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Evaluating Decarbonization Strategies in Commercial Real Estate: An Assessment of Efficiency Measures and Policy Impacts

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ABSTRACT

This paper presents a comprehensive decarbonization assessment for a commercial real estate property in the United States, analyzing various strategies to reduce energy consumption and greenhouse gas emissions. The study evaluates the effectiveness of energy efficiency measures, renewable energy technologies, and policy frameworks, highlighting the importance of a multi-tiered approach to decarbonization. Key findings include the need for a long-term vision, stable policies, and innovative financing solutions to overcome barriers and achieve significant emissions reductions. The financial analysis reveals a compelling case for adopting decarbonization strategies, considering both short-term costs and long-term benefits. The paper advocates for a forward-thinking approach to align immediate actions with broader environmental goals, enhancing the commercial real estate industry's value proposition and contributing to a sustainable energy future.

Keywords: Decarbonization; Commercial real estate; Sustainability; Energy efficiency; Renewable energy; Technological advancements; Policy frameworks; Incentives; Barriers to adoption; Strategic planning

1. Introduction

The commercial real estate sector is discerning its pivotal role in abating climate change and is thus adopting aggressive decarbonization strategies. This paper provides an analysis of a comprehensive decarbonization assessment that concentrates on an American commercial property's transition towards energy efficiency and environmental stewardship. Situating itself within the larger context of sustainability initiatives, this assessment lays out a multi-tiered approach for the commercial real estate sector, encompassing the adoption of advanced building performance standards and the integration of renewable energy technologies. The study evaluates the property's energy consumption and greenhouse gas emissions, offering a roadmap for implementing efficiency upgrades, such as state-of-the-art hvac systems and electrification of energy sources. It also forecasts the economic ramifications of adherence to existing and probable regulatory regimes, underscoring the cost-benefit dynamics of retrofitting initiatives versus potential penalties under carbon pricing frameworks. The paper's detailed insights into an American commercial real estate's decarbonization trajectory provide a scalable template for energy policy, financial analysis, and corporate governance in the broader real estate industry, contributing to the discourse on global efforts to cultivate a more sustainable future.

2. Literature Review

While the global average increase in carbon emissions from commercial building operations has been moderate, substantial variations exist between countries. Some nations, such as the United States, have experienced a decline, while others, like China, have seen a sharp rise. Economic growth particularly in the service sector, has been a significant driver of increased carbon emissions, indicating a direct impact of economic activity on the carbon footprint of commercial buildings. However, countries exhibit varying levels of decarbonization efficiency, with most falling below 10%. Spain stands out with an impressive average efficiency of nearly 30%, showcasing exemplary decarbonization practices. Specific factors, including carbon intensity per unit area and per GDP, GDP growth, and population growth, influence the emissions profiles of commercial buildings. A decline in carbon emissions in some countries suggests a decoupling effect, where economic growth in the service industry no longer necessarily leads to increased carbon emissions, thanks to technological advancements and efficiency improvements. Prioritizing energy efficiency and transitioning to clean energy sources can help reduce carbon emissions. Accelerated efforts and effective policy implementation worldwide are necessary to achieve meaningful decarbonization[1].

The integration of sustainable building practices in the commercial real estate sector, through certification systems such as Energy Star and LEED, has resulted in measurable financial benefits, as evidenced by buildings with such certifications commanding higher rental rates compared to non-certified buildings[2]. Furthermore, efforts to decarbonize the real estate sector, as part of a broader climate change mitigation strategy, have become increasingly critical. The real estate industry is a significant contributor to energy consumption and GHG emissions; therefore, adopting energy efficiency measures and renewable energy sources is essential for meeting global decarbonization goals. The Carbon Risk Real Estate Monitor project, supported by the EU's Horizon 2020, is an illustration of an initiative aiming to develop tools for assessing carbon risks and facilitating the transition to a low carbon building stock, recognizing the tangible downside risks of climate change on property values and the necessity for proactive mitigation efforts[3].

In the commercial sector, Combined Heat and Power systems represent a strategic technology for decarbonization, offering considerable energy efficiency improvements and cost savings. Despite their initial economic attractiveness, the long-term decarbonization impact of CHP installations may lessen as electricity grids incorporate more renewable sources. The challenge for the commercial industry lies in balancing these immediate financial incentives with the diminishing environmental returns of CHP systems over time, in the face of evolving energy policies aimed at grid decarbonization. This necessitates careful consideration of investment strategies within the commercial real estate market to ensure alignment with both economic performance and sustainability objective[4]. Building performance standards and energy efficiency incentives can transform the design, construction, and operation of commercial real estate, reducing the sector's environmental impact. Carbon pricing, including mechanisms like carbon taxes or emissions trading, motivate businesses to lower their carbon emissions by incorporating the cost of environmental impact into their financial structures. Such frameworks could push for more significant adoption of sustainable energy sources and encourage investments in climate-friendly technologies across commercial operations. These strategies align with the wider goal of commercially driven decarbonization, which seeks not only to mitigate climate change but also to gain economic advantages through improved business practices and positioning in a low-carbon future[5].

In the context of the commercial sector, which also grapples with the need for decarbonization, strategies like those in transportation can be applied. The adoption of renewable energy, energy efficiency improvements, and technological innovation are pivotal. Utilizing green energy sources like solar or wind power, investing in smart building technologies to optimize energy use, and exploring innovative solutions such as green hydrogen for power and heating are examples of potential parallels. Additionally, carbon emissions in commercial real estate are influenced by building design, materials, and operational practices. Just as in transportation, a combination of policy incentives and economic mechanisms could be employed to encourage sustainable investment and development. The commercial sector also faces the challenge of varying emission footprints, which can be managed through tailored approaches to building management and the integration of sustainable practices across construction, maintenance, and occupancy phases[6].

In the maritime sector, the European Union's decarbonization initiatives closely parallel the commercial real estate industry's efforts, where regulatory pressures, market-based, and goal-based measures are steering both towards sustainability. Financial implications such as the need for investment in clean technology and infrastructure, as well as the consideration of carbon trading schemes, are common to both. Just as shipping is incentivized to increase efficiency or risk asset stranding, real estate faces depreciating values for buildings that fail to meet new energy standards. The move towards renewable energy, whether in new ship propulsion methods or in 'nearly-zero-energy' buildings, underscores a broader, industry-wide shift to reduce carbon footprints and align with the EU's stringent climate objectives[7].

3. Methodology

This assessment employs a rigorous methodological framework to analyze the decarbonization strategies for a commercial real estate property located in United States. The methodology encompasses a multiphase approach, beginning with collecting and processing historical energy consumption and greenhouse gas emissions data from the property over specified reporting periods. Primary data, including estimated direct and indirect emissions figures, were compiled and contextualized within the broader trends in energy usage and efficiency benchmarks. The assessment methodology also compared the property's performance against established building performance standards across various states and local jurisdictions to determine compliance and potential fines for non-compliance post-2030

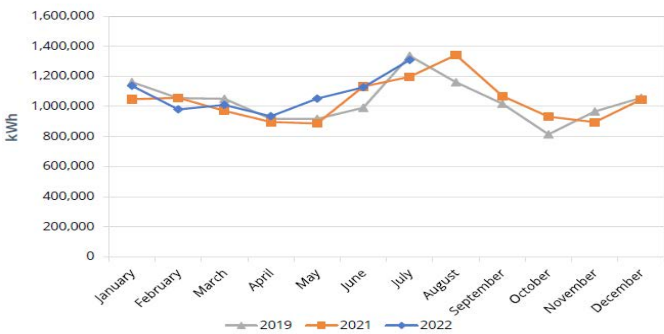

Figure 1: Electricity consumption pattern.

As shown in (**Figure 1**) electricity usage increases over the summer months when the cooling load increases, and the chiller energy use goes up. Electricity usage in the winter is also higher due to the electric heating in the fan coil units

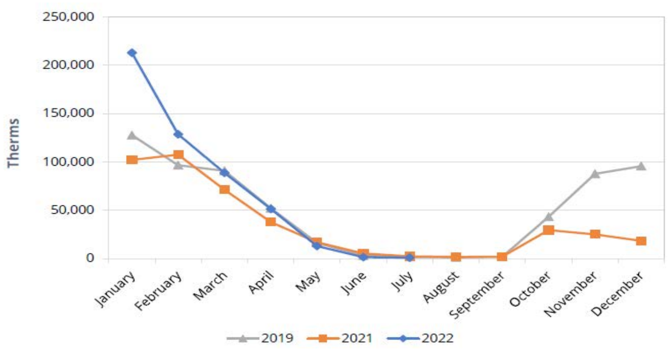

Figure 2: Gas consumption pattern.

As shown in (**Figure 2**) it is expected, natural gas usage is highest over the winter for heating. The base load of natural gas usage includes domestic water heating, kitchen cooking, and kitchen domestic water heating. It is unclear why January 2022 showed higher natural gas consumption than the previous two years. Additional investigation is required. The tenants' gas usage is estimated in this report from CBECS (Commercial Building Energy Consumption Survey) 2018 published data for mercantile buildings[8]. Buildings in the mercantile category use 35.7 cubic feet of natural gas per square foot. Tenant gas use was estimated using the CBECS total minus the known gas use for the center. The estimated tenants' gas usage in therms is 156,918 for the 2019 calendar year. Based on this usage, emissions are calculated as shown in (**Figure 3, Table4**) and (**Table 1**).

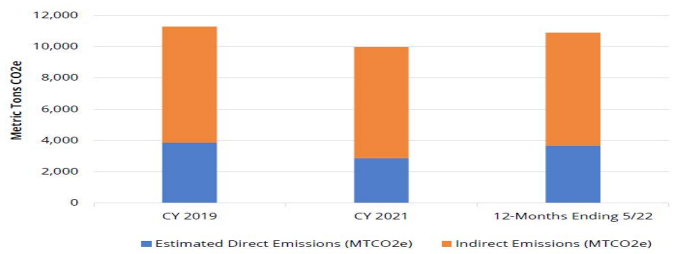

Figure 3: Carbon Emissions from building energy use.

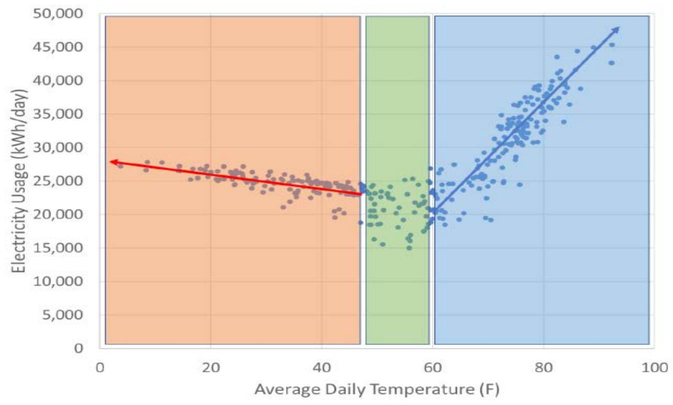

Figure 4: Energy usage in relation to temperature.

Analytical models were used to evaluate the effectiveness of implemented and proposed energy reduction measures, such as the installation of modern chillers and LED lighting, alongside the operational optimization of energy plants. The mid- and long-term impact of these measures on the property's carbon footprint was forecasted, considering both current and future emissions factors for the local grid, with reference to regional clean energy initiatives. (**Figure 4**) shows daily electric energy usage plotted against daily temperature for the largest of the base building electricity accounts with utility company. A few observations are listed below:

- The heating and cooling sequence of operation as reported by the facility staff is validated that heating primarily takes place below 47°F and cooling started at 60°F.
- Electricity usage related to heating increases as temperatures decrease signifying some combination of electric heat, increased pumping energy, and additional HVAC fan runtime.

The profile is largely flat between 48°F to 58°F when the chiller and boiler plants are both off. Smaller standalone systems may still be heating and cooling when the central plant is off. The Figure 4 illustrates baseline energy consumption approximately 20,000 kWh per day for conditions where neither of the plants are activated. There is a strong correlation between warmer days and increased energy consumption for Outside Air Temperature greater than 60°F. Furthermore, there is a strong correlation of cooler days corresponding to increased energy consumption; however, the slope of this line is less than the cooling data and this could indicate the presence of some electrical space heating although the primary fuel source for heating is natural gas consumed in the boiler plant.

Table1: Emissions summary.

REPORTING PERIOD	ESTIMATED DIRECT EMISSIONS (MTCO2E)	INDIRECT EMISSIONS (MTCO2E)	TOTAL EMISSIONS (MTCO2E)
CY 2019	3867	7412	11279
CY 2021	2877	7096	9974
12-Months Ending 5/22	3673	7220	10894

Table 2: List of energy conservation measures (ecms) recommended.

PROPOSED YEAR	PROJECT DESCRIPTION	IMPLEMENTATION COST	ENERGY COST SAVINGS ($/YEAR)	SIMPLE PAYBACK (YEARS)	EQUIVALENT CO2 REDUCTION
2021-22	Previously Completed Efforts	--	-	--	386
2023	Retro-Commissioning	$200,000	$67,100	1.9	364.1
2024	Monitoring-Based Commissioning	$44,000	$33,200	1.1	179.6
2025	Condensing Natural Gas Boilers	$55,000	$82,460	0.7	665
2026	Efficient Chiller Replacement	$240,000	$28,400	6.7	135.8
2028	PHASE 1: Rooftop Photovoltaic Array	$8,120,000	$433,750	10.3	2,076.20
2029	Domestic Hot Water Upgrades	$1,900	$30	46.7	0.8
2031	Tenant HVAC Improvements	-	...	---	999.6
2035	Central Heating Plant Electrification	$2,000,000	($34,160)	NA	322.8
2040	PHASE 2: Campus Photovoltaic Array Expansion	$24,230,000	$1,000,000	13.6	4,784.40
2045	Transformational Technology	---	---	---	1,365.00
	TOTALS	$34,890,900	$1,610,780	21.7	11,279.20

Building upon the energy consumption and emissions data, ECMs were recommended to reach the decarbonization target as show in (**Table 2**). The study further integrated policy analysis, examining the potential influence of legislative actions on decarbonization pathways. The methodological focus expanded to include the exploration of capital-intensive recommendations, such as photovoltaic array installation and transformational technology investments, projecting their implications for emission reductions and financial viability.

Emerging technologies were assessed for their suitability for retrofit projects, and best-practice methodologies were outlined for incorporation into the property's long-term decarbonization strategy. In synthesizing these diverse methodological elements, the study not only emphasized energy efficiency and emissions reduction but also considered the financial and strategic dimensions of ensuring compliance with evolving regulatory landscapes in the context of North American commercial real estate. Figure 5 shows the projected reduction in emissions as the ECMs will be implemented

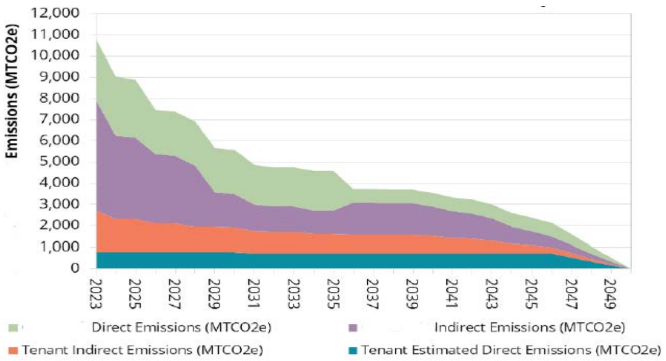

Figure 5: Carbon Emissions Reduction.

In conclusion, this multi-faceted methodological approach facilitated a nuanced understanding of the property's current carbon risks and provided a robust decarbonization roadmap aligned with science-based targets, anticipating future regulatory requirements and market expectations within the commercial real estate sector.

4. Grid Decarbonization

A key component of the decarbonization roadmap is the expectation that the utility grid will become cleaner over time, resulting in fewer carbon emissions for electricity use. There are several drivers for the reduction in carbon emissions:

• Market-based drivers as renewable energy sources are competitive with conventional methods of power production over their lifetimes.

• Consumer demand for clean power as part of their own policies for prevention of climate change and reduction of pollution.

US DOE's National Renewable Energy Laboratory (NREL) provided modeling as part of the Cambium analysis to predict the emissions rates of the US utility grid by state into the future[9].

This paper is using the "Mid" case for analysis here, although an aggressive approach can be used. "Mid" case analysis means that the central estimates for inputs such as technology costs, fuel prices, and demand growth with no nascent technologies are considered while predicting the emission statistics. Electric sector policies as they existed in September 2022 are considered in the analysis. Tax credits (IRA's PTC and ITC) are assumed to start phasing out in 2038.

Additionally, Federal Inflation Reduction Act (IRA) promotes efficiency of buildings and implementation of solar energy using tax credits and tax deductions.

If the site proceeded with Business as Usual (BAU) and the only change was the emissions rate of the electricity grid, there would be a resulting drop in emissions of 64% by 2050 for electricity consumption. Figure 6 shows the decline in emissions rate over time based on the "Mid" case in Cambium[9]. Overall, this would result in a 45%reduction in emissions since the fossil fuel emissions rate remains the same. Therefore, it is necessary to enact energy saving projects to achieve a higher reduction in carbon emissions to approach or achieve net zero.

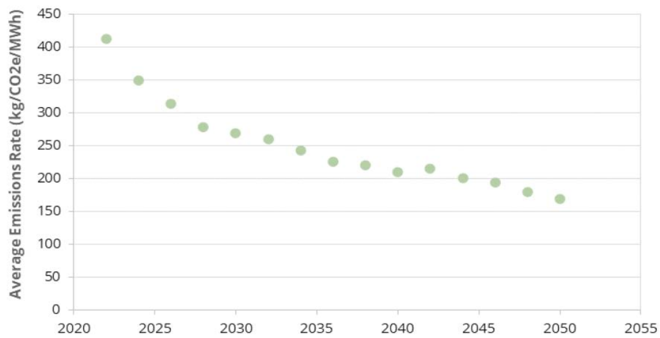

Figure 6: NREL Cambium Emissions Data[9].

Using the estimated 11,279 metric tons of carbon emissions for calendar year 2019 as the basis the social cost related to those emissions is $503,423 per year. The social cost of carbon is $16.50/MWH for this calculation.

The social cost of carbon (SCC) is an estimate in dollars of the economic damage that would result from emitting one (1) additional ton of carbon dioxide into the atmosphere. The SCC puts the effects of climate change into economic terms to help policymakers and other decisionmakers understand the economic impacts of decisions that would increase or decrease emissions. The SCC is currently used by local, state, and federal governments to inform billions of dollars of policy and investment decisions in the United States and abroad.

5. Incentives

Incentives shown in project economics are estimates and are subject to change based upon utility programs and final decisions on specific projects. New incentives may be available based on the legislative act passed in the state which will encourage electrification and installation of renewable energy. The property may also take advantage of Inflation Reduction Act provisions that provide tax deductions for energy efficiency projects. The tax incentives are also being finalized in how the benefit may be claimed. Under the recently passed Inflation Reduction Act (IRA), the IRS 179D program for energy efficiency retrofits allows existing buildings to pursue a tax deduction by reducing energy use by up to 50%. These deductions were increased to Maximum deduction of $5.00 per sq ft, from the prior deduction of $1.80 per sq ft. The amount of the deduction depends on the mix of ECMs implemented and the per cent energy reduction obtained. 25% reduction in energy use is the lowest level of performance at the bottom of the scale.

The renewable energy projects are also eligible for significant tax credits of up to 50% under the incentives outlined in the IRA. The level of tax credit is based on project location as well as several factors regarding the labor rates and source of materials used. 30% to 40% of project cost may be likely for this property under this section of the IRA.

6. Discussion

Assessments of various decarbonization strategies indicate that specific measures, such as improving HVAC efficiency or enhancing building insulation, yield immediate impacts and favorable returns on investment. However, these can be capital-intensive, and a clear view of their long-term benefits is crucial. The report infers that a blend of immediate and long-term investments, including the adoption of renewable energy, can lead to substantial emission reductions and additional benefits like increased asset value and occupant comfort.

Policy instruments and incentives act as catalysts or barriers for commercial real estate decarbonization. While building performance standards set ambitious decarbonization targets, the reliability of incentives can affect financial planning. Stable policies and long-term incentives are necessary to ensure a relentless progression toward emission reduction goals, giving stakeholders the confidence to invest.

The potential of technological advancements to create smarter, more efficient buildings is undeniable, yet barriers such as cost and integration challenges persist. Overcoming these barriers may require policy support, innovative financing solutions, and industry-wide knowledge sharing. Financial implications are central to decarbonization discussions in the commercial real estate sector. An evaluation of the costs associated with retrofitting buildings versus the long-term operational savings is pivotal, especially given the uncertainties surrounding energy prices and regulatory compliance penalties. A robust risk analysis should consider the total lifecycle costs of decarbonization projects, helping stakeholders balance upfront investments with anticipated long-term benefits.

Strategic planning for decarbonization involves aligning immediate actions with a long-term vision that goes beyond ad-hoc updates to embrace systemic changes. This strategy is vital for building resilience, attracting environmentally conscious tenants and investors, and maintaining competitiveness in a dynamic market.

7. Conclusion

This Decarbonization Assessment provides a valuable case study for the commercial real estate sector in North America, showcasing a holistic approach to reducing carbon emissions through various energy efficiency and renewable energy strategies. The analysis gives a comprehensive view of the necessity for commercial real estate stakeholders to navigate the complexities of decarbonization while respecting economic, technological, and regulatory landscapes.

Key takeaways from the assessment underscore the importance of integrating immediate and scalable long-term decarbonization measures, emphasizing the role of innovative technologies and building retrofits in achieving significant emissions reductions. Additionally, the analysis highlights the critical influence of stable policy frameworks and the availability of incentives that are essential to fostering a conducive environment for commercial real estate stakeholders to make substantive investments in sustainability initiatives. The financial analysis reveals that while the upfront costs of implementing decarbonization strategies can be substantial, the long-term benefits-which include lower operational costs, compliance with stringent regulations, and avoidance of potential fines-provide a compelling case for their adoption. It also illustrates the need for commercial real estate owners to conduct thorough risk assessments and to engage in proactive financial planning to evaluate the full life-cycle cost and return on sustainability investments.

Strategic planning emerges as a fundamental component in the transition toward a low-carbon economy within the commercial real estate sector. The assessment advocates for a forward-thinking approach that aligns with broader environmental goals, ensuring that immediate actions contribute to a resilient, competitive, and sustainable future.

The conclusion calls upon commercial real estate stakeholders not only to consider the insights from this specific property's decarbonization assessment but to view it as a scalable template that can be adapted for wider application across the sector. The trajectory towards a sustainable energy future is not only a response to climate imperatives but also an opportunity to enhance the value proposition of the commercial real estate industry. This path requires a collaborative effort, in which transparency, innovation, and responsible investment practices converge to transform the built environment.

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