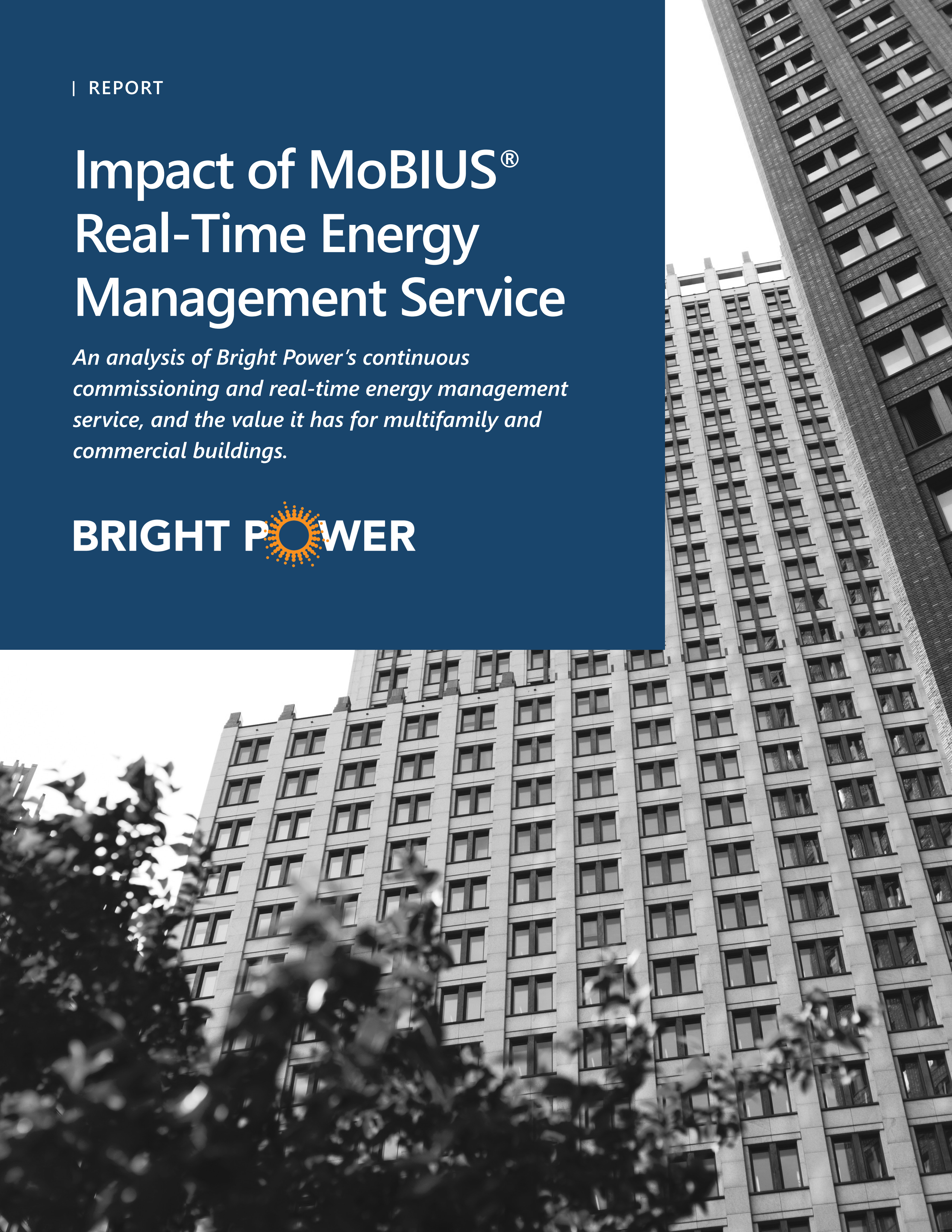
| REPORT

Impact of MoBIUS® Real-Time Energy Management Service

An analysis of Bright Power's continuous commissioning and real-time energy management service, and the value it has for multifamily and commercial buildings.

BRIGHT POWER



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Executive Summary

Summary

Bright Power's MoBIUS® (**Management of Building Information, Utilities, & Systems**) service monitors real-time energy and equipment usage, optimizes equipment performance and control settings and provides continuous training to building operators and managers across multifamily and commercial buildings. After piloting this service for three years with two clients, Bright Power began deploying MoBIUS to more buildings in the fall of 2018. This research intended to answer the following questions:

> **Are MoBIUS buildings consuming less energy over time compared to buildings without MoBIUS?**
>
> **Are energy savings at MoBIUS buildings more predictable than buildings without MoBIUS?**
>
> **Is energy consumption less volatile in buildings with MoBIUS than in buildings without?**

We analyzed data from 15 multifamily and commercial buildings that were engaged in MoBIUS for the full year 2019 and compared that to data from 100 control buildings that were not engaged in a real-time energy management service but were enrolled in Bright Power's EnergyScoreCards benchmarking platform.

KEY FINDINGS

Buildings engaged in MoBIUS **reduced their energy spend by an average of 5.2%** in 2019 compared to 2018.

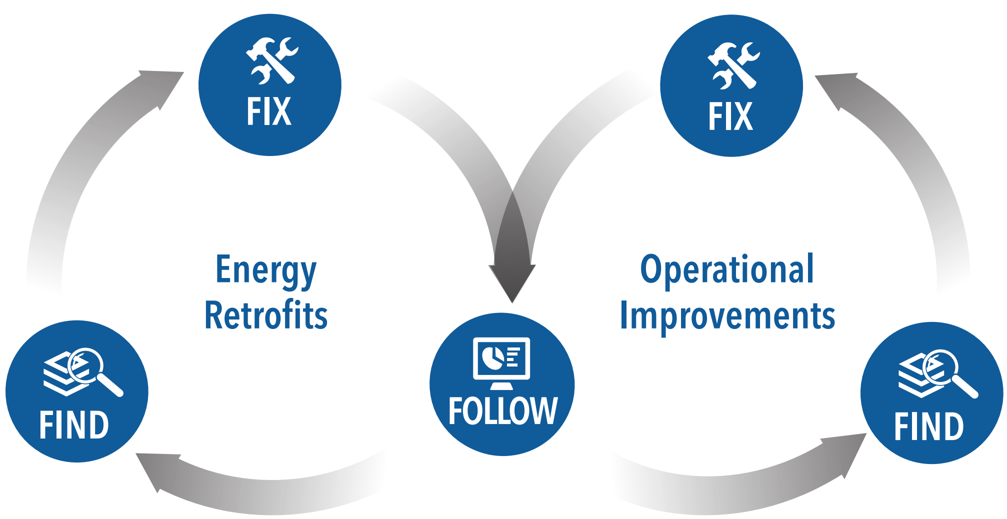
Buildings engaged in MoBIUS were **63% more likely to achieve energy savings** during the two-year period compared to the control buildings.

MoBIUS buildings had **less volatile energy use patterns throughout the year** compared to the control buildings.

What is MOBIUS Real-Time Energy Management Service?

MoBIUS utilizes real-time energy monitoring hardware for analytics and continuous commissioning to detect and diagnose equipment performance issues, improve building operations, and reduce energy consumption. Bright Power experts use the data to provide both on-site and remote technical support, fix systems and equipment, and follow systems performance. The building staff receives training to improve ongoing operations and enhance the owner's organizational capacity.

MoBIUS embodies Bright Power's **Find, Fix, Follow** approach to operational improvements for buildings. With MoBIUS, the Bright Power team follows the building's performance in real-time, finds any additional waste, provides operational fixes, and then continues to follow the progress of the operational improvements.



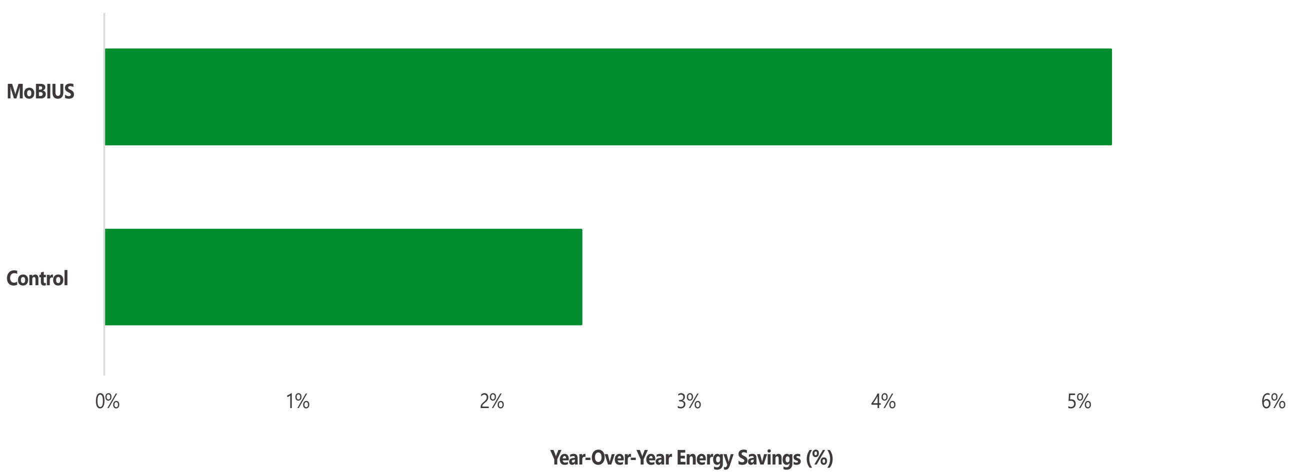
Results

We analyzed the impact and value of MoBIUS for multifamily and commercial real estate owners over a two-year period. The study compared the energy usage of 15 buildings that were actively engaged in Bright Power's MoBIUS service with 100 control buildings not engaged in a real-time energy management service. This study analyzed the total weather normalized energy each building consumed (in millions of British Thermal Units or MMBtu) in 2018 and 2019. The key findings are described below.

MoBIUS buildings saved twice as much energy as buildings not engaged in MoBIUS.

Buildings engaged in **MoBIUS reduced their energy usage by 5.2% on average** from 2018 to 2019, saving twice as much on energy as buildings not engaged in a real-time energy management service. The control group saw a 2.5% average decrease in energy savings during the same period.

Figure 1: Average Year-Over-Year Savings



MoBIUS buildings had more predictable energy usage.

Buildings engaged in **MoBIUS were more likely to achieve more significant energy savings** than buildings not engaged in MoBIUS. Exactly 80% of MoBIUS buildings saw greater energy savings than the average 2.5% energy savings from the control group, with over 58% of MoBIUS buildings achieving additional savings over 5%. Only one of the MoBIUS buildings saw its energy use increase. In this study, MoBIUS buildings were 63% more likely to achieve energy savings during the two-year period than the control buildings.

Figure 2: Probability of Saving Energy

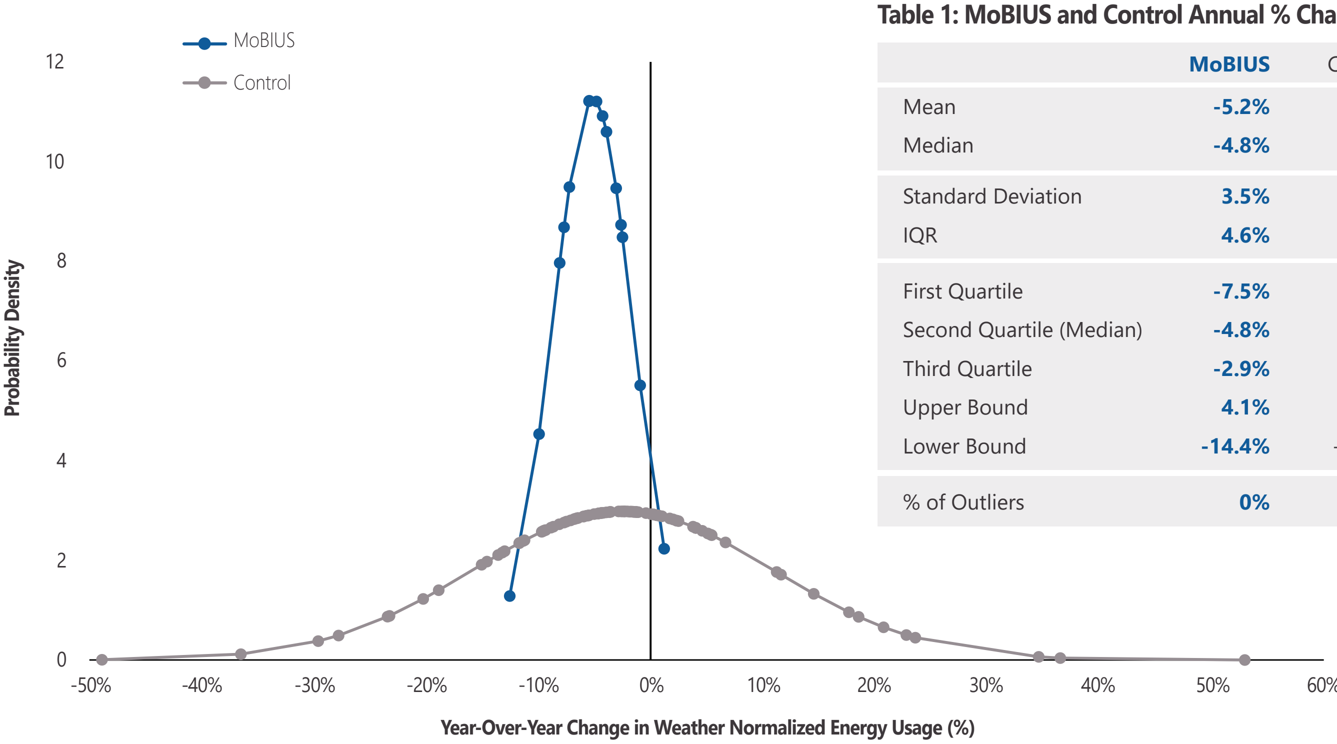


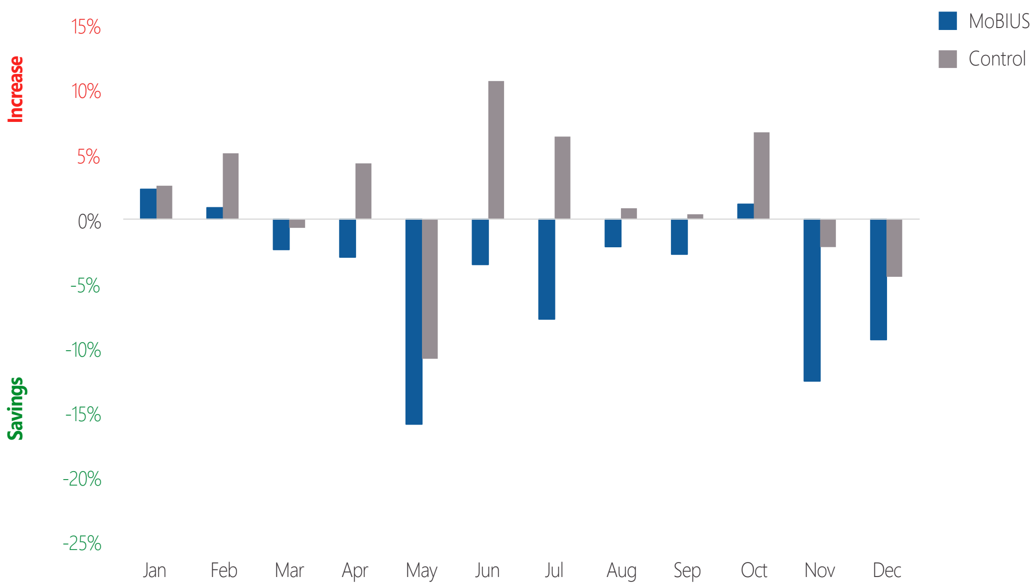
Table 1: MoBIUS and Control Annual % Change

	MoBIUS	Control
Mean	-5.2%	-2.4%
Median	-4.8%	-2.5%
Standard Deviation	3.5%	13.4%
IQR	4.6%	8.7%
First Quartile	-7.5%	-7.5%
Second Quartile (Median)	-4.8%	-2.5%
Third Quartile	-2.9%	1.2%
Upper Bound	4.1%	14.3%
Lower Bound	-14.4%	-20.6%
% of Outliers	0%	15%

MoBIUS buildings more consistently achieved greater energy savings.

Buildings engaged in **MoBIUS had higher and more consistent energy savings** month-to-month. MoBIUS buildings also had **less volatility** in the amount of savings each month.

Figure 3: Average Energy Usage Change 2018 to 2019

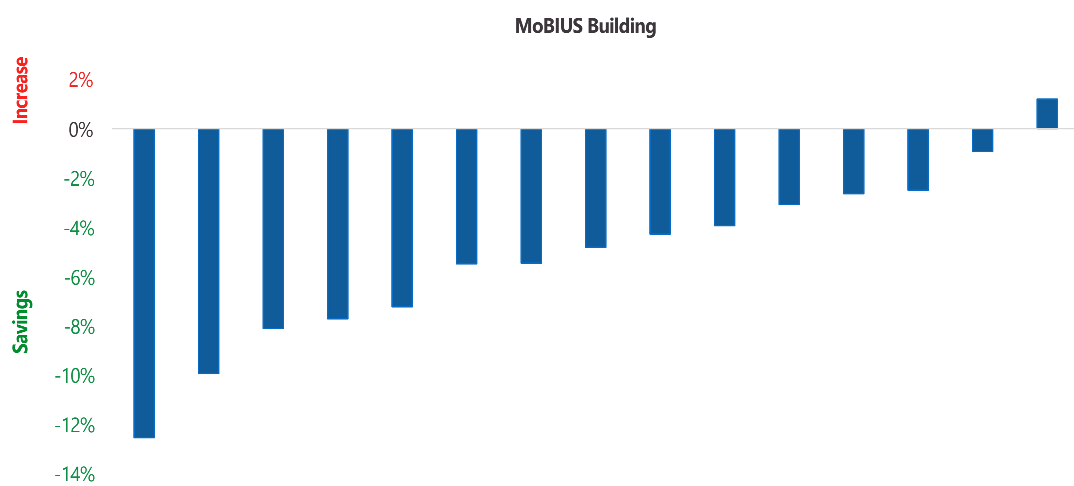


Analyzing each building's percent change, year-to-year, focused the analysis on comparing a building's energy usage to its own previous performance. The buildings are compared against their historical energy usage, rather than the average performance of the entire dataset.

Savings Potential

A deeper analysis exhibits that **93% of MoBIUS buildings realized savings** from 2018 to 2019, as seen in **Figure 4**, whereas 66% of the control dataset saw energy savings. The maximum savings for a MoBIUS building year-over-year was 12.4%. While this alone is noteworthy, it is also worth highlighting that eight of the MoBIUS buildings have realized savings over multiple years of engagement beyond this report. This can be seen in *Case Study: Deeper Insight Into a Median MoBIUS Site* (pg. 29) of the report.

Figure 4: MoBIUS Buildings' Energy Usage Change



Industry Impact

Leveraging real-time data analysis paired with an energy management engagement can yield significant and more predictable savings to building owners. This research demonstrates that multifamily—both market rate and affordable—and commercial building owners can benefit from a real-time energy management service like MoBIUS.

If building owners act on the results of this study to more broadly adopt MoBIUS and similar ongoing commissioning and real-time energy management, expect this to lead to **deeper energy savings**, **reduced building carbon emissions**, and **growth in the real-time** energy services marketplace. Further, reducing the amount of volatility of energy usage improves cash flow and budgeting for building owners and operators.

Beyond operational benefits, a real-time energy management service can equip building owners with the tools to comply with New York City’s Local Law 97 (LL97), which will require building owners to reduce carbon emissions below specific caps starting 2024. LL97 supports New York State’s goal of net-zero carbon emissions by 2050. Continuous commissioning with real-time energy management can help building owners achieve reliable energy and carbon savings, better maintenance and operation of building systems, and compliance with carbon emissions limits.

While this study was limited to a two-year research period, we believe additional analysis will show continuous savings and better long-term predictability of energy usage for buildings engaged with MoBIUS or a similar service.

Special Thanks

This research was made possible by the generous support from the New York State Energy Research and Development Authority’s (NYSERDA) Novel Business Model grant program. It is with sincere gratitude that we extend our appreciation to NYSERDA for continued support to the energy and sustainability industry as we work together to meet and hopefully surpass the state's energy and carbon reduction goals.

Purpose

GOALS
RESEARCH QUESTIONS
HYPOTHESES

Goals

The purpose of this research is to:

- Understand the impact and value of Bright Power's MoBIUS ongoing energy management service for multifamily and commercial real estate owners.
- Use two years of data to analyze the results delivered through MoBIUS compared to a control group, or buildings without MoBIUS.
- Quantify the potential MoBIUS has to decrease energy costs, both predictable and unexpected.

Research Questions

Bright Power aims to answer the following questions using evidence gathered through our research:

- How do buildings engaged in Bright Power's MoBIUS service perform compared to a control group of buildings not engaged in MoBIUS or a similar program during the same year?
- How predictable are energy costs for MoBIUS buildings over time compared to control buildings?

Hypotheses

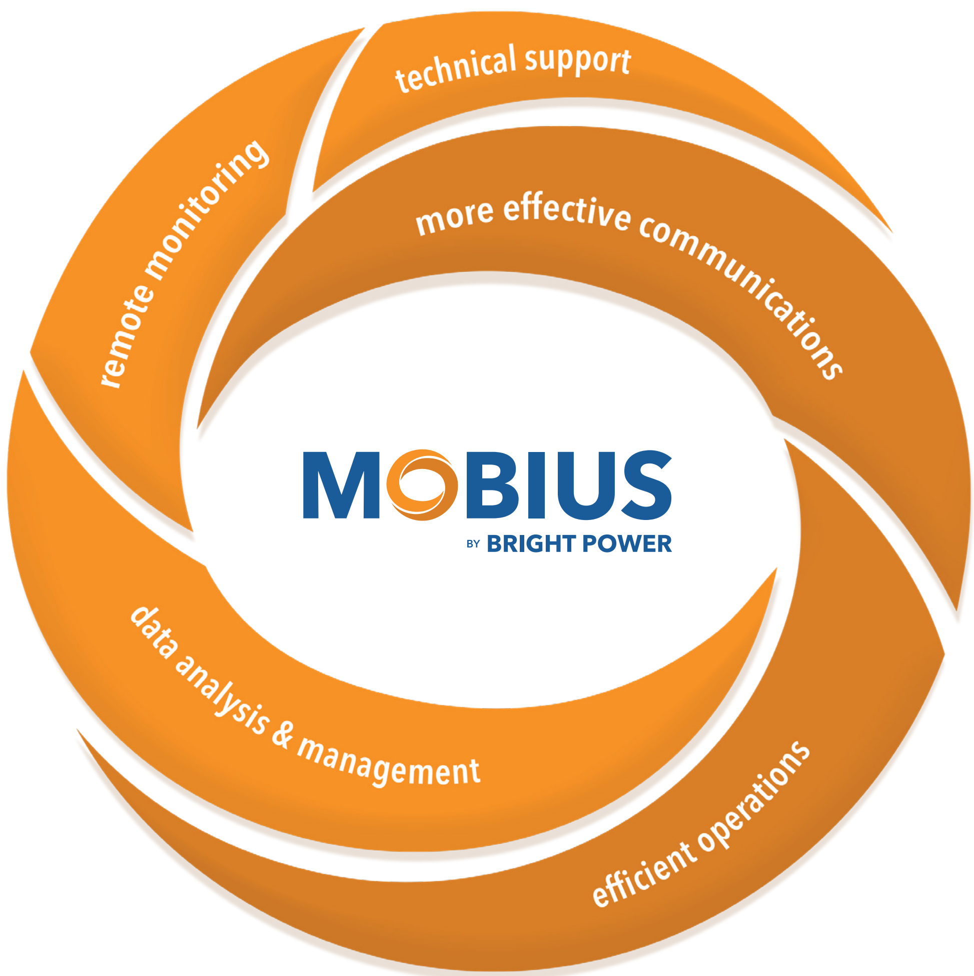
Bright Power's hypotheses for this research are the following:

- MoBIUS buildings perform better over time as compared to control buildings.
- MoBIUS buildings consume more predictable amounts of energy, with any volatility being quickly corrected, compared to control buildings.

Bright Power's MoBIUS

Bright Power believes the successful operation of sustainable buildings—both new and existing—depends on using real-time data analysis, optimizing systems and controls, and having hands-on technical experts to turn data analysis into actionable insights. Without these strategies, building owners run the risk of wasting valuable time and money on equipment and systems that don't run properly.

MoBIUS utilizes real-time energy monitoring and expert staff to deliver a comprehensive energy management service. Real-time monitoring and analytics identify opportunities to reduce energy consumption while Bright Power experts provide on-site and remote technical engineering support to fix, prioritize, and maintain systems equipment. The MoBIUS service also includes continuous staff training to enhance organizational capacity.



A typical MoBIUS engagement can include:

> **Full equipment inventory of all owner-operated plant equipment.**
>
> **Creating a custom building operations manual, detailing existing equipment and their sequence of operations.**
>
> **Remote monitoring system tailored to the building.**
>
> **Cloud-based issues log to track and identify operational and capital repair scopes.**
>
> **Routine on-site training with building maintenance staff and management teams.**
>
> **Access to the real-time monitoring analytics platform.**
>
> **Continuous analysis by a dedicated Energy Engineer.**
>
> **Technical support for on-site repairs, training, and preventative maintenance.**
>
> **Quarterly reporting, including month-over-month utility comparison, recommendations, and a summary of progress.**

Find, Fix, Follow

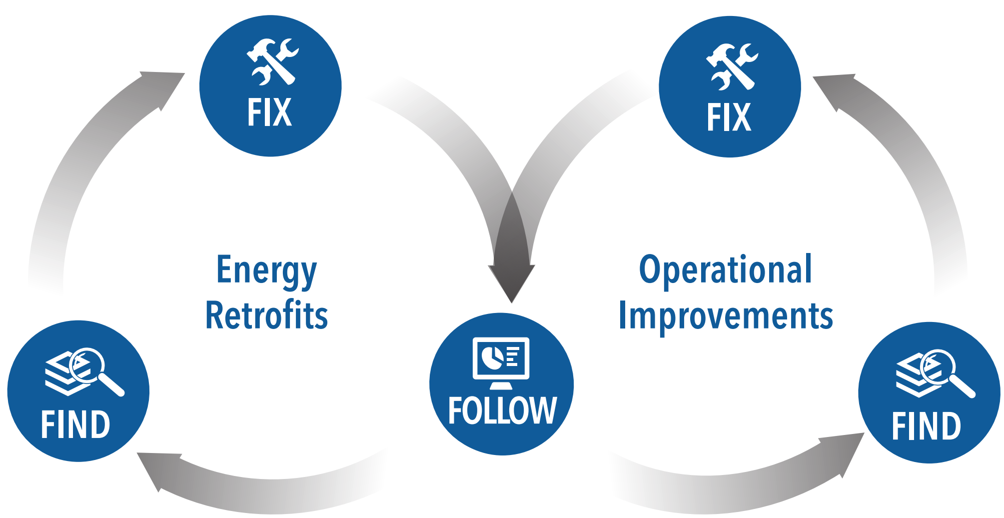
Bright Power's approach to energy management leverages practical on-the-ground experience and data from tens of thousands of buildings to comprehensively **Find**, **Fix**, and **Follow**.

We **Find** energy waste through utility bill analytics and site investigations. We find opportunities for solar and other zero-carbon renewables. We then find incentive and rebate programs to reduce costs and increase the return on investment.

We **Fix** buildings to eliminate waste and maximize performance, increasing building value, and tenant comfort while decreasing operating costs. Through turnkey project implementation, retro-commissioning, and project management, we make sure the work gets done on time, on budget, and with energy savings.

We **Follow** the data and react quickly to performance issues, ensuring that buildings achieve their financial and environmental goals. As we follow, we find new opportunities to improve performance even further. Lower energy costs, longer equipment life, and enhanced asset values are the result.

MoBIUS embodies Bright Power's find, fix, follow approach to operational improvements for buildings. With MoBIUS, Bright Power follows the building's performance in real-time, finds any additional waste, provides operational fixes, and then continues to follow the progress of the operational improvements.



Analysis

MoBIUS OUTPERFORMS CONTROL
CASE STUDY

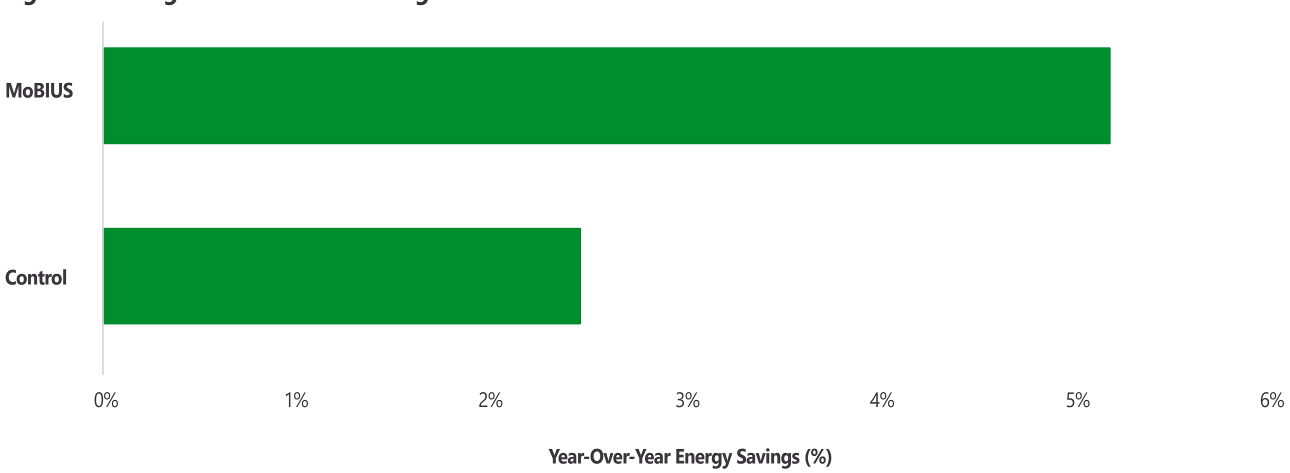
This study compares the energy usage of 15 buildings that were actively engaged in Bright Power's MoBIUS service, with 100 control buildings not engaged in a real-time energy management service. Bright Power performed the analysis of the total energy usage of the buildings in both study groups over two years from 2018 to 2019. Rather than looking at specific fuels, we analyzed the buildings based upon their total energy consumption (electric, gas, oil, and steam combined in total BTU/SF/Heating Degree Day (HDD) + BTU/SF/Cooling Degree Day (CDD)) year-over-year.

MoBIUS Performance vs. Control

MoBIUS buildings saved 2x more energy on average compared to the control group.

The year-over-year energy usage of MoBIUS buildings compared to the control group, seen in **Figure 1**, illustrates that MoBIUS buildings consumed an average of 5.2% less energy in 2019 compared to 2018. In contrast, the control group saved an average of 2.4%. The data supports the hypothesis that MoBIUS improves buildings' performance by achieving more considerable energy savings than the control buildings.

Figure 1: Average Year-Over-Year Savings

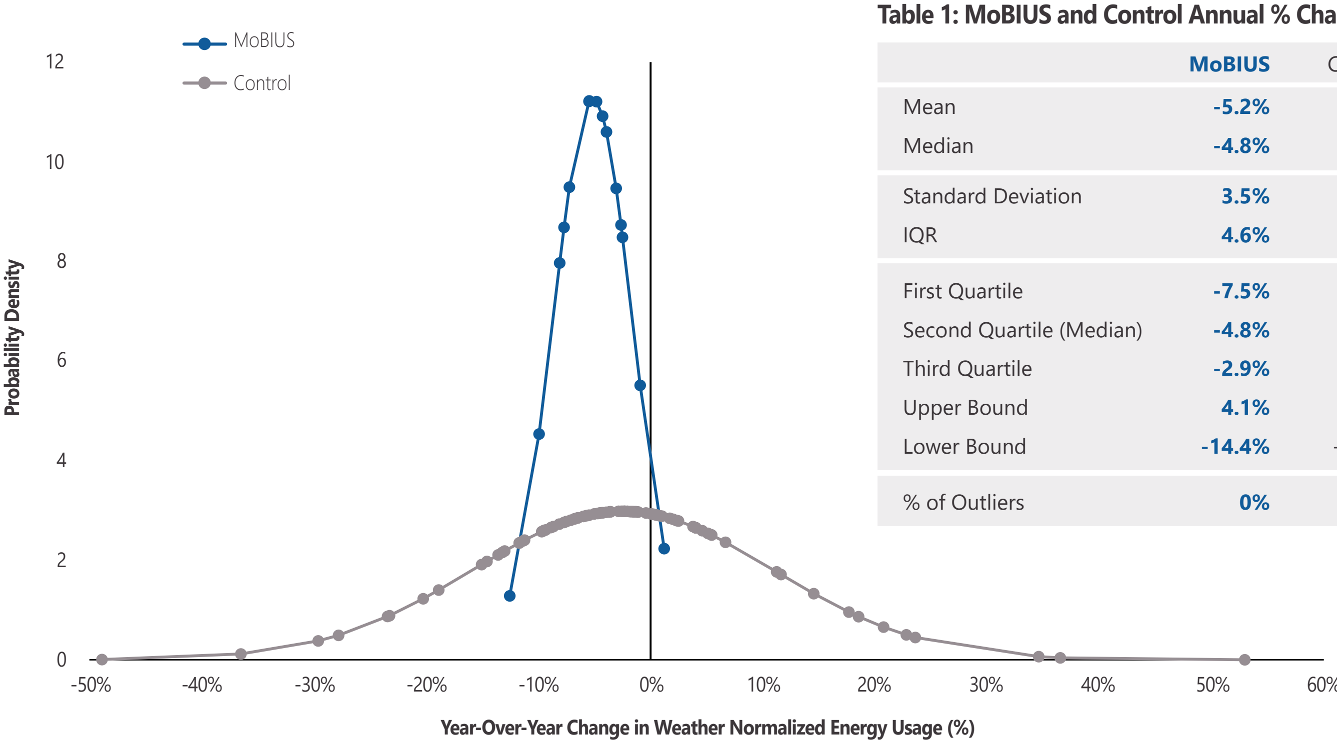


MoBIUS buildings had a higher probability of saving energy compared to the control group.

We analyzed the data distribution to compare the annual savings and volatility of energy consumption between MoBIUS and control buildings. Comparing the spread of annual usage data shows that **MoBIUS buildings experienced less volatility in energy consumption year-over-year** than the control group. While the control group experienced an average decrease in energy usage in 2019 compared to 2018 in this study, MoBIUS buildings were 63% more likely to achieve energy savings during the two-year period.

As shown in **Figure 2 and Table 1**, the MoBIUS buildings had a smaller standard deviation and interquartile range (IQR) than the control buildings. The smaller range of values implies that the MoBIUS buildings experienced less volatility with their annual energy consumption.

Figure 2: Probability of Saving Energy



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Upper Bound	4.1%	14.3%
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% of Outliers	0%	15%

Comparing the proximity of the mean and median values within each dataset and looking at the shape of the density curves show that the datasets were not perfectly normal distributions. The density curves display skewed distributions due to the upper half and lower half of the data having a different amount of spread. In other words, the smallest and largest annual percent changes in energy consumption are not symmetric around the average annual percent change.

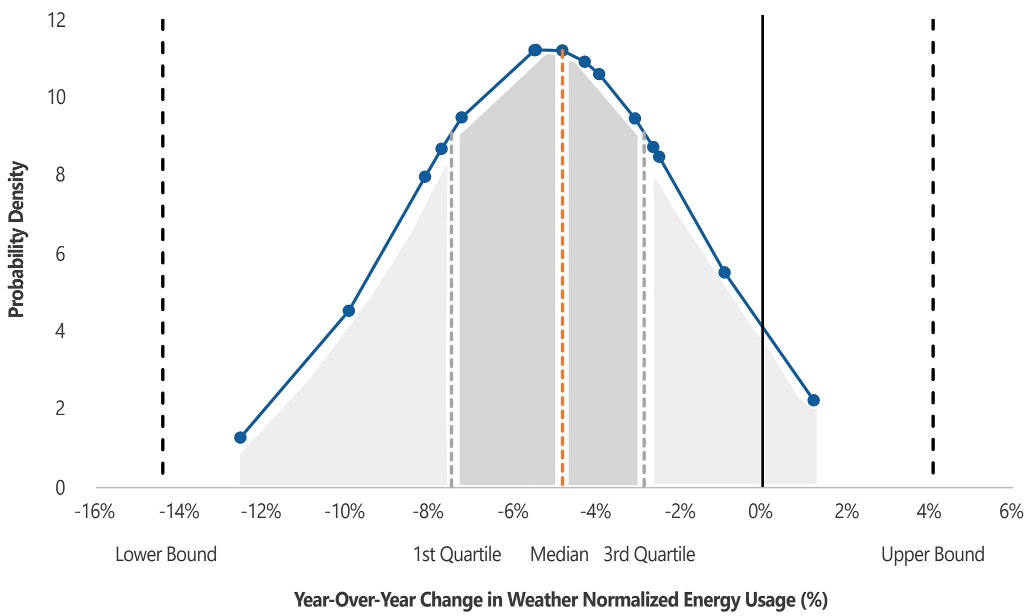
The MoBIUS density curve has a low skewness of -0.3, which indicates the distribution is approximately symmetric and has little volatility. The skewness of the control density curve is 1.6, which indicates the outliers highly skew the distribution. Having a greater skew, as is the case with the control group, exhibits that the **control group has more volatility in its energy usage.**

The predictability and volatility of building performance is represented in the spread of the data on the density curves, the number of outliers, and the probability of achieving energy savings. The control buildings experienced a more dramatic change between the average and median than the MoBIUS buildings, which led this research team to investigate outliers.

Using the Interquartile Rule to calculate the upper and lower bounds, it was determined that the MoBIUS annual percent change in energy consumption did not have outliers, whereas 15% of the control buildings were identified as outliers. The control group also had more buildings with annual percent change values further away from the median than MoBIUS buildings, which is explained by the wider interquartile range. This larger spread of data points in the control dataset depicts that year-over-year energy consumption is less consistent and less predictable than the MoBIUS dataset.

Figure 5 illustrates where the quartiles and bounds exist on the graph of the MoBIUS density curve, showing that no MoBIUS buildings experienced an annual change in energy usage outside of the upper and lower bounds. The interquartile range displays that 50% of the MoBIUS buildings achieved energy savings between 2.9% and 7.5%. By comparison, 50% of the control buildings experienced between a 1.2% increase and a 7.5% decrease in energy consumption. Therefore, there is greater volatility in the control group's energy consumption compared to the MoBIUS group.

Figure 5: Probability of Saving Energy With MoBIUS

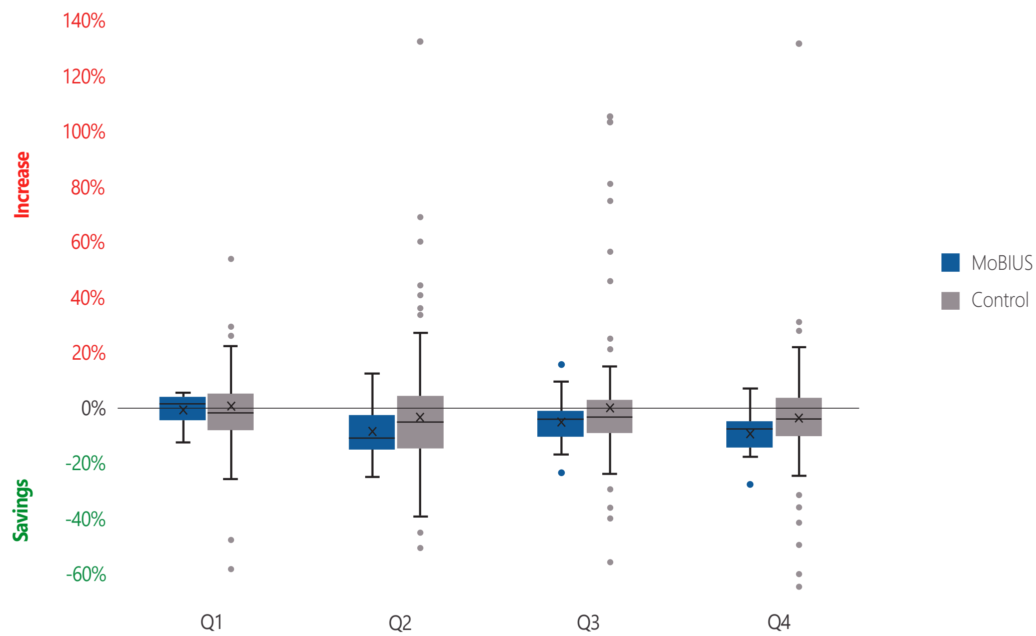


The density curves of the year-over-year percent change in energy consumption for the MoBIUS and control buildings also speak to the probability of achieving annual energy savings. In this study, **MoBIUS buildings were 63% more likely to achieve energy savings than the control buildings during the two-year time period**. Therefore, the data supports the hypothesis that MoBIUS reduces volatility associated with building energy performance.

Where energy consumption is volatile, costs are unpredictable. The data presents **significantly more predictability in the year-over-year change in energy consumption of MoBIUS buildings** compared to the control group, which can result in more consistent year-to-year costs.

The volatility of energy performance in the control buildings can be seen in **Figure 6 and Figure 2** (pg. 21). There are several outliers in the control dataset and a greater difference between the average and median percent energy usage change compared to the MoBIUS dataset.

Figure 6: Quaterly Percentage Energy Usage Change



MoBIUS saved energy more consistently throughout the year.

Without MoBIUS intervention, control buildings experienced an increase in year-over-year energy consumption more months of the year compared to MoBIUS buildings. For instance, 44% of the control buildings experienced at least six months where energy increased in 2019 compared to 2018, whereas only 13% of MoBIUS buildings experienced at least six months where energy increased.

Figure 3 and Figure 7 compare the average and median of the percent change in weather normalized energy usage from 2018 to 2019 for each month. These graphs also depict that **MoBIUS buildings consumed less energy, more consistently than the control buildings** in 2019 compared to 2018. Comparing the average energy usage change between the MoBIUS and control buildings for each month exemplifies that the MoBIUS buildings outperform the control buildings every month of the year. When comparing the median energy usage change between the two datasets, it illustrates that the MoBIUS buildings outperformed the control buildings eight out of 12 months of the year. MoBIUS produces greater year-over-year savings than the control buildings, and the service also improves energy performance throughout the majority of the year.

Figure 3: Average Energy Usage Change

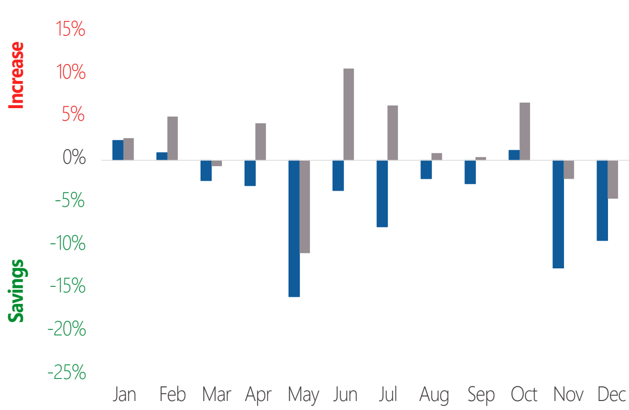
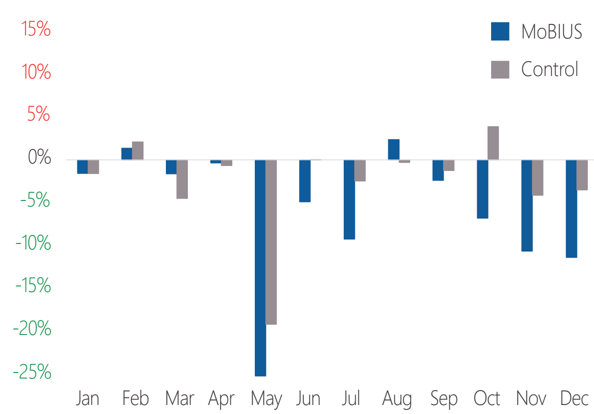


Figure 7: Median Energy Usage Change



MoBIUS saved energy across various building types.

The dataset was assessed in various configurations to identify any trends based on meter type, heating fuel type, and building use-type.

MoBIUS buildings showed **consistent and greater percent savings for both master-metered and sub-metered buildings compared to control buildings**. Sub-metered MoBIUS buildings typically experienced more considerable percent savings in the first year of MoBIUS engagement compared to master-metered MoBIUS buildings.

As displayed in **Figure 8 and Figure 9**, master-metered control buildings frequently performed more inefficiently than sub-metered control buildings. Additionally, there was a greater difference between the change in energy usage of master-metered MoBIUS and control buildings compared to the sub-metered buildings. As a result, it was concluded that master-metered buildings could benefit significantly from MoBIUS to prevent annual spikes in energy consumption.

Figure 8: Master-Metered Average Energy Usage Change

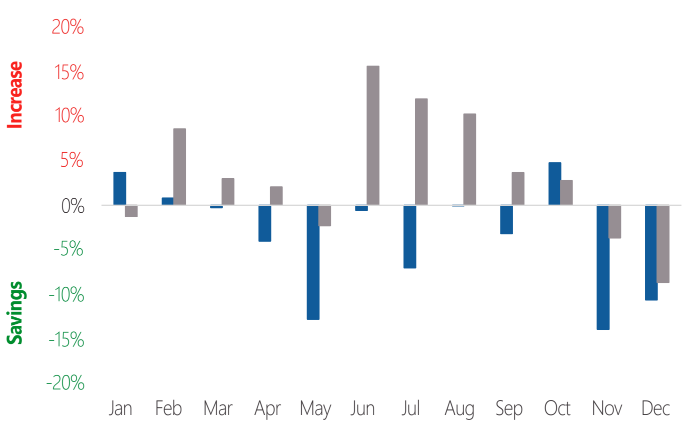
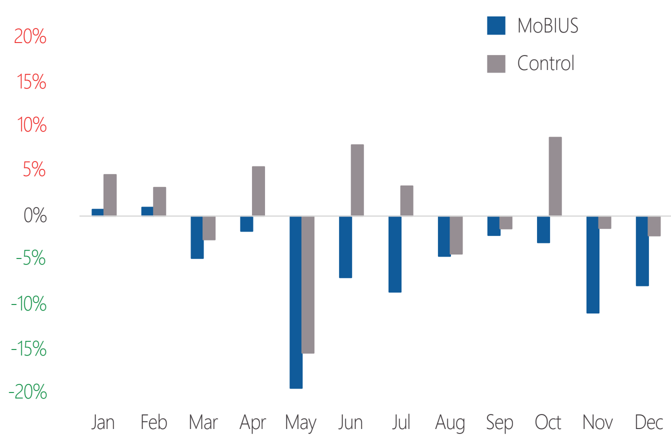


Figure 9: Sub-Metered Average Energy Usage Change



When evaluating by heating fuel type, the datasets show that **MoBIUS saved energy across all fuel types**, displayed in **Figure 10 and Figure 11**. Other conclusions are not reliably consistent due to the limited sample sizes for oil, electric, and steam fuel types.

Figure 10: MoBIUS Average Energy Usage Change by Heating Fuel

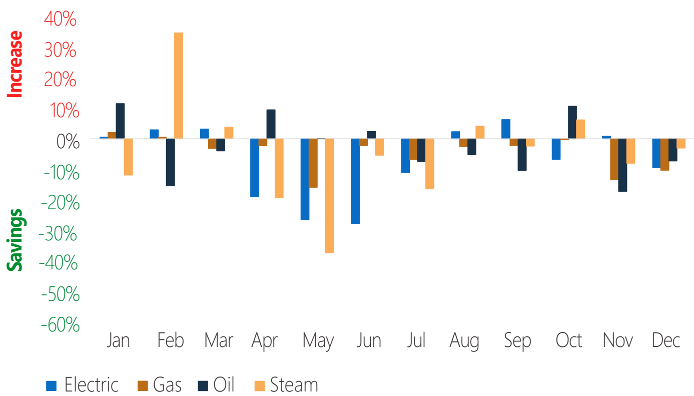
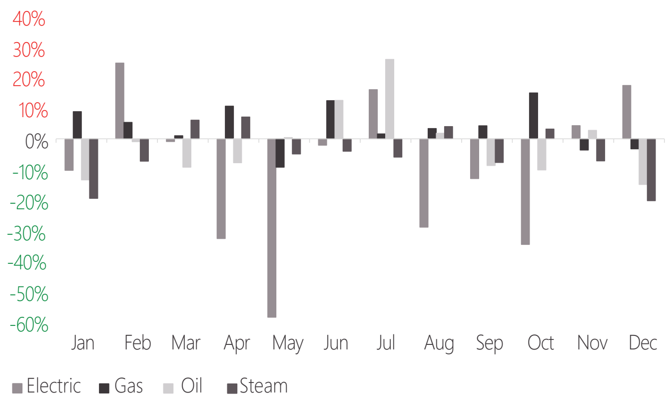


Figure 11: Control Average Energy Usage Change by Heating Fuel

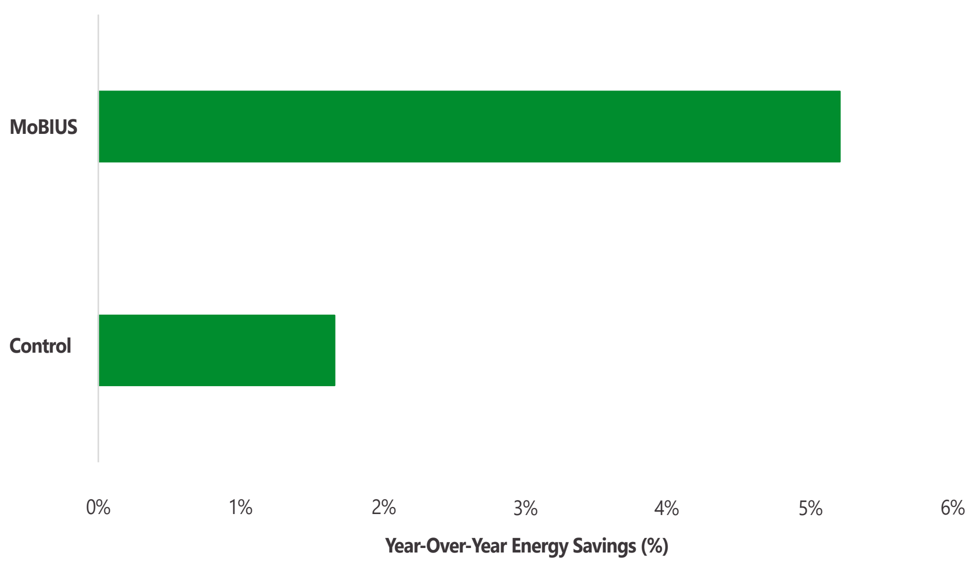


Multifamily buildings engaged with MoBIUS saved more energy.

The year-over-year percent energy savings of the multifamily and commercial buildings within each dataset were then analyzed to understand the savings for the two building use-types. As shown in **Figure 12**, **multifamily buildings with MoBIUS proved to save three times more energy on average** than multifamily buildings in the control group.

Due to the limited number of commercial buildings (two buildings) in the MoBIUS dataset, the sample size of commercial buildings was not large enough to draw statistically significant results. However, the commercial MoBIUS buildings did experience an average annual energy savings of 5%. The commercial control buildings experienced an average annual energy savings of 8%.

Figure 12: Multifamily Average Year-Over-Year Savings



CASE STUDY

Deeper Insight Into a Median MoBIUS Site

By looking at a median performing site that has been engaged with MoBIUS for three years—beyond the bounds of this study—we can see the impact MoBIUS has over time. MoBIUS intends to continue to improve the energy performance and deepen the energy savings potential each year as the MoBIUS team learns the site, equipment, and people that manage and operate the buildings.

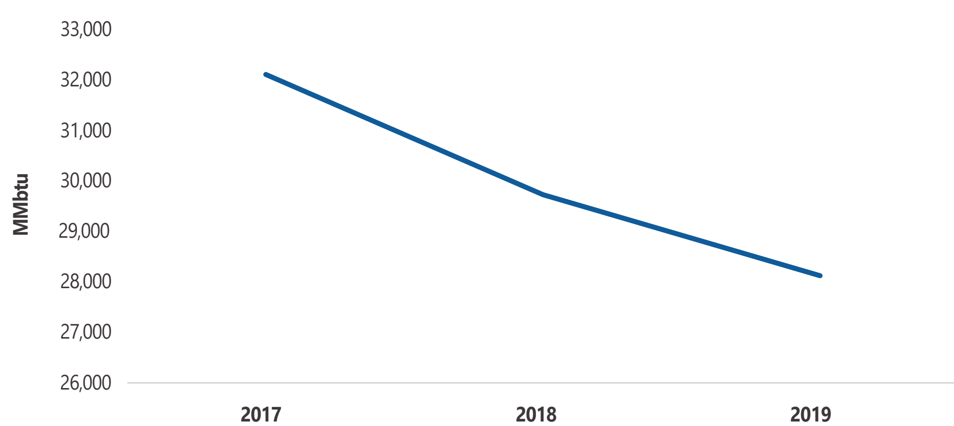
Figure 13 illustrates a 7.4% decrease in 2018, and a further 5.4% decrease in 2019, resulting in a **12.4% total decrease in energy consumption from 2017 to 2019**.

These savings were attained through multiple ongoing efforts, including:

- Optimizing equipment control set points.
- Training for on-site staff.
- Coordinating subcontractors and vendors.
- Retrofitting existing equipment and placing new equipment online.
- Continuous commissioning for large central plant systems.

It is worth noting that this building added additional energy-consuming equipment in 2019 that was previously not operational and was still able to maintain energy savings, thanks to MoBIUS.

Figure 13: Total Energy Consumption

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Data Characteristics

ENERGY USE INTENSITY PROFILES
BREAKDOWN BY DATA TYPE

Energy Use Intensity Profiles

The raw graphed data for this analysis, seen in **Figure 14 and Figure 15**, illustrate the two years of weather normalized energy consumption in British Thermal Unit (BTU) per square foot (SF), for both the MoBIUS and control buildings, to understand their energy intensities. The graphs show that the control buildings had a wider range of energy use intensities (EUI) than the MoBIUS buildings. However, the majority of the buildings in both datasets fell within a similar range of EUIs.

Figure 14: MoBIUS Monthly Energy Usage

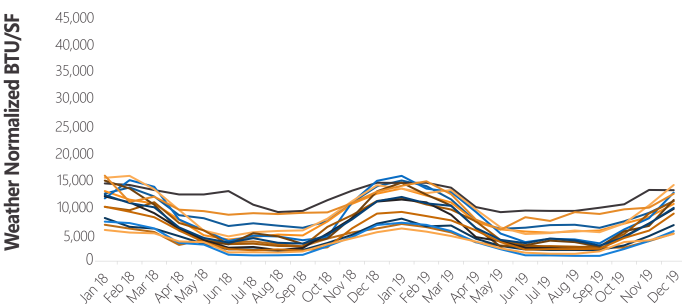
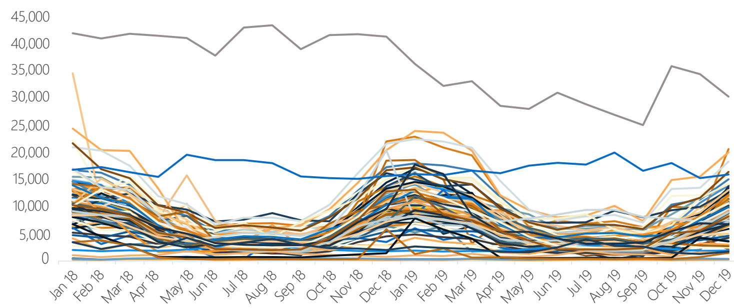


Figure 15: Control Monthly Energy Usage



Although the average square footage of the MoBIUS buildings is 2.4 times larger than the average size of the control buildings, the mean and median values of the two-year average EUIs are very similar, as seen in **Table 2**.

Table 2: Comparing Two-Year Average EUI

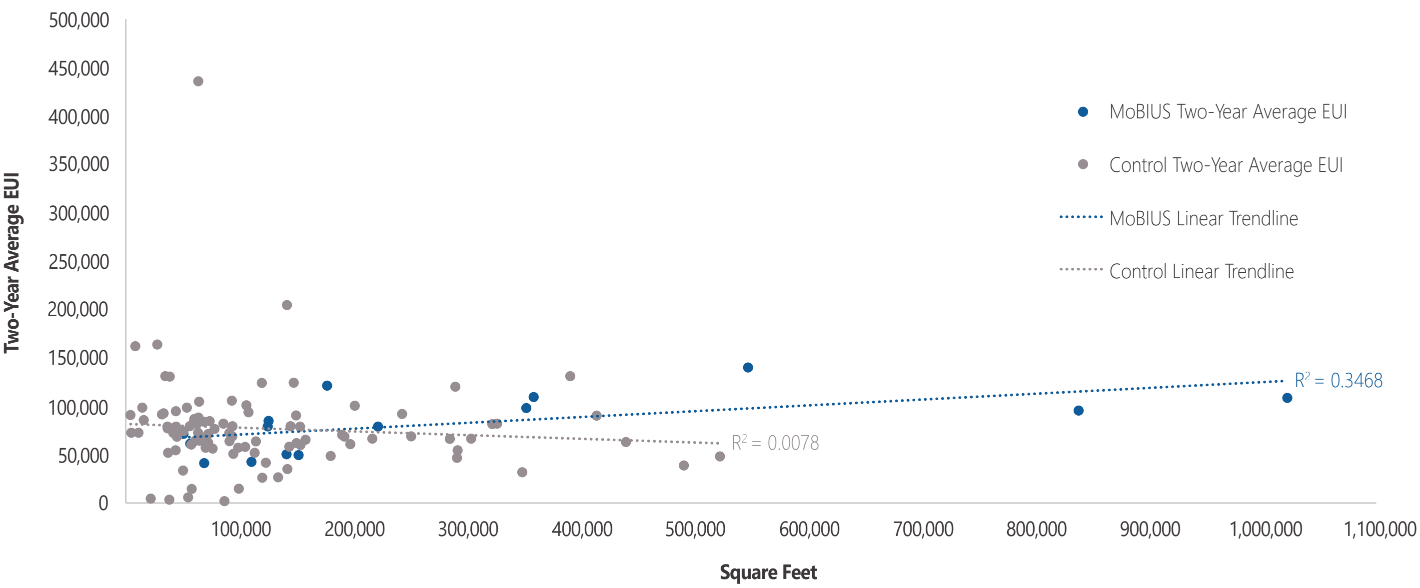
	MoBIUS	Control
Mean	**82,159**	77,011
Median	**79,074**	72,593

A building's EUI depends on its type and tenant usage.

"*Generally, a low EUI signifies good energy performance. However, certain property types will always use more energy than others.*"[1]

As displayed in **Figure 16**, low R-squared values convey there is no linear correlation between the square footage of the buildings and their energy use intensities. Therefore, the square footage of a building does not dictate its EUI.

Figure 16: Two-Year Average EUI



[1] *What is energy use intensity (EUI)? (n.d.). Retrieved from https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-energy*

Breakdown by Data Type

An analysis was performed on the buildings by their meter billing type, heating fuel type, and building use-type.

Meter Billing Type | Figures 8 and 9 (pg. 26) compare the average percent savings among the MoBIUS and control buildings by meter billing type. Bars above the x-axis indicate that energy consumption increased the following year, whereas bars below the x-axis mean that energy consumption decreased the following year. There were eight master-metered MoBIUS buildings, 35 master-metered control buildings, seven sub-metered MoBIUS buildings, and 65 sub-metered control buildings.

Heating Fuel Type | Figures 10 and 11 (pg. 27) display the average percent change in weather normalized energy usage by month from 2018 to 2019 for each heating fuel. The graphs have the same range on the y-axis to compare performance between the MoBIUS and control buildings. It is important to keep in mind the sample sizes because the majority of buildings in both datasets used gas as their heating fuel type.

Building Use-Type | The building use-type in both datasets were either multifamily or commercial. 14% of both datasets were commercial buildings. However, that meant that only two of the MoBIUS buildings were commercial buildings. The small sample size of commercial buildings in the MoBIUS dataset made it difficult to draw statistically significant results on the performance of commercial buildings. **Figure 12** (pg. 28) compares the average year-over-year percent energy savings between the multifamily MoBIUS and multifamily control buildings.

Methodology

MoBIUS DATASET
CONTROL DATASET
STATISTICAL METHODS
ASSUMPTIONS
CHALLENGES

To test the hypotheses, two datasets were compiled and compared using data available in EnergyScoreCards. The datasets consisted of energy usage data over a two-year period from 2018 to 2019 for 15 buildings that were actively engaged in Bright Power's MoBIUS service ("MoBIUS buildings") and 100 buildings that were not engaged in a real-time energy management service ("control buildings"). All buildings included in this report are located in New York City, which is the only location where MoBIUS was offered at the time of this research.

A randomized control trial (RCT) would be used to test this study's hypotheses, however data availability and completeness limited the ability to have a truly randomized control group. As a result, the control group consisted of both randomly selected buildings, as well as a set of more curated buildings with characteristics similar to the MoBIUS buildings included in the dataset. An unintended result of this selection approach was that 65 of the 100 control buildings were notably smaller and older than the MoBIUS buildings. Additionally, data availability and completeness limited the sample size of the MoBIUS dataset. Since Bright Power's MoBIUS service is relatively new, few buildings met the two years of data threshold to be included in the study.

The unintended dissimilarity of the control dataset compared with the MoBIUS dataset, combined with the small sample size of the MoBIUS dataset, limits how the study's conclusions can be applied (without further research). These limitations were taken into consideration while drawing conclusions for this study, specifically in regard to how volatility is interpreted.

MoBIUS Dataset

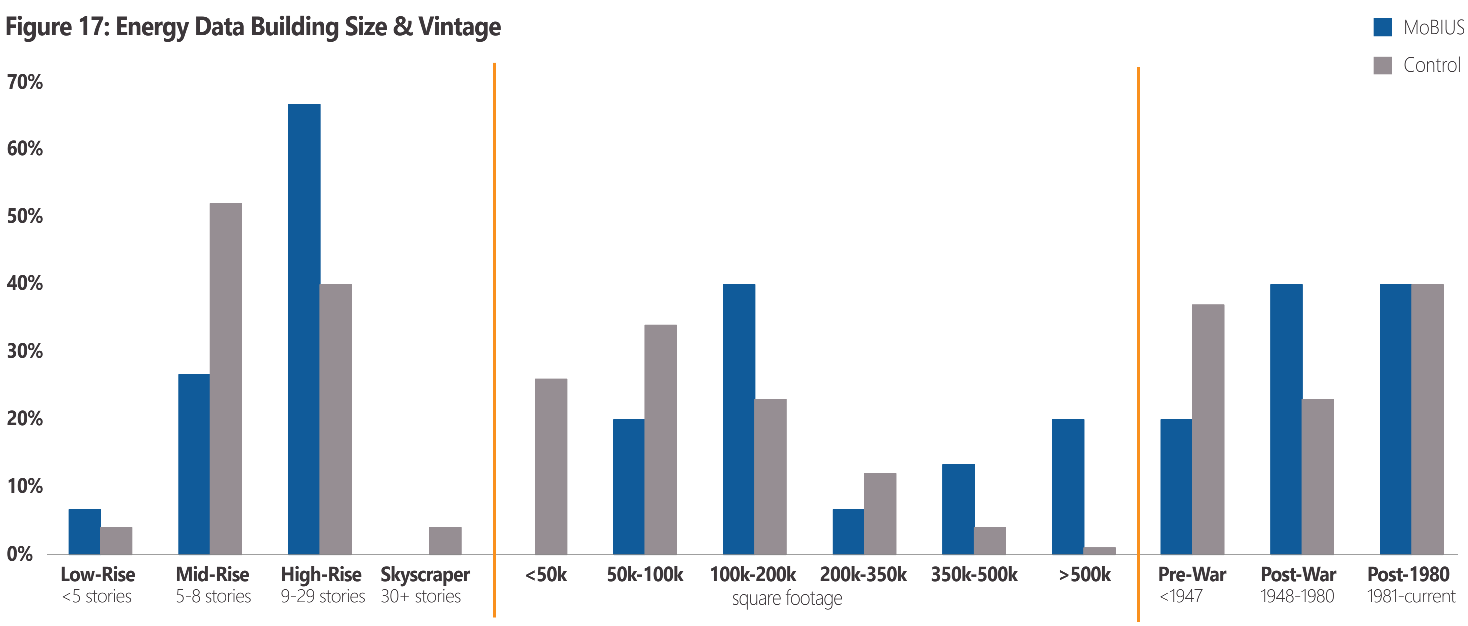
The MoBIUS dataset includes buildings that were engaged with Bright Power's MoBIUS service during at least 10 months of 2019 and where there were two years of complete energy data. Fifteen buildings met these criteria. Eight of those buildings were engaged with MoBIUS service during all or part of 2018. Of the 15 MoBIUS buildings in the dataset, two were commercial and 13 were multifamily buildings. The two commercial buildings in the MoBIUS dataset were higher education buildings.

Control Dataset

The control buildings were subscribed to Bright Power's EnergyScoreCards utility bill-based benchmarking service but had not undergone any major energy-targeted retrofits[2] by Bright Power during the 2018 or 2019 analysis period. The 100 control buildings were chosen using a selection process based on building characteristics only and not energy performance.

Figure 17 shows a visual comparison of the different building sizes and vintages that make up the MoBIUS and control datasets.

Figure 17: Energy Data Building Size & Vintage



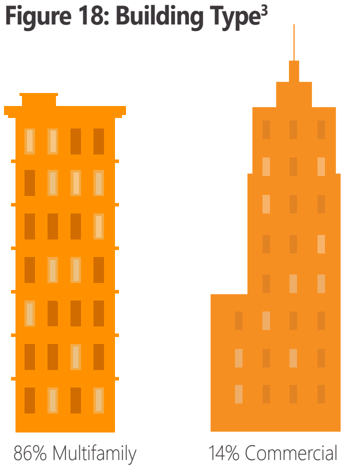
[2]*Major energy-targeted retrofits in this report are defined as projects with work scopes where Bright Power was engaged as the retrofit consultant, site manager, contractor, or as part of a capital intensive repair involving funding or financing incentives to reduce energy consumption at the building. This does not include capital projects in which an owner did not engage Bright Power, of which Bright Power was not aware, where retrofit work may have impacted energy performance.*

The selection process also ensured that a proportion of the control buildings had similar building characteristics to the MoBIUS buildings, including:

Site Type
Fuel Type
Meter Billing Type
Number of Stories
Decade Built
Building Use-Type

For each MoBIUS building (15), one control building was selected with the same five building characteristics listed above to create a one-to-one match. Twenty of the 100 control buildings had four out of five characteristics that matched MoBIUS buildings' characteristics. The remaining control buildings (65) were selected from Bright Power's New York City EnergyScoreCards database solely based upon whether they were multifamily or commercial to ensure the proportion of multifamily and commercial buildings in the control dataset matched the proportion of multifamily and commercial buildings in the MoBIUS dataset, as shown in **Figure 18**.

Figure 18: Building Type[3]



All of the commercial buildings in the MoBIUS dataset (two) were higher education buildings. Commercial buildings in the control dataset with similar use-types to the higher education buildings in the MoBIUS group were selected to ensure there were commercial control buildings that matched the five building characteristics of the higher education MoBIUS buildings. This selection method was intended to eliminate any possible biases from the EnergyScoreCards selection base while providing a similar control group to analyze and compare against the MoBIUS buildings.

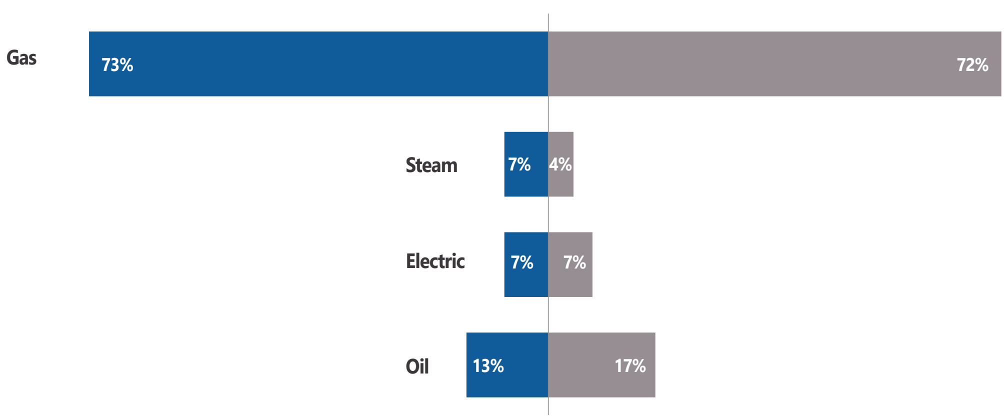
[3]This report provides analysis on both commercial and multifamily buildings. The graphics represent 100% of the buildings in this analysis, both MoBIUS and control building groups.

Figures 19 and 20 show visual comparison of the datasets based on meter type and heating fuel.

The control buildings had an average of 2% savings in 2019 compared to 2018. The data was selected from EnergyScoreCards and did create a selection bias, despite avoiding energy performance in our selection process. Buildings chosen in this analysis represent a group of properties that are actively tracking their energy usage, complying with Local Law 84, and may not accurately represent owners who are not complying with benchmarking laws or choosing to track their energy consumption. Therefore the 2% savings seen in this control group may, or may not, be attributed to the involvement with EnergyScoreCards and the owners' compliance with local policy.

Figure 19: Meter Type

Figure 20: Heating Fuel



Statistical Methods

After determining the MoBIUS and control datasets, each building's energy usage data from 2018 and 2019 were sourced from the EnergyScoreCards database.

The process of adjusting energy usage figures by accounting for, and then dividing the seasonal usage by the intensity of weather (HDD or CDD) allows for the normalization of energy usage data from different years. The weather normalized energy usage (in MMBtu) was calendarized monthly, broken out by heating and cooling consumption. The average baseload (non-seasonal energy usage) was calculated per year for this analysis.

This calculation takes into account which months are considered heating or cooling.

HEATING MONTHS

January–April & October–December

***Weather Normalized Energy Usage**: (Actual heating degree days / twenty-year-normalized heating degree days) × ([Total Kilowatt (Kw)/Therm/Gallon (Gal)]-[baseload])*

***Baseload Calculation**: Average the months of May–September each year.*

COOLING MONTHS

May–September

***Weather Normalized Energy Usage**: (Actual cooling degree days / twenty-year-normalized cooling degree days) × ([Total Kw/Therm/Gal]-[baseload])*

***Baseload Calculation**: Average the months of January–April plus October–December each year.*

Energy usage is assumed to be in units of BTU/SF/HDD for the heating season and BTU/SF/CDD for the cooling season. For all figures, unless noted otherwise, weather normalized energy usage is calculated as such: **BTU/SF/HDD for the heating season or BTU/SF/CDD for the cooling season**.

Eight control buildings, and no MoBIUS buildings, had the same heating and cooling fuel. For those eight buildings, the same methodology was applied, with the exception of assuming no baseload usage. Estimation was conducted on two control buildings to fill in missing energy usage data.

The **total heating and cooling energy usage** for each building was added to produce the building's total energy usage in MMBtu. Then it was converted to BTU. The square footage of each building was sourced from the EnergyScoreCards database. The total weather normalized energy usage was divided by the square footage of the building to understand each building's EUI.

Graphing the monthly weather normalized energy consumption (BTU/SF/HDD/CDD) **established a baseline to understand the amount of energy consumed normalized for size and weather**. The two-year average EUI of the buildings in both datasets were calculated. We compared the mean and the median of the two-year average EUIs to understand potential similarities and trends.

The difference in energy use for each building was compared against itself from 2018 to 2019 annually. The year-over-year change was also broken down for each month to compare energy performance during specific months. Since each building in both datasets has a different energy consumption profile, this research team decided to analyze by the percent change per building to properly compare the change between various buildings as compared to themselves. We calculated the percent change in energy consumption for each building to **compare a building's performance in 2018 to its performance in 2019 to determine savings**.

In order to analyze the **consistency of the savings** among MoBIUS and control buildings, we compared the number of months that experienced a decrease or increase in energy usage in 2019. We also looked for trends to determine if certain months achieved greater savings than other months and if those trends were related to the heating or cooling season.

To gain deeper insight into the performance of a MoBIUS building over a longer period of time, we examined the energy usage of a MoBIUS building in this study that had the median annual percent energy usage change. We identified the ongoing efforts that took place at the MoBIUS building and analyzed its energy usage from 2017-2019.

The performance of the MoBIUS and control buildings were also compared based upon building characteristics. Energy usage analysis was conducted on the **meter type**, **heating fuel type**, and **use-type of the buildings**. To analyze the impact of a building's meter billing type on building performance, the research team categorized buildings as master-metered or sub-metered. Master-metered refers to a building with one, or multiple, owner paid meter(s) associated with all tenant usage. Sub-metered refers to buildings where the utility company individually meters the tenant for their usage. The owner paid utility meter analyzed in this report would not include any tenant usage. The heating fuel was determined by the fuel code. If a building had more than one heating fuel, it was associated with the primary heating fuel indicated in its fuel code. The use-type of the buildings was either multifamily or commercial.

Density curves of the year-over-year percent change in energy consumption from 2018 to 2019 were developed to measure and compare the spread of data in the MoBIUS and the control building datasets. First, the year-over-year percent energy usage change from 2018 to 2019 was calculated for each building, then the mean, median, and standard deviation of those values were found.

The Normal Probability Density Function in Excel produced the values to be plotted to create the density curves. For this study's purposes, the Probability Density Function was also used to calculate the probability buildings achieved annual savings. In other words, the probability that each group of buildings experienced a negative annual energy usage change was found by calculating the area under the curve that is less than a 0% change in energy usage. The two resulting probabilities were compared to determine how much more likely it was for MoBIUS buildings to experience energy savings compared to the control buildings during the two-year time period.

In order to identify the best method to describe the spread of the data, we compared the symmetry of the MoBIUS and control density curves to determine how close they are to a normal distribution. The more symmetric the curve, the closer the distribution is to a normal distribution. Comparing the mean and median of the same dataset helped determine if the data's distribution was normal because, in a normal distribution, the mean and the median are the same.

The shape and skewness of the density curves also helped determine the symmetry of the distribution. The higher the skew implies more outliers are skewing the mean and standard deviation. When a distribution is skewed, **using the median and interquartile range is more robust** than using the mean and standard deviation to describe the data.

The interquartile range is a measure of variability that identifies which data points fall within the middle 50% of the dataset. The Interquartile Rule was used to identify outliers and understand the spread of the data. The spread of the data shows how much variation lies in the dataset. The percentage of outliers in the MoBIUS dataset was compared to the percentage of outliers in the control group. The spread of the data and the number of outliers speak to the **amount of volatility** in year-over-year energy consumption the control buildings experienced.

A box and whisker plot was developed to compare the year-over-year percent energy usage change by quarter of the MoBIUS and control buildings. The box and whisker plot displays the spread of the data for each quarter. A building in the control dataset that was identified as an extreme outlier was excluded from the box and whisker plot for scale and legibility. Further investigation into the utility bill history of the building’s oil account appears to show missing energy usage data. However, our data is reflective of what was listed on the utility bill provided by the owner. Missing oil usage data is not uncommon with oil accounts because it is submitted less frequently, and often irregularly, compared to other fuel accounts.

Assumptions

The following methods were used to quantify the impact of MoBIUS on buildings, and the authors believe these assumptions are defensible:

- Savings are assumed to be energy consumption savings unless stated otherwise.
- Buildings in the control group are assumed not to have conducted operational changes with outside vendors as consultants in 2018 or 2019, although it could include code compliance and repair work.
- In the energy consumption analysis, the weather normalized energy consumption is divided by the square footage to calculate the energy per square foot. There is an understanding that this is not a perfect normalization because a building can differ depending on the building's end-use. This report was only normalized by building square feet despite this since the sample selection was chosen from a largely multifamily use-type to align with the MoBIUS sample set.
- The following information about the buildings is retrieved from EnergyScoreCards and assumed to be accurate: site type, number of stories, fuel code, payment code, year built, and square footage.

Challenges

While we chose all available MoBIUS sites that met our criteria, we recognize the following challenges:

- Small data sample size for MoBIUS sites
- Lack of variety in heating fuel types across the sample sets
- Different sample sizes for meter types
- Limited date range to analyze due to MoBIUS service start date

Data Quality Limitations:

- The heating system distribution type data was not available for all control buildings.
- We only compared data over a two-year period. Ideally, we would like to expand our analysis to a four- or five-year study. This would allow us to see year-over-year trends. Since MoBIUS is a new program, we could not expand the date range of this report. In the case study analysis included in this report, MoBIUS sites continue to save year-over-year. This study could not make that comparison against the control group due to the limited time frame of analysis.
- Data gaps and overlaps existed in the original datasets, and were addressed through estimation (as described earlier in the report) or remedied by investigating utility bills.

Since oil bills include multiple months in one bill, some sites with oil were not entered into EnergyScoreCards when we first ran our analysis. They needed to be re-analyzed in April when the data was updated for the previous year's winter months. This issue highlights the importance of having a person, or team, dedicated to managing and tracking energy consumption for an organization so data can be accurately and reliably accounted for, reviewed, and analyzed.

Conclusions

KEY FINDINGS
FUTURE RESEARCH QUESTIONS

Key Findings

This research identified the potential for **deeper energy savings for buildings where the MoBIUS service is engaged** compared to the control dataset. The MoBIUS service provides owners real-time data on equipment performance with analysis *(Find)*, technical support for executing upgrades and control changes and onsite staff training *(Fix)*, and ongoing transparency on utility consumption *(Follow)*; embodying Bright Power's *Find, Fix, Follow* approach. The findings in this report have shown:

> **Buildings engaged in MoBIUS reduced their energy spend by an average 5.2% in 2019 versus 2018, saving twice as much as buildings not engaged in a real-time energy management service.**
>
> **Buildings engaged in MoBIUS were 63% more likely to achieve energy savings during the two-year period than the control buildings.**
>
> **MoBIUS buildings had less volatile energy use patterns throughout the year compared to the control buildings.**

This research focused on the change in usage between two years at a limited number of buildings in both datasets. It may not have fully captured the impact a continuous ongoing service, like MoBIUS, can provide a building owner over multiple years of engagement.

Additional research questions were identified to analyze further and understand the full impact MoBIUS has on buildings over time.

Future Research Questions

- How do MoBIUS buildings perform three (or five) years into a MoBIUS engagement compared to a control group over a three-year (or five-year) period?
- How do MoBIUS and control building performance compare with larger sample sizes of buildings with heating fuels that are not gas?
- How does the heating system distribution of the building impact energy usage over time?
- How does MoBIUS building performance and spending compare to control building performance in different geographic regions?
- How does the performance of MoBIUS buildings compare with a control group where larger datasets are broken down by the type of building based upon occupant usage and therefore have similar energy use intensities?
- Is there a correlation between master-metered buildings having higher energy use intensities? If so, are the BTU/SF savings for master-metered buildings significantly larger than the BTU/SF savings for sub-metered buildings?
- How does weather normalization impact the results for shoulder months?
- Questions to ask owners of control buildings in a survey to understand what, if any, efficiency improvements were conducted on the buildings:
    - How many small-scale retrofits were completed in 2018 and 2019?
    - How much money was invested in capital repairs in 2018 and 2019?
    - Were additional facility managers or additional internal operations personnel hired during the 2018-2019 time period?
    - Was the energy performance of the building a focus in 2018-2019?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Appendix

GLOSSARY
ACRONYMS

Glossary

Site Type: Explains the end-use of a building. In this instance, the site type would be one of two types: multifamily or commercial.

Master-Metered: A meter billing type for a building with one, or multiple, owner paid meter(s) associated with all tenant usage.

Sub-Metered: A meter billing type for a building that has individual meters for each tenant. The utility company directly meters individual tenants for their usage.

Fuel Codes: Indicates how a building is fueled.

> **Heating Fuel**: Indicates how a building's heating is fueled. For this research, buildings had at least one of the following fuels: oil, gas, electricity, or steam.
>
> **Cooling Fuel**: Indicates how a building's cooling is fueled. For this research, buildings had at least one of the following fuels: oil, gas, or electricity.

Payment Codes: Indicates how utilities are paid. For example, tenants may pay for their bills directly, a building owner may pay for utilities directly, or a building owner may pay for a utility and then bill their tenants for their energy or water consumption.

Multifamily Buildings: A building type that consists of multiple separate residential housing units within one building or complex. In this study, all multifamily sites consist of one building on the property.

Commercial Buildings: A building type that is used for commercial purposes only and does not have housing units. They may include educational buildings, warehouses, and retail buildings. In this study, all commercial sites consist of one building on the property.

Mean: The sum of a list of numbers, divided by the number of elements in the list.[4]

Median: "Middle value" of a list. The smallest number such that at least half the numbers in the list are no greater than it. If the list has an odd number of entries, the median is the middle entry in the list after sorting the list into increasing order. If the list has an even number of entries, the median is the smaller of the two middle numbers after sorting.[4]

Standard Deviation: The standard deviation of a set of numbers is the root-mean-square (rms) of the set of deviations between each element of the set and the mean of the set.[4]

Quartiles: There are 3 quartiles. The first or lower quartile (LQ) of a list is a number (not necessarily a number in the list) such that at least 1/4 of the numbers in the list are no larger than it, and at least 3/4 of the numbers in the list are no smaller than it. The second quartile is the median. The third or upper quartile (UQ) is a number such that at least 3/4 of the entries in the list are no larger than it, and at least 1/4 of the numbers in the list are no smaller than it.[4]

Interquartile Range: The interquartile range (IQR) of a list of numbers is the upper quartile minus the lower quartile.[4]

IQR = 3rd Quartile - 1st Quartile

Interquartile Rule: The Interquartile Rule uses the following equations to identify outliers outside the upper and lower bounds:

Upper bound = 3rd Quartile + (1.5×IQR)
Lower bound = 1st Quartile - (1.5×IQR)

Skewed Distribution: A distribution that is not symmetrical.[4]

If skewness is less than -1 or greater than 1, the distribution is highly skewed. If skewness is between -1 and -0.5 or between 0.5 and 1, the distribution is moderately skewed. If skewness is between -0.5 and 0.5, the distribution is approximately symmetric.

[4] *Glossary of Statistical Terms (n.d.). Retrieved from https://www.stat.berkeley.edu/~stark/SticiGui/Text/gloss.htm*

Probability Density Function: The chance that a continuous random variable is in any range of values can be calculated as the area under a curve over that range of values. The curve is the probability density function of the random variable. That is, if X is a continuous random variable, there is a function f(x) such that for every pair of numbers $a \leq b$,

$$P(a \leq X \leq b) = (\text{area under } f \text{ between } a \text{ and } b);$$

f is the probability density function of X. For example, the probability density function of a random variable with a standard normal distribution is the normal curve. Only continuous random variables have probability density functions.[5]

Energy Use Intensity: Energy Use Intensity (EUI) expresses a building's energy use as a function of its size or other characteristics. EUI is expressed as energy per square foot per year and is calculated by dividing the total energy consumed by the building in one year (typically measured by kBtu) by the total gross floor area of the building.

Weather Normalization: Weather normalization is the process of adjusting energy usage figures by eliminating the effect of weather so one can more accurately compare energy usage data from different years, or from different locations.

Randomized Control Trial: An experiment in which chance is deliberately introduced in assigning subjects to the treatment and control groups. For example, we could write an identifying number for each subject on a slip of paper, stir up the slips of paper, and draw slips without replacement until we have drawn half of them. The subjects identified on the slips drawn could then be assigned to treatment, and the rest to control. Randomizing the assignment tends to decrease confounding of the treatment effect with other factors, by making the treatment and control groups roughly comparable in all respects but the treatment.[5]

[5] *Glossary of Statistical Terms (n.d.). Retrieved from https://www.stat.berkeley.edu/~stark/SticiGui/Text/gloss.htm*

Acronyms

BTU: British Thermal Unit

CDD: Cooling Degree Day

EUI: Energy Use Intensity

Gal: Gallon

HDD: Heating Degree Day

IQR: Interquartile Range

kW: Kilowatt

MMBtu: Millions of British Thermal Units

RCT: Randomized Control Trial

SF: Square Feet

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Bright Power

Our mission is threefold. Increase the performance and value of buildings. Improve the comfort, health, and productivity of occupants. Eliminate negative impacts on the planet.

Since 2004, Bright Power has changed the built environment by dramatically reducing carbon emissions and improving building performance. From design to ribbon cutting, energy auditing to implementing improvements, and performance benchmarking to ensuring results, we deliver deep value to all stakeholders in real estate—owners, operators, investors, occupants, communities, and the planet that houses all of us.

We started by connecting the benefits of investing in solar and energy efficiency together. Then we simplified the process of making and evaluating investment decisions through the creation of a simple but rigorous analytics platform, EnergyScoreCards. We developed deep engineering expertise in how to make buildings better for occupants while lowering energy usage, both for existing buildings and new construction.

We learned about all the rebates, tax credits, and other financial incentives that improve the financial returns of our solutions. And when we realized that our customers didn't just want advice, they wanted action, we built a full turnkey construction operation to implement the solutions we recommend. Finally, since energy waste creeps back if no one is watching, we created an energy management service, **MoBIUS**, that brings our energy savings and troubleshooting expertise to your operations team.

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