

Balancing Energy Demands and Conservation for Sustainable Growth:
Colorado's Challenge and Solutions

Team Members: Zijia Wang, Kaiwei Xiao, Tianjian Xie

Abstract:

Due to environmental problems such as climate change, energy consumption has become a popular topic these years. No doubt that for sustainable development, we need to replace more fuel energy that can cause environmental problems with clean energy. However, development is not a single topic, the changes in usage of the energy should be connected with reality situations. So in this project, we are going to talk about the possibility that the Colorado state can balance the energy consumption and sustainability based on using renewable energy by analyze the data provided by the official websites. By the conclusion of the study of Colorado green energy status, the usage of renewable energy that has the greatest potential in Colorado is the solar energy. Based on the data of solar stations in Colorado state, we made a shiny map for the energy production and made the prediction for the solar energy.

Introduction:

Colorado is known for its beautiful landscapes, booming economy, and thriving population. However, as the state continues to grow, it faces a challenge in balancing energy sustainability with population growth. As Colorado's population grows, the demand for energy increases, putting pressure on the state's energy infrastructure and increasing greenhouse gas emissions. This demand is not sustainable in the long term, as traditional energy sources such as coal and natural gas are finite and contribute to climate change.

To address this challenge, Colorado is taking steps to increase its use of renewable energy sources. The state has set a goal of reaching 100% renewable energy by 2040, and it is already a national leader in wind and solar power production. Additionally, Colorado has implemented policies to promote energy efficiency and has invested in smart grid technology to better manage energy demand. However, the state still faces obstacles in its transition to renewable energy. For example, the variability of renewable energy sources such as wind and solar power can make it difficult to maintain a consistent energy supply. Additionally, the high costs of renewable energy infrastructure can be a barrier to widespread adoption. Despite these challenges, Colorado remains committed to balancing energy sustainability with population growth.

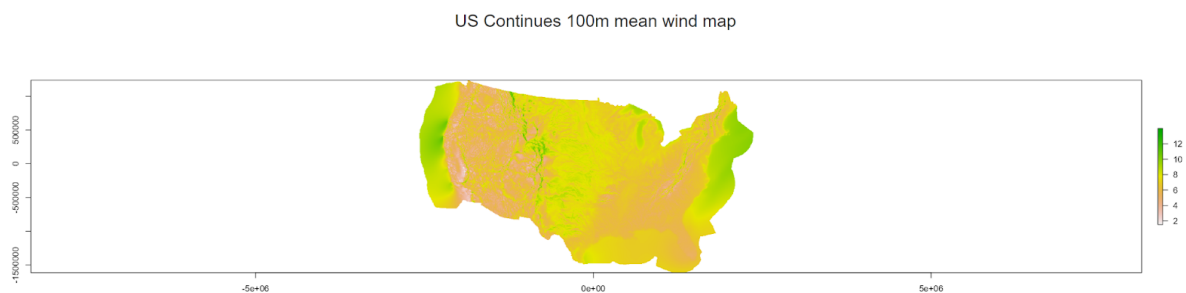
By continuing to invest in renewable energy and adopting policies that promote energy efficiency, Colorado can reduce its reliance on traditional energy sources and pave the way for a more sustainable future. In 2019, the governor of Colorado presented a proposal aiming to generate 100% of the state's electricity using renewable resources by 2040. In 2021, renewable energy sources contributed to 35% of Colorado's total electricity net generation. Wind power had the most significant share of renewable net electricity generation, accounting for 77%. Utility-scale and small-scale solar combined accounted for 14%, followed by hydroelectric power at 8%, and biomass at 1%.

Colorado boasts a significant potential for solar energy, particularly in the southern region near the New Mexico border. The state ranks 13th in utility-scale solar power-generating capacity with 1,054 megawatts installed as of 2021, and a further 750 megawatts of solar power capacity is expected to be added by the end of 2022. Small-scale solar power generating systems, which have a capacity of less than 1 megawatt, continue to expand and made up almost 40% of Colorado's total solar generation in 2021. To encourage

the installation of solar panels, including community solar gardens, which are solar panels shared by multiple households, Colorado provides rebates and tax incentives to homeowners and businesses. The Bureau of Land Management has created the Solar Energy Program to promote solar energy across six southwestern states, and four areas in Colorado have been identified as Solar Energy Zones (SEZ), which are ideal for utility-scale solar development. The potential of solar energy means to balance the sustainability, develop the solar electricity production is the future.

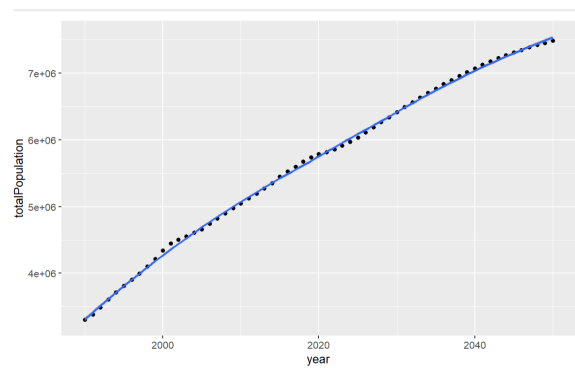
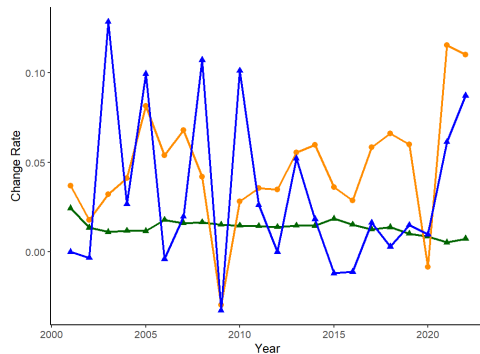
Problem Statement:

As we explore strategies for balancing energy demands in Colorado, it is important to consider a range of renewable energy resources. Four key resources that we will consider are solar, wind, biofuel, and nuclear. Solar energy is abundant in Colorado, with an average of 300 days of sunshine per year, making it a promising option for renewable energy. Wind energy is also a viable option in certain regions of the state. However, it is worth noting that the map shows limited potential for wind power generation in Colorado. Biofuel is another renewable energy resource, but due to concerns about land use and food security, we will not consider it as a primary option in this analysis. Finally, nuclear energy, while often touted as a viable option for clean energy, is not currently utilized in Colorado, with the state having no nuclear power plants. By considering the potential of solar and wind energy, as well as exploring new options for clean energy, we can work towards a more sustainable and resilient energy future for Colorado.



Based on the US Continues 100m mean wind map, we can see that most of the strong wind resources are located offshore, while the onshore wind resources are generally weaker. This means that areas such as Colorado may have limited potential for wind power generation, as the wind speeds may not be sufficient to generate significant amounts of electricity. However, this discovery has led us to explore other renewable resources such as solar power. With its abundant sunshine, Colorado has great potential for solar power generation, making it a viable alternative to wind power.

Proposed Solution:



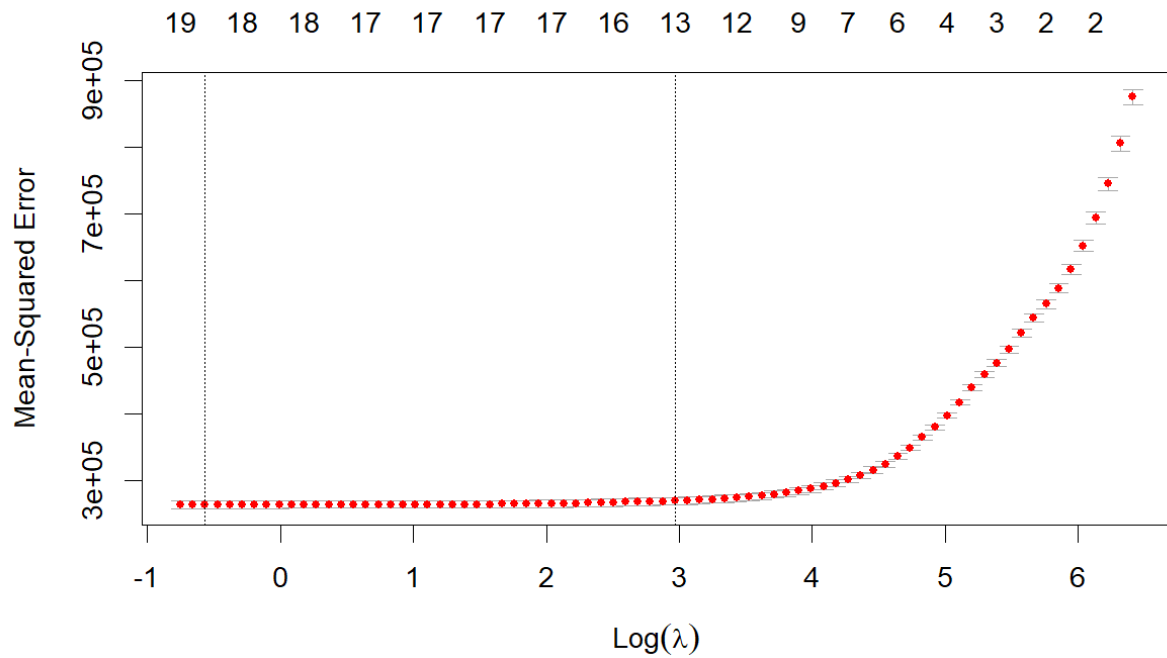
Colorado's carbon emissions peaked in 2007 when there were 99.3 million metric tons of energy-related carbon dioxide released into the air. That followed a nearly 40-year stretch during which emissions steadily rose and eventually doubled from 1970. Beginning in 2007, emissions have slowed. In 2019, there were 91.7 million metric tons of emissions, an 8% decline. Emissions had been rising each year from 2015 through 2019, however, matching the period of time during which Colorado's population boomed. By looking at the estimation of the population, it's necessary to improve the use rate of green energy to reduce the emissions.

As we mentioned before, we think the solution is to develop the most potential energy resource in Colorado which is solar energy.

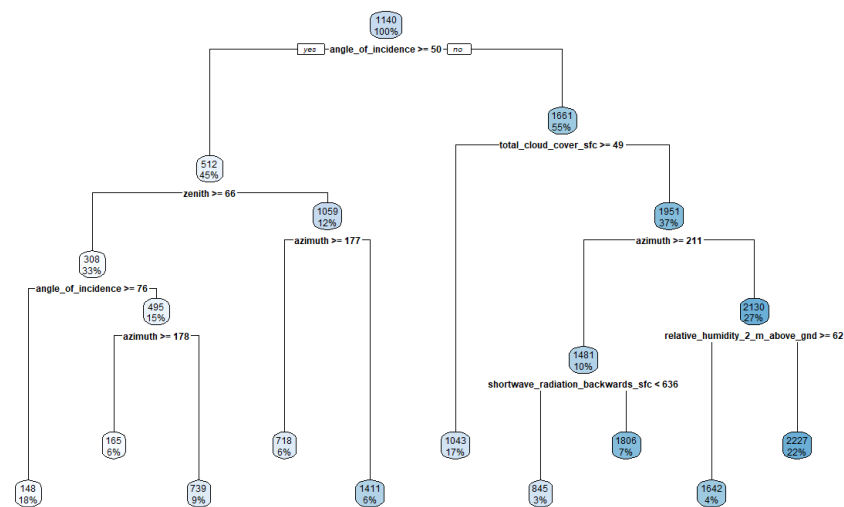
Since we've decided the energy that is better to be used in future, we've fitted some models based on our data to see the prediction of the solar energy production.

Findings:

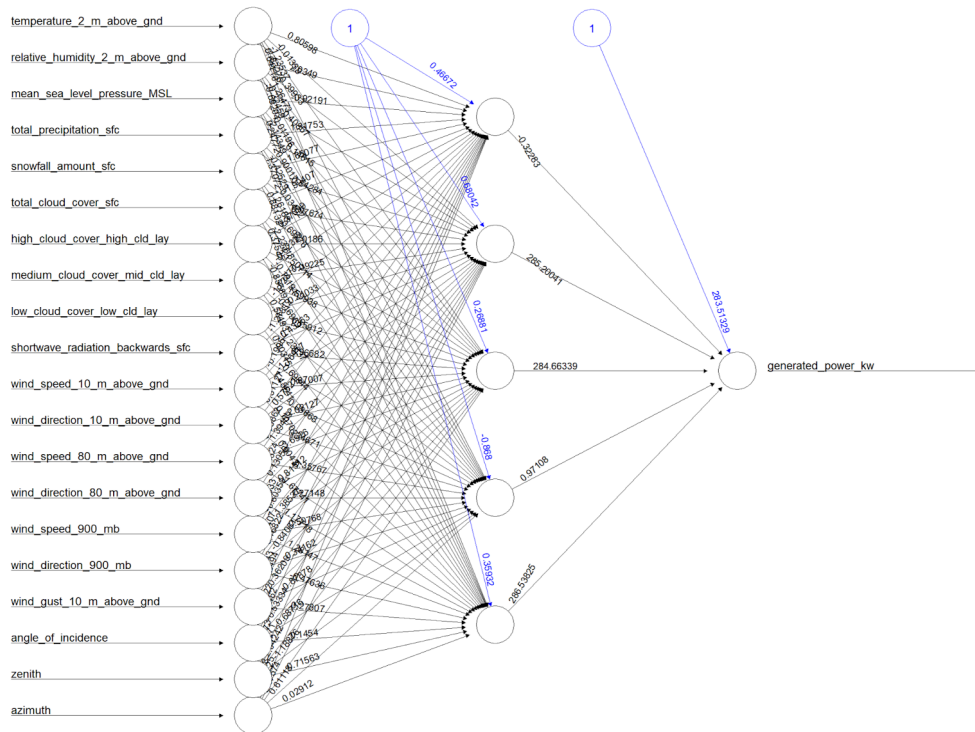
By fitting the LASSO regression to the solar production data, we got the MSE, which is 251849.3. This MSE looks too large, may because the data is not fitting well by the LASSO.



So we fit a tree regression for that again,



Now the MSE is 289460.2, even worse. Then we tried a neural network model,



Again, we get worse MSE which is 889776.1. So we might say the data set is too noisy, can't fitting well with complex regression models.

Summary:

In conclusion, Colorado faces a critical challenge of balancing energy demands and conservation for sustainable growth. As the state continues to grow, finding ways to promote sustainability while meeting energy demands is becoming increasingly urgent. As the above parts show, Colorado does not have so many choices, wind energy is already commonly used in electric production, and the citizens will not choose nuclear energy. So in the rest of choices, solar energy is the most possible solution. By the most reliable model we fitted above, the LASSO regression gave the prediction of 1119.174 kw as generated power, with MSE 251849. This means for each one solar plant build, 1119.174 kw of electricity will be produced.

To encourage the usage of solar energy, the Colorado Government can provide incentives such as tax credits, rebates, and subsidies for homeowners and businesses to install solar panels. These incentives can significantly reduce the upfront costs of solar panel installation, making it more affordable for more people. Once the families and businesses install the solar panels, they can also sell the unspent electricity back to the utilities, this can further reduce the cost of their electric usage. By those preferential policies, we can see huge improvement in solar energy usage.

Citation:**Data:**

[Population Colorado | Colorado Information Marketplace | data.colorado.gov](https://data.colorado.gov)

[Colorado Profile \(eia.gov\)](https://eia.gov)

Articles:

[VP Harris to talk green energy in Colorado, a major fossil fuel producer | FOX31 Denver \(kdvr.com\)](https://www.fox31denver.com)

[Here's how we can balance conservation and development | World Economic Forum \(weforum.org\)](https://www.weforum.org)