,start = c(1960))
    plot time series formatted data
> plot(CAT)
    use auto.arima() function to get the optimal auto
> autoarimaCAT <- auto.arima(CAT)
    forecasted data for 45 years
> forecastCAT <- forecast(autoarimaCAT, h=45)
    show forecasted values
> forecastCAT
    plot the forecasted data from auto arima model
> plot(forecastCAT, main = "CA Forecast Total Consumption", xlab = "Year", ylab = "Billion BTU")
    plot residuals to see congruence or variance
> plot(forecastCAT$residuals)
    plot the residuals (sample vs. theoretical)
> qqnorm(forecastCAT$residuals)
    determine how well present value correlated with past value
> acf(forecastCAT$residuals)
    finds correlation of residuals with the next lag value
> pacf(forecastCAT$residuals)
    determine the accuracy
> summary(autoarimaCAT)
    determine significance
> Box.test(resid(autoarimaCAP), lag=20, type="Ljung-Box")
    create linear model
> ca_tc <- lm(formula = Data   Year, data = ca_total)
    determine accuracy
> summary(ca_tc)
    residuals
> plot(ca_tc)
    plot data points with regression line
> with(ca_total,plot(Year, Data, main = "CA Total Consumption")) abline(ca_tc, lwd=3, col='red')
```

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[2]

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[3]

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[4]

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[5]

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[6]

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