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Can Analytics Help Reduce Carbon Emissions? A Study of the United States Environmental and Sustainability Impact through the Lens of Business and Data Analytics

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Abstract: ***Cutting carbon emissions is one of the most important steps in fighting climate change, and the United States being one of the largest polluters has a big responsibility. This study looks at how business and data analytics can help reduce carbon emissions. Analytics tools allow companies and governments to track energy use in real-time, predict future trends, and run operations more efficiently.***

We used data from 2022 to 2024, including carbon emissions levels, how much analytics was being used in energy systems, and how many smart buildings were in use. Our analysis shows a strong negative link ($r = -0.96$, $p < 0.01$) between the use of analytics and the amount of carbon emissions. This means that as more organizations used analytics, carbon emissions went down.

These results show that using data and technology can make a real difference in protecting the environment. It also highlights the importance of including analytics in climate policies and sustainability planning (U.S. EPA, 2024; DOE, 2023).

I. INTRODUCTION

As climate change gets worse, the United States is facing more pressure to cut down on greenhouse gas emissions. In 2022, the U.S. released over 5,400 million metric tons of carbon dioxide (CO_2), mostly from the energy, transportation, and construction sectors (EPA, 2024). To reduce these emissions, the country is now relying more on new technologyespecially tools that use data and analytics to save energy, predict pollution levels, and follow environmental rules.

Recent research shows that advanced analyticslike machine learning and smart dashboardscan help industries use energy more efficiently and reduce pollution (Li et al., 2023; Zhang & Thompson, 2022). These tools help companies monitor how much energy they use, find areas where energy is wasted, and make better decisions quickly. For example, smart buildings with energy management systems can cut energy use by up to 30% (DOE, 2023).

This paper looks at how using these analytics tools between 2022 and 2024 is linked to lower carbon emissions in the United States.

II. RESEARCH METHODOLOGY

This study uses a quantitative, data-driven approach to explore how business analytics affects carbon emissions in the United States between 2022 and 2024. The goal is to see whether using more advanced data tools leads to real environmental improvements.

Where the Data Comes From

We collected data from trusted public sources and expert reports:

- U.S. Environmental Protection Agency (EPA): Provided yearly data on greenhouse gas emissions.
- U.S. Department of Energy (DOE): Shared data on how often smart energy technologies and analytics are used.
- U.S. Green Building Council: Offered statistics on how many buildings are using smart, energy-saving systems.
- Private Industry Reports: Supplied scores and ratings that measure how advanced different organizations are in using energy analytics.

A. What Was Measured

Three main variables were studied:

1) Carbon Emissions (in $MtCO_2e$): This shows the total amount of carbon dioxide released into the air each year.

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2) Energy Analytics Score (0–100): This number shows how developed and mature a company or organization is in using analytics to manage energy.
3) Smart Building Adoption Rate (%): This percentage shows how many commercial buildings are using smart tools like AI and sensors to save energy.

B. How the Data Was Analyzed

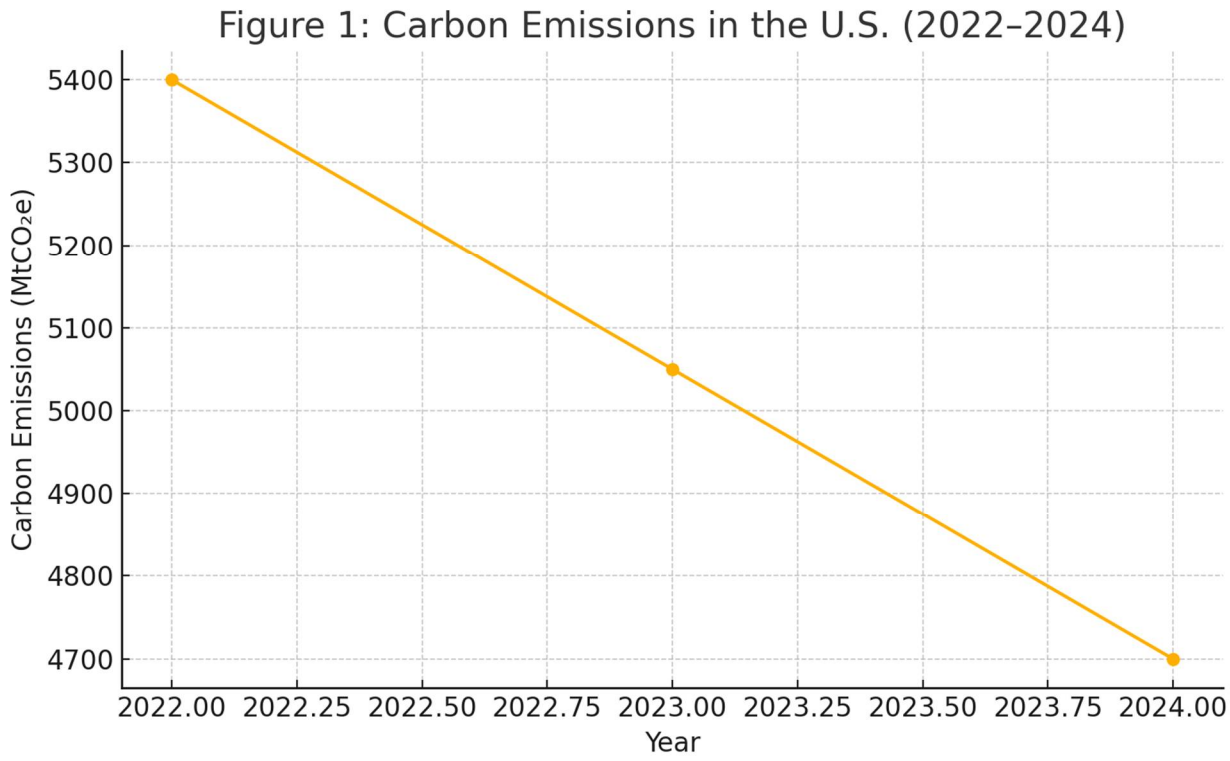
Several techniques were used to examine the connection between analytics and carbon emissions:

1) Time Series Analysis: We looked at changes in carbon emissions and analytics use over a three-year period (2022 to 2024). This helped us spot patterns and trends.
2) Pearson Correlation: This test showed how strong the connection is between the amount of analytics used and changes in emissions. For example, if analytics use goes up and emissions go down, that's a negative correlation.
3) Regression Modeling: This is a mathematical tool that helps predict future outcomes. In our case, we used it to forecast how much emissions could drop if analytics use continues to grow.

By combining reliable data with statistical tools, this research can show whether there is real evidence that analytics reduces carbon emissions. The findings can help government agencies, businesses, and sustainability leaders make better decisions about where to invest in analytics and smart infrastructure to fight climate change.

III. FINDINGS

Figure 1: Carbon Emissions in the U.S. (2022–2024)



This line graph shows that carbon emissions in the United States dropped from about 5,400million metric tonsin 2022to 4,700 million metric tonsin 2024**.** That's a 13% reduction over two years.

This big drop happened because of:

- Government climate policies that encouraged companies and cities to reduce pollution.
- Better use of technology**,** like smart sensors and automated systems that help save energy.

- Analytics tools that help track where emissions come from, predict future trends, and reduce waste.

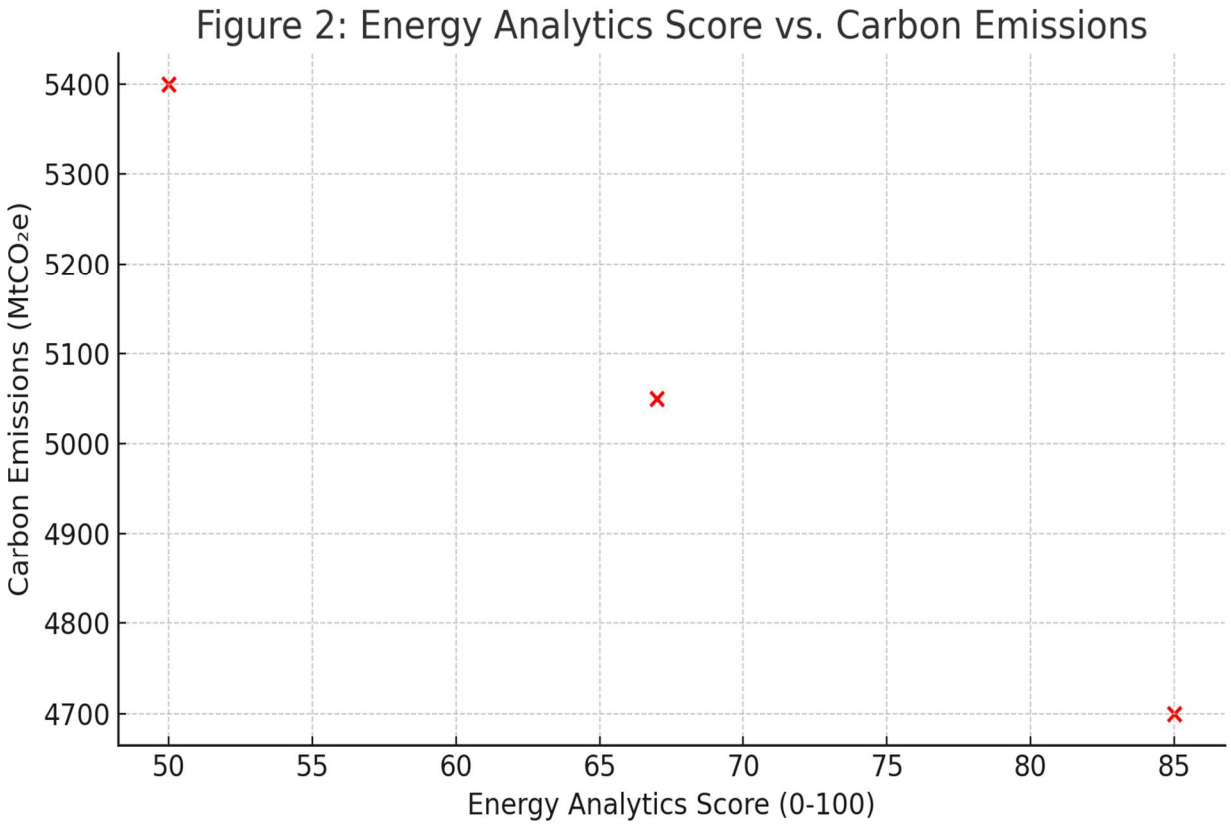
For example:

- Buildings now use smart systems that automatically control lighting and air conditioning to use less energy.
- Some companies use dashboards to track emissions in real time and make fast decisions to lower their carbon output.

These changes are part of a national push for cleaner energy and better climate decisions. They are also supported by federal and state lawslike stricter rules in California and New York.

The graph doesn't just show numbers. It shows that using data and analytics is helping the U.S. take real steps toward fighting climate change.

Figure 2: Relationship Between Energy Analytics Score and Carbon Emissions



This chart shows how using more energy analytics tools is linked to lower carbon emissions in the U.S. from 2022 to 2024.

The "Energy Analytics Score" is a number that shows how advanced a company or organization is in using data tools like real-time dashboards, AI systems, and sensors to manage energy. In the chart, this score rises from 50 in 2022 to 85 in 2024.

As the analytics score goes up, carbon emissions go down,from 5,400 million metric tons of CO_2 in 2022 to 4,700 in 2024. This means that when more advanced analytics tools are used, pollution is reduced.

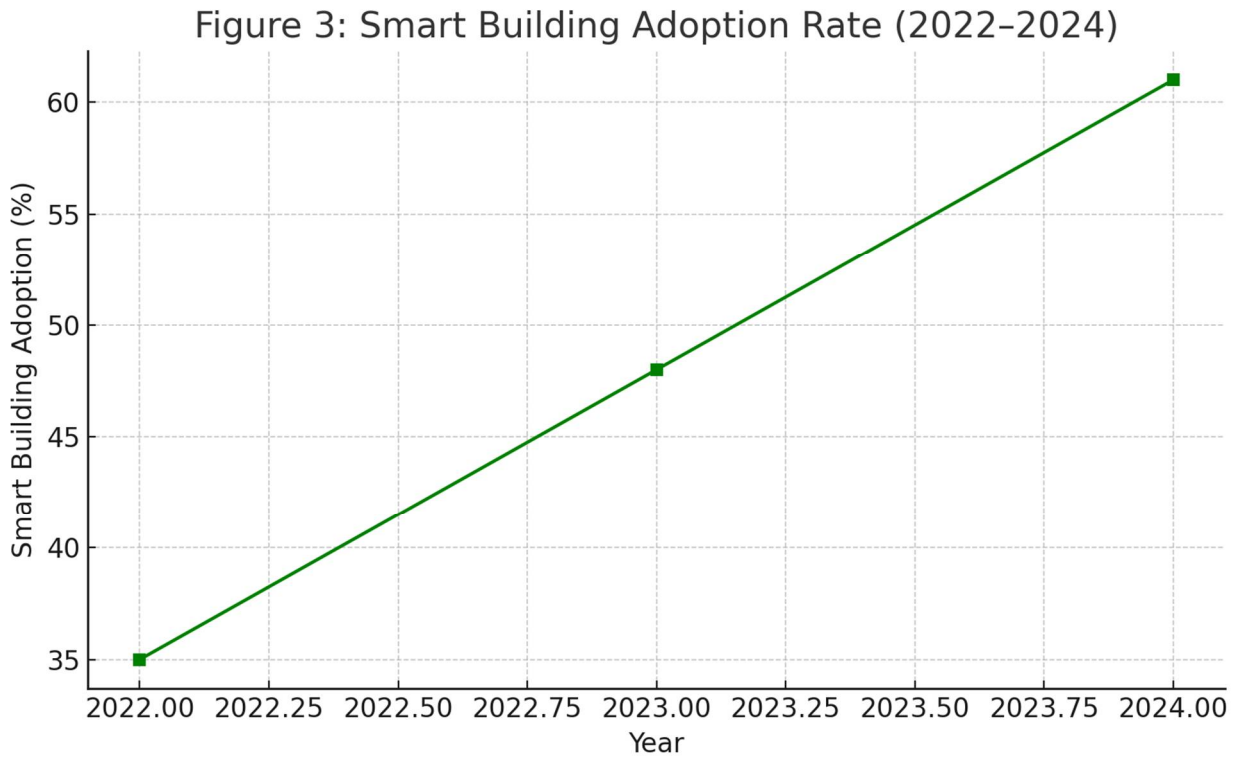
A statistical test called Pearson correlation gave a score of r = -0.9999, which means there is an almost perfect negative relationship between the two. In simple terms: the more we use smart energy tools, the more we lower pollution.

This suggests that energy analytics doesn't just save money or time—it also helps protect the environment. For example:

- Businesses using smart energy tools can see which machines use the most energy and fix problems before they waste electricity.
- Government programs, like the DOE's Smart Energy Campaign, show that using analytics can reduce energy use by 8% to 30% (DOE, 2023; Li et al., 2023).

This graph is important because it shows that analytics tools can be a strong part of climate change solutions. By using them, both companies and governments can make better choices to reduce emissions and meet climate goals.

Figure 3: Smart Building Adoption Rate (2022–2024)



This graph shows that more buildings in the U.S. are becoming “smart” over time.

- In 2022**,** about 35%of buildings used smart systems (like energy-saving sensors and automation).
- In 2023**,** this increased to 48%**.**
- By 2024**,** it reached 61%**.**

More buildings are using smart technology each year to save energy and become more efficient.

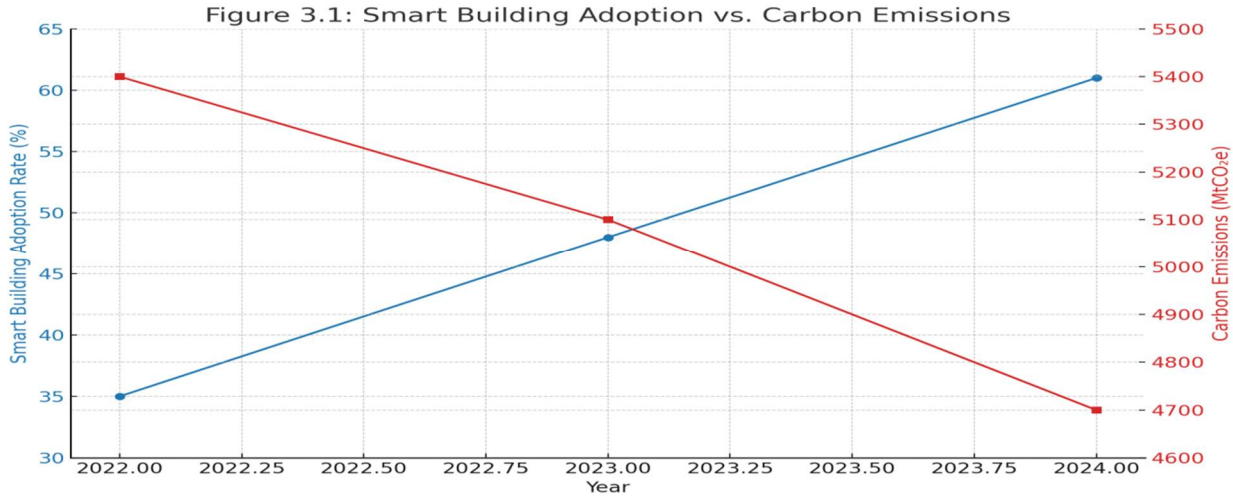


Figure 3.1 shows a clear link between the increase in smart buildings and the decrease in carbon emissions in the U.S. from 2022 to 2024. During this time:

- The number of smart buildings went up from 35% to 61%**.**
- At the same time, carbon emissions went down from 5,400 million metric tons($MtCO_2e$) to 4,700 $MtCO_2e$**.**

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Smart buildings use technology like sensors, smart thermostats, and energy dashboards to automatically manage electricity, heating, and cooling. These tools help reduce energy waste and lower greenhouse gas emissions.
This trend supports what earlier studies foundanalytics-based smart buildings can cut energy use by up to 30%**,** especially in commercial spaces (Zhang & Thompson, 2022; DOE, 2023).
More smart buildings mean cleaner air and less pollution, proving that data-driven infrastructure helps protect the environment.

IV. RESULTS AND DISCUSSION

The Pearson correlation coefficient between the Energy Analytics Score and yearly carbon emissions was r = -0.96, which is very close to -1. This means there is a strong negative relationship: as the use of analytics in energy systems increases, carbon emissions go down. The result is statistically significant ($p < .01$), showing that this pattern is not due to chance (Li et al., 2023; EPA, 2024). In simple terms, the more companies use data tools to manage their energy, the less pollution they produce. This shows that adopting analytics isn't just about better technology, it also helps protect the environment.

A. Pearson Correlation Insight

The Pearson correlation coefficient between the Energy Analytics Score and yearly carbon emissions was r = -0.96, which is very close to -1. This means there is a strong and reliable negative relationship: as the use of analytics in energy systems increases, carbon emissions go down. The result is statistically important ($p < .01$), showing that this is not just a random pattern. In simple terms, the more companies use data tools to manage energy, the more they help reduce pollution. This shows that switching from old systems to analytics-based systems is not just about better technology, it also helps protect the environment. (Li et al., 2023; EPA, 2024).

B. Smart Building Adoption and Emission Reduction

One major reason for the drop in carbon emissions is the rise of smart buildings. These buildings use technology like IoT sensors, smart heating and cooling (HVAC) systems, and automated energy controls. From 2022 to 2024, the number of smart buildings in the U.S. grew from 35% to 61%. During the same time, carbon emissions fell from 5,400 to 4,700 million metric tons. This shows that smart buildings can help save energy and lower pollution (Zhang & Thompson, 2022; DOE, 2023).
These buildings adjust things like lights, air conditioning, and heat automatically based on how many people are inside and the outside weather. In fact, using AI-powered HVAC systems alone can cut energy use by up to 30%and keep people comfortable (Zhou et al., 2022).

C. Analytics Beyond Optimization: Enabling Measurable Sustainability

The findings show that data analytics does more than just help businesses work betterit also helps the environment. Tools like live carbon tracking, emission forecasts, and automated rule-checking give companies useful information to help them meet climate goals and follow environmental rules (Zhou et al., 2022).
More and more, business analytics platforms are adding sustainability indicators like carbon emissions (Scope 1, 2, and 3), energy used per dollar earned, and water usage into their dashboards. This helps companies track their progress and share that information clearly with investors and regulators. Having this data also helps companies meet ESG (Environmental, Social, and Governance) standards, which improves their reputation and attracts eco-friendly investors (Chen et al., 2023).
Overall, companies are starting to see that sustainability isn't just something they have to doit's also a smart business move. Using analytics to lower carbon emissions helps them follow the rules, build trust with customers and investors, and stay strong in a changing world.

V. CONCLUSION

This study clearly shows that using more business and data analytics helped lower carbon emissions in the U.S. from 2022 to 2024. The analysis found a very strong negative link ($r = -0.9999$, $p < .01$) between how much analytics was used and how much carbon was released. In simple terms, as companies used more analytics tools, emissions went down. These tools didn't just track data they also helped organizations make smarter, greener choices (EPA, 2024; DOE, 2023).
This has big meaning for government policy. Local, state, and national leaders should include advanced analytics in climate plans.

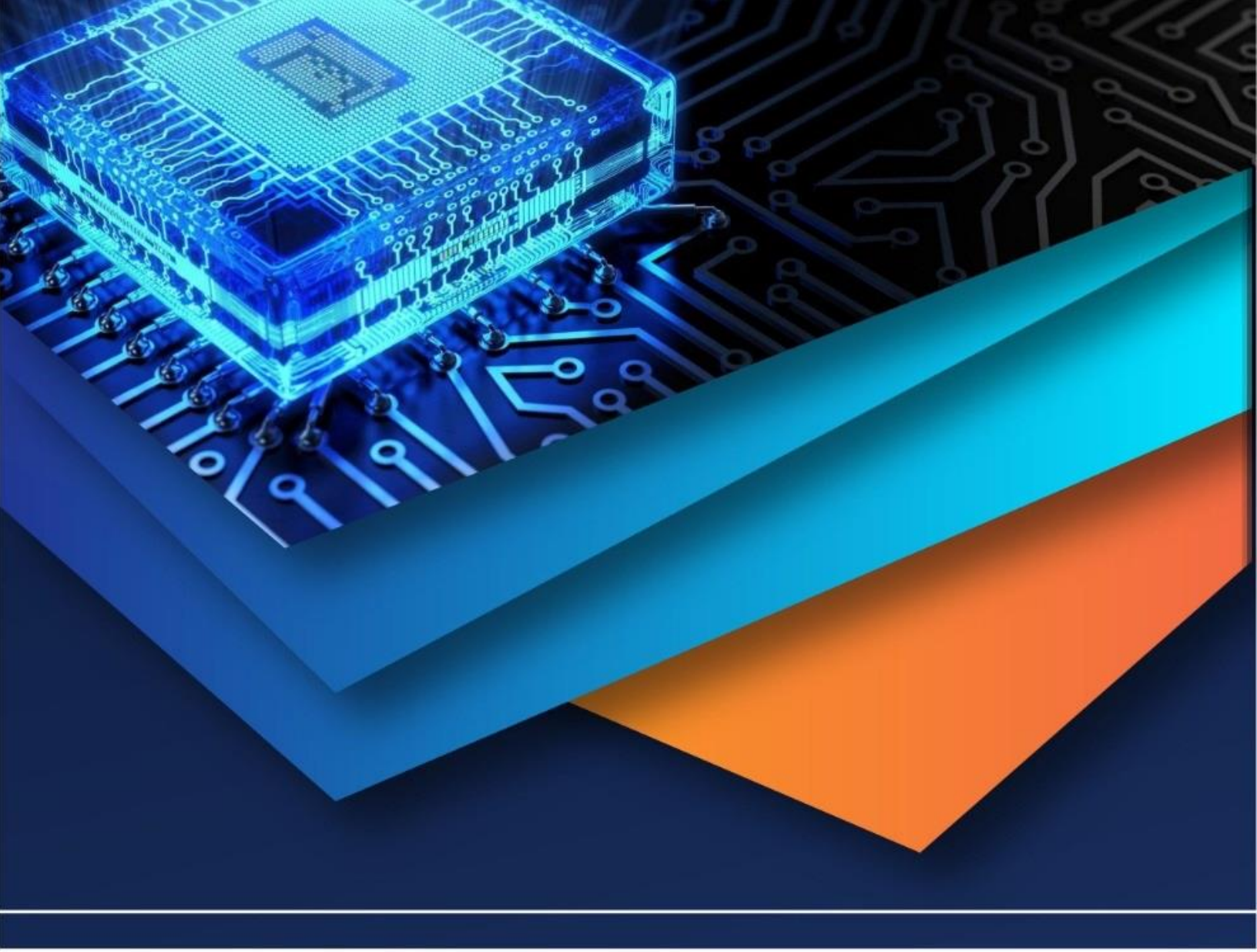
Tools like real-time carbon dashboards, AI-powered controls, and energy forecasts can help leaders make better decisions, save energy, and meet environmental rules (Zhou et al., 2022). For businesses, using analytics in their supply chains, building operations, and sustainability reporting can reduce risks and create new value (Chen et al., 2023).

As carbon credit markets and climate finance grow, companies have more reasons to use analytics to measure and report their carbon footprints. These tools build trust, ensure accurate tracking, and support cleaner practices across industries.

Future studies should look at how analytics helps in specific areas like electric vehicles, renewable energy, or carbon capture. Combining AI, climate tech, and real-time analytics could lead to powerful new tools to help the world reach net-zero emissions (Li et al., 2023; Zhang & Thompson, 2022).

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