Research Article

Improving Foundational Understanding regarding Facility Transition through a Survey Assessment of Industry Professionals involved in Commercial Building Decommissioning

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ABSTRACT

Commercial buildings are asset intensive facilities and therefore have unique challenges in the asset lifecycle management. When procedures and guidelines on decommissioning are not enforced, these buildings can be left unattended for years. As a result, the lack of maintenance may expedite asset deterioration, thus leaving less material salvageable for future use. This study aims to better understand current trends in the decommissioning of commercial buildings by surveying industry professionals across three possible dimensions 1) planned decommissioning, 2) condition assessments on commercial buildings, and 3) current awareness of procedures and guidelines. Through correlation analysis, the study explores how professionals' roles in the industry relate to these three dimensions, offering valuable insights into the dynamic interplay shaping decommissioning practices. This study analyzes data collected through a Qualtrics survey designed to target construction and facilities management professionals. The 720 respondents were associated with the International Facilities Management Association and the American Institute of Architects. Results of the study show that planning for decommissioning mostly occurs once a building has been vacated or due to reactionary planning in an attempt to save a facility for reuse or remodeling. There is a consensus among the survey respondents that condition assessments on unoccupied/vacated buildings should be conducted annually. Results also indicate that although there are instances where vacated facilities maintained a minimal supply of utilities, there are many instances where facilities have had lights switched off, doors locked, and the building completely shut down. This study provides results that identify key variables as to what may influence how a building is decommissioned and promote standardized decommissioning procedures and guidelines for commercial buildings.

Keywords: Decommissioning; Condition assessments; Cold hold shutdown; Warm hold shutdown; Commercial buildings; Decommissioning procedures

1. INTRODUCTION

A lack of consistent guidelines on decommissioning can leave buildings vacant for extended periods at the end of their useful life. These buildings may experience accelerated deterioration due to a lack of proper upkeep, which would leave less material salvageable for future use. Although the option to leave the building vacant for extended periods may be less expensive and procedurally less complicated, it is not always legal, safe, or cost-effective. Fire protection systems are often not operational, leaving the building vulnerable to fire hazards. When electricity is neglected and/or shutdown, lighting becomes unavailable, leaving fall and structural hazards a risk to unauthorized occupants. Over time any asbestos or lead in the facility will deteriorate (Glazerman, 1987; Young-Corbett, 2012), increasing the risk of future remediation, which can be expensive. Temporary fences around the facility assist in preventing people from trespassing on the building site, but these are not infallible and safety hazards can remain. Ideally, once the doors are closed, and the structure is vacated, it is prudent for facility managers and property owners to assess the remaining structures and utilities, determine security needs, and maintain the site to pre-decommissioning standards (Laraia, 2018).

Peters (2020) defines decommissioning as "the process of shutting down a building and/or removing it from operation or use". Decommissioning can also be defined as an orderly shutdown or removal of the building's systems to prepare the building for long-term dormancy, termed "mothballing" (Osterberg, 2022; Kesling & Johnson, 2006). For years, commercial building owners have largely considered problems associated with the design, operation, and maintenance of their buildings and the consideration of the treatment of redundant structures has been limited to the end of life. One of the consequences of this lack of prior planning for the decommissioning stage has been the relatively high number of facilities left in a semi-abandoned state for numerous years at the end of the service phase of a facility (Bailey & Galecka, 2018).

A comprehensive decommissioning plan with guidance from consultants makes a complicated, arduous shutdown process manageable and protects workers, nearby residents, and the environment. Decommissioning guidelines and procedures also ensure that the closure of a facility or operation can be completed in a way that will allow facility managers to make the best possible choice for the facility's future. As such, decommissioning is a by-product of proper prior planning, following a set of guidelines and procedures, and a continued assessment of the building's condition once vacated (Gallant & Bickle, 2005).

The **purpose of the research** discussed herein is to investigate the current state of decommissioning practices and identify the following:

- Professions involved in building decommissioning.
- Whether decommissioning of commercial buildings is currently planned or unplanned and whether it *should* be a part of an organization's long-term facility plan.
- Professionals' familiarity with warm and cold hold decommissioning scenarios.
- Whether condition assessments should be part of the decommissioning process.
- Professionals' awareness of decommissioning guidelines used in other industries/specific states and whether these should be part of guidelines for decommissioning commercial buildings.

In this study, built environment professionals are asked to complete a survey spanning three dimensions that address the topic of decommissioning: 1) planned decommissioning and professionals involved, 2) condition assessments on commercial buildings, and 3) current awareness of available procedures and guidelines. This research defines commercial buildings as buildings where commercial activities occur, and include government and privately-owned office buildings, retail properties such as shopping centers and malls, and industrial properties such as warehouses and manufacturing facilities (Cushman-Roisin & Cremonini, 2021).

2. LITERATURE REVIEW

It is typical for commercial building owners to primarily consider decisions associated with building design, operation, and maintenance. Consideration regarding the treatment of structures that are no longer needed or occupied has been limited to the end of life (Gladu, 2004). One of the consequences of this lack of attention during the planning stage is that, at the end of the service phase of a facility, there have been a relatively high number of facilities left in a semi-abandoned state for many years (Laraia, 2018).

When a company resolves to vacate a building, its owners may realize that shutting down is almost as complicated as construction (Bailey & Galecka, 2008). Proper decommissioning of facilities or even parts of a facility is vital to the overall success of an organization's strategic plans for the property. This is because vacating a facility entails extensive planning, finances, and risk assessment (Bailey & Galecka, 2008; Peters, 2020; Kesling & Johnson, 2006; Gladu, 2004). Failure to plan could have damaging financial and legal consequences, thus causing negative public exposure.

There is an increasing interest in reducing the environmental impact of buildings (NIST, 1995). Various Life Cycle Assessment guidelines have provided in-depth discussions regarding design, construction, operations & maintenance, demolition, and disposal stages (e.g., Fuller, 2016; Fuller & Peterson, 1995; Lavappa & Kneifel, 2021; Bayer et al., 2010; EPA, 2014). At the time of this study, decommissioning, specifically in reference to shutting down or removing a building's systems to prepare the facility for long-term dormancy at the final stages of a building's life cycle, has rarely been discussed. Bayer et al. (2010) note that "the decommissioning phase is relatively less important than the materials placement and operations phase, as it makes a significantly lower contribution to the (environmental) impacts." While this may be the reasoning behind the scarcity of literature discussing decommissioning, decommissioning is still regarded as a major phase within the asset's life cycle.

The role of planning in facility management has special significance and is part of the building owner or organization's company business plan (Roper & Payant, 2014). For example, Laraia et al. (2018) indicates that a convenient part of a facility's long-term strategy is to plan for decommissioning to save costs when the time to decommission comes and reuse the buildings, building components, and equipment. In facilities management, salvageable building components are profitable assets that can help the decommissioning project, in many ways, to defray decommissioning costs.

Bailey and Galecka (2008) highlight investigation as the initial step during decommissioning. The investigation phase includes assessing current facility conditions to determine the most cost-effective and efficient manner to exit the property. Facility Managers could use a facility condition assessment to address this. A facility condition assessment is the process of developing a comprehensive picture of the physical condition and the operational performance of buildings and infrastructure; analyzing the results of data collection and observations; reporting and presenting findings (Mayo & Karanja, 2018). The current conditions of assets such as roofing, mechanical, plumbing, structural, and electrical are addressed, and asbestos, as well as lead surveys, carried out as part of the condition assessment to investigate any abatement required before close-out to address environmental and safety & health concerns (Gladu, 2004). Several shutdown options may be recommended once all the evaluations and inventories have been completed.

Bailey and Galecka (2008) highlight two shutdown scenarios as decommissioning options. These include cold hold and warm hold options. A **cold hold** fundamentally entails turning off the lights and utilities and locking the doors. Though this may be the least expensive option, it is not always legal, especially considering that fire protection systems are not operational, electricity is off, and any asbestos is left to deteriorate over time. An organization taking the cold-hold shutdown option must consider whether they are doing all they can to protect people – authorized to be in the facility or not – from hazards and the environment (Kesling & Johnson, 2005). The **warm hold** approach entails a minimal supply of the facility's water and heat to keep pipes from bursting during the cold season and maintain fire protection systems. This also involves the removal of some equipment and a competent person walking the site periodically to satisfy insurance and fire protection requirements, thus alleviating potential risks as best as possible (Bailey & Galecka, 2008). Therefore, it is essential to determine site security needs, evaluate remaining structures and utilities, maintain the site to pre-decommissioning standards, and ensure proper regulatory reporting (Laraia, 2018).

A decommissioning project is complicated and requires attention to detail, which leads organizations to work with firms or independent engineers who are well-versed in the details of the decommissioning process (Laraia, 2018; Bailey & Galecka, 2008). Team members servicing a building may include: project or facility managers (usually from inside the organization who will assess the physical property and capital inventory); environmental consultants (who will conduct an environmental assessment such as the need for remediation due to asbestos, lead, or other contaminants); engineers (structural engineers from inside or outside the company who will assess the structural integrity of the building components as well as MEP engineers to design the layout for any utilities that may need to be removed, capped, or maintained for as long as the building is not occupied); and design-commission contractors (who may be required to design and carry out any needed removal of asbestos or other hazardous materials) (Laraia, 2018; Bailey & Galecka, 2008).

Decommissioning should be planned and executed with advice from qualified professionals and cooperation with local agencies. Ideally, decommissioning would be planned according to best practices, general recommendations, and regulations of the Environmental Protection Agency (EPA), the American National Standards Institute (ANSI), the Occupational Safety and Health Administration (OSHA), and other governing bodies (Gallant & Blickle, 2005). An example of this is the Cessation of Regulated Operations (CRO), an EPA program that requires the owner or operator of a reporting facility that is ceasing operations to submit an inventory of chemicals and submit a decommissioning plan for the removal of items such as refrigeration equipment for air conditioning systems and cooling systems which may harbor environmental safety hazards. It would enable the facility owner to make the best choice for its future and should be part of a facility manager's risk assessment plan. Planning and executing decommissioning with direction from qualified professionals and following best practices ensures that a facility's closure is completed safely for workers, the community, and the environment and allows the facility owner to make a practical choice for its future, since abandoning a building may have severe consequences (Laraia, 2018; Bailey & Galecka, 2006; Kesling & Johnson, 2005; EPA, 2004). Examples of such consequences are shown in Table 1.

This study seeks to build upon the limited literature regarding decommissioning to establish a foundational understanding of decommissioning practices. This is achieved through a survey designed to first identify base-level relationships between industry and various aspects of decommissioning practices. The identification of variables and their potential correlation to decommissioning practices is the first step towards expanding the base knowledge in this area and promoting future research that will help standardize decommissioning procedures for commercial buildings.

3. METHODOLOGY

3.1 Data Collection and Cleaning

The study discussed herein analyzes data collected through a Qualtrics platform survey targeting professionals within the built environment, including architects, engineers, building owners, facility managers, and construction managers. These participants are selected from the American Institute of Architects (AIA) and International Facilities Management Association (IFMA) databases due to both organizations' international reach. The respondents are subsequently divided into three professional groups:

Group I - architects;

Group II - facility managers and building owners; and

Group III - construction managers, project managers, and engineers.

Data cleaning, quality management, and statistical analysis are carried out using IBM Statistical Package for Social Sciences (SPSS version 27.0) software tool. This involves

TABLE 1.—Examples of Crisis Consequences of Abandoned Commercial Buildings.

Year	Commercial building crisis	Consequences	Reference
1987	Trespassers break into a closed-down tire company and steal the copper components of transformer cores left on-site. **They inadvertently release Askerol, a hazardous PCB-containing oil, into a nearby stream in Ohio. Proper decommissioning would have previously, and properly, handled this material.**	$8 million cleanup paid for by taxpayers.	Ohio EPA, 2004.
2004	A man enters the closed-down Howard Paper Mill to steal a length of electrical wiring. **This industrial site, though unoccupied, had not been disconnected from the city's power grid in Dayton, Ohio.**	Twelve thousand volts flowed through him, burning 40 percent of his body. The following explosion and fire burned a 40- foot-tall power pole and cut power to nearby buildings.	Bailey & Galecka, 2008; Office of Policy Development and Research (PD&R), 2014.
2010	Trash fire leading to roof collapse due to a break-in in an abandoned commercial building in Illinois. **This may have been avoided had there been an active fire suppressant system.**	Two fatalities and 19 firefighters were hurt during the collapse.	National Institute for Occupational Safety and Health (NIOSH), CDC, 2011.
2021	Fire in an abandoned building in Riverside, California. **This may have been avoided had there been an active fire suppressant system.**	$30,000 worth of damage.	My news LA.com

checking for potential data errors, such as formatting errors, duplication, and missing data where participants failed to respond. Survey responses that contain missing data are marked, and respondents contacted via email. Respondents who did not reply with the information necessary to fill in this data are excluded from the subsequent analysis.

3.2 Questionnaire

The questionnaire consists of four main topic sections:

1) planning;
2) condition assessments;
3) guidelines; and
4) general information.

These four main sections, and their subsequent questions topics (and variables), are shown in Table 2. The variables under "general information" relate to the respondents' professional group, with the determining factor being their response regarding their current role industry. A question regarding the respondent's current work location was also included, primarily to show the locational spread among respondents and is not analyzed further within the scope of this study. By investigating the relationships between professionals' roles and the dimensions of planning, condition assessments, and awareness of guidelines, this study aims to highlight some of the factors that may influence current practices in decommissioning of commercial buildings.

The condition assessment questions concern specific building assets as garnered from the American Society for Testing and Material's (ASTM's) UNIFORMAT II (Charette & Marshall, 1999) and MasterFormat (CSI, 2020; Waugaman et al., 2022), the standards for organizing specifications for most commercial building design and construction projects in North America. Particular reference is given to UNIFORMAT II's Chart 4.5 (Charette & Marshall, 1999), where the relationship between UNIFORMAT and MasterFormat is described. Data collection is based on a taxonomy of building assembly systems in UNIFORMAT II for Building Elements. Classifications of these building assembly systems provide a commonly used outline for data collection and permit comparison between institutions, including Level 1 -

TABLE 2.—Study Variables.

Section	Variables
Planning	Involvement in decommissioning at stages.
	Decommissioning as part of an owner's long-term strategic plan for the facility.
	Third-party team member involvement.
	Cold hold and warm hold shutdown scenarios.
Condition Assessments	Frequency of condition assessments on unoccupied commercial buildings.
	Asset prioritization for condition assessments on unoccupied commercial buildings.
	Additional assets that should be included in condition assessments of unoccupied commercial buildings.
Procedures and Guidelines	Awareness of decommissioning procedures and guidelines currently in use.
	Procedures and guidelines that should be in use.
	Comments and suggestions on decommissioning procedures and guidelines in use.
General Information	Current role in the industry
	Current work location (country and state, if applicable)

TABLE 3.—Existing Decommissioning Guidelines.

Current Guidelines	Source
1. Offshore Petroleum Decommissioning Guideline – January 2018 – Offshore Petroleum and Greenhouse Gas Storage act 2006 (OPGGS Act).	International Offshore Decommissioning Regulations: https://www.iogp.org/
2. Decommissioning offshore oil and gas exploration or production wells.	Bureau of Safety and Environmental Enforcement https://www.bsee.gov/what-we-do/environmental-compliance/decommissioning
3. Decommissioning Guidance: Consolidated Decommissioning Guidance (NREG-1757). Standard Review Plan for Evaluating Nuclear Power Reactor License Termination Plans (NUREG-1700. Rev. 1).	United States Nuclear Regulatory Commission https://www.nrc.gov/waste/decommissioning/reg-guides-comm/guidance.html
4. Cessation of Regulated Operations Program. State of Ohio 2001; 2004	Ohio Administrative Code (Chapter 3745-352)
5. Decommissioning Implementation Guide	U.S. Department of Energy
6. Decommissioning State Buildings – Guidelines	Department of Administration Risk Management

Major Group Element, Level 2 - Group Elements, and Level 3 - Individual Elements.

The questions regarding guidelines are designed considering those set at the state and local level, as well as those for federal buildings (e.g., Cessation of Regulated Operations Program (Ohio Administrative Code, 2004); the U.S. Department of Energy; Nevada Department of Administration Risk Management) and the current guidelines set out by the Oil & Gas and Nuclear industries (e.g., International Association of Oil and Gas Producers IOGP, 2018; Department of Energy (DOE), 2017; Bureau of Safety and Environmental Enforcement (BSEE) (n.d.); International Atomic Energy Agency (IAEA), 2014) as displayed in Table 3. Not all of these guidelines are strictly enforced and/or regulated and may not cover all types of commercial buildings.

3.3 Data Analysis

Within the scope of this study, descriptive analyses are used to determine the overall percentages of the responses relative to each variable. This is accomplished by using cross-tabulation, which involves grouping each of the variables shown in Table 2, tabulating these, and examining the relationship in tabulated data to show any potential association between these variables and the respondents' role in the industry.

Inferential statistics are also explored using the Chi-Square Test of Independence to examine the relationship between the respondents' current role in industry and the categorical variables listed under the sections planning, condition assessments, and procedures & guidelines. The Chi-Square Test of Independence test serves to determine relevant associations between the variables and whether these associations are statistically significant. The null hypothesis (H0) assumes that the variables related to planning, condition assessments, and procedures & guidelines in decommissioning are independent from the professionals' role in the industry. The alternative hypothesis (Ha) assumes that there is a significant association between the variables. The significance level (alpha) is set at 0.05 (5%) in the study. A Chi-Square Test of Independence is conducted for each of the variables shown in Table 2 against the single variable of "current role in the industry". The formula for Chi-Square is as follows:

$$x^2_{df} = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

df = degrees of freedom = (r – 1)(c – 1); where r is the number of rows, c is the number of columns, O is the observed cell frequencies, and E is the expected cell frequencies.

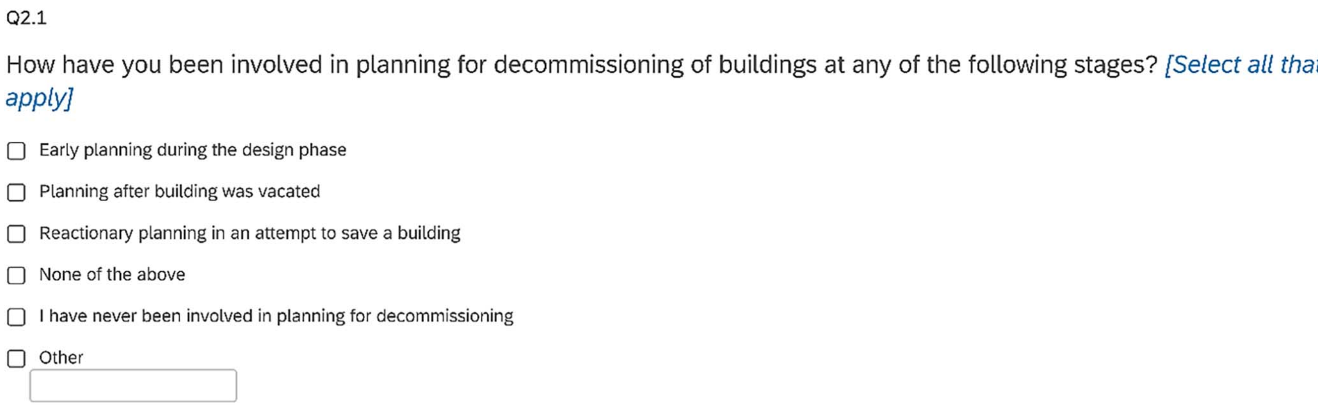
Cramer's V tests are also conducted to identify the strength of these associations between the variables in Table 2 under the sections planning, condition assessments, procedures & guidelines and the current role in the industry. The formula for Cramer's V is:

$$V = \sqrt{\frac{x^2}{(N)\min(r-1,\ c-1)}}$$

Where x^2 is the chi-square statistic for the cross-tabulation, N represents sample size, and min (r – 1, c – 1) indicates the number of rows or the number of columns in the contingency table, whichever is smaller.

According to Cohen (1988), a V between 0.1 and 0.3 indicates a weak association, V between 0.4 and 0.5 points at a medium association, and a V greater than 0.5 indicates a strong association. To control for multiple comparisons and to lower the risk of Type I errors[5], the alpha significance level is adjusted using the Bonferroni correction post-hoc procedure to 0.05/[(number of tests conducted)].

Some of the survey questions are single answer selections. However, the survey also includes questions with multiple responses (select all that apply). In analyzing these types of questions, cross-tabulation allows us to investigate each of the responses separately. Recoding the response data to read zero (0) = no and one (1) = yes results in only responses coded as one (1) to be counted as an affirmative response. Therefore, the analysis provides the percentage of participants who answer with an affirmative response within each answer based on "select all that apply," giving a richer source of data to understand the


Q2.1

How have you been involved in planning for decommissioning of buildings at any of the following stages? *[Select all that apply]*

- Early planning during the design phase
- Planning after building was vacated
- Reactionary planning in an attempt to save a building
- None of the above
- I have never been involved in planning for decommissioning
- Other

FIGURE 1.—"Select All That Apply" Sample Question.

respondents' answers better. Figure 1 shows an example of a "select all that apply" question. All personal identifiers are removed in the analysis to safeguard the participants' privacy and anonymity.

4. RESULTS

4.1 Respondents and Characteristics

A total of 881 respondents completed the questionnaire, with 720 respondents meeting the required criteria of currently working with commercial buildings for this study. The respondents represent 48 U.S. states, the District of Columbia, and Puerto Rico (n = 438, 85%); four Canadian provinces (N = 13, 3%); and 33 other countries (N = 26, 3%). These survey demographics are shown in Figure 2. Of note, 205 respondents did not indicate the country they worked in, but those respondents still completed the survey. Survey participants are members of IFMA and AIA with positions in facility management, architecture, engineering, construction management, or project management.

The questionnaire is geared towards professionals who work with commercial (n = 503, 70%), government (n = 191, 27%), and private (non-residential) facilities (n = 26, 3%), resulting in the aforementioned 720 usable responses (n = 720). To ensure that the data are not skewed towards one profession, the data are grouped, as demonstrated in Figure 3. Group I consists of architects, Group II consists of facility managers and building owners, and Group III consists of construction managers, project managers, engineers, and others. These groupings are constructed such that the professions may have similar roles within the project lifecycle. For example, facility managers and owners are more likely to deal with operations and maintenance than the other professions. Of the respondents, 51% list their current role as architects, 29% identify as facility managers or building owners, and 20% identify as working as engineers, construction managers, or project managers. Results from respondents who declined to state their current role are eliminated from the analysis.

4.2 Planned Decommissioning Analysis

The first aim of the survey is to identify whether decommissioning is currently planned for regarding commercial

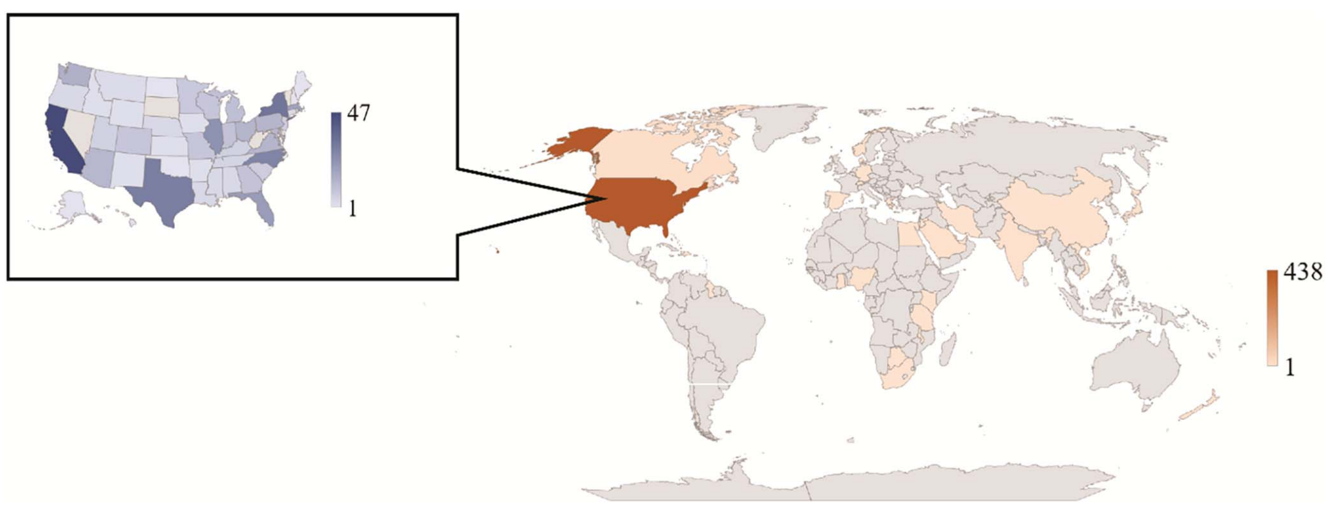


FIGURE 2.—Distribution of Responses.

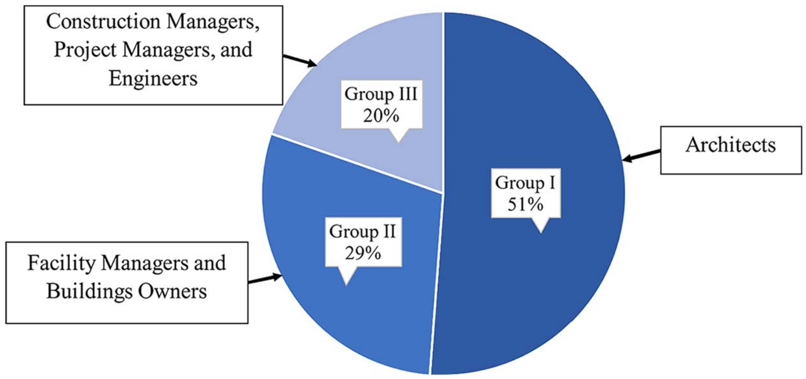


FIGURE 3.—Characteristics of Respondents.

buildings. This section includes a question on whether the participants have previously been involved in decommissioning at various stages, ranging from early to reactionary planning. The next question aims to determine whether the respondents believe decommissioning should be part of a building owner's long-term strategic plan for a facility. The study also intends to discover whether the participants were familiar with or had been involved in decommissioning scenarios (warm and cold hold) and, finally, which professionals, in their opinion, should be involved in decommissioning. Each of these questions are also analyzed by their professional grouping to identify possible associations between industry and decommissioning planning.

4.2.1 Involvement in decommissioning: When asked to select which decommissioning stages the respondent had been involved in, most indicate that they had been involved in planning for decommissioning after the building was vacated or as a reactionary response in an attempt to "save" the building. As shown in Figure 4, these two possible responses account for 47% of the responses from architects (Group 1), 50% of the responses from facility managers and building owners (Group II), and 57% of the responses from construction managers, project managers, and engineers (Group III).

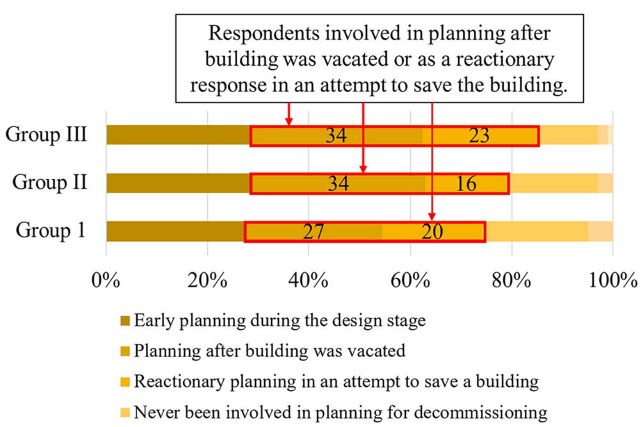


FIGURE 4.—Involvement in Planning of Decommissioning.

4.2.2 Long-term strategic plan: In response to whether decommissioning should be part of a building owner's long-term strategic plan, nearly half of the facility managers and building owners (Group II, 48%) respond with: "definitely yes." As shown in Figure 5, respondents focusing on the answers in the affirmative (the total of definitely yes and probably yes) result in 76% of facility managers and building owners (Group II), and 67% of construction managers, project managers, and engineers (Group III). Although 53% of the architects also gave affirmative responses, they have the most significant number of respondents that remained neutral (Group I, 32%).

4.2.3 Cold hold and warm hold shutdown scenarios: In a cold hold shutdown scenario, a building owner turns off the lights, locks the doors, and completely vacates the structure. In the warm hold shutdown scenario, a building owner retains a minimal supply of the facility's water and heat to keep pipes from bursting during the cold season and to maintain fire protection systems. Participants of this survey are asked whether they are familiar with or have personally been involved in these shutdown scenarios.

More than half of the architects (Group I, 54%) state that they have not been involved in or initiated a cold hold shutdown scenario. Conversely, many facility managers and building owners (Group II) state that they are familiar

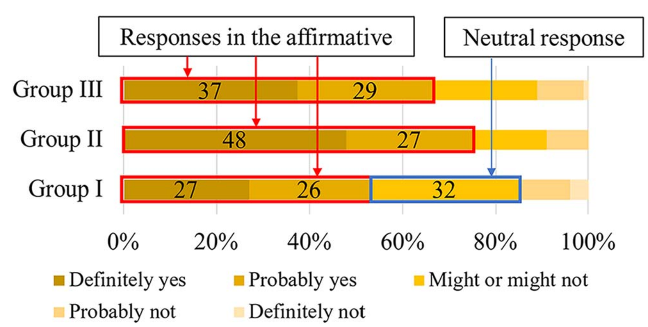


FIGURE 5.—Decommissioning as Part of a Building Owner's Strategic Plan for the Facility.

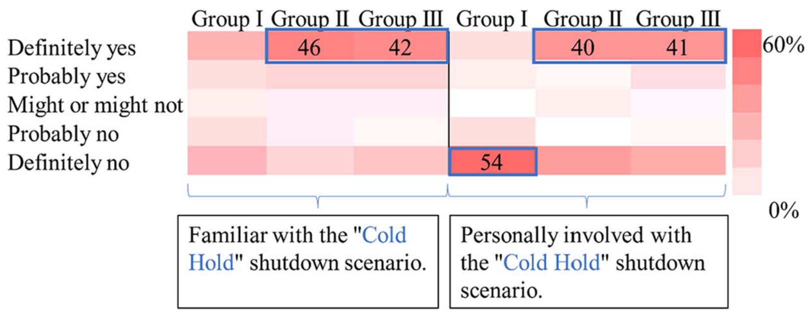


FIGURE 6.—Descriptive Statistics Regarding the Cold Hold Shutdown Scenario.

with the cold hold shutdown scenario (46%) and have been personally involved in or initiated this scenario (40%), as shown in Figure 6. Similarly, many construction managers, project managers, and engineers (Group III) declare that they are familiar with (42%) and have been personally involved in or initiated (41%) a cold hold shutdown scenario.

For a warm hold shutdown scenario, under half of the architects indicate that they have not been involved in or are unfamiliar with the warm hold shutdown scenario (Group I, 47%). In contrast, many facility managers & building owners (Group II) indicate that they are familiar with (44%) and have been involved in or have initiated (42%) the warm hold shutdown scenario (Group II), as have construction managers, project managers, and engineers (Group III) with 43% stating they are familiar with it and 41% stating they have been involved in or have initiated the warm hold shutdown scenario (Figure 7).

4.2.4 Third-party involvement: Other studies (Laraia, 2018; Bailey & Galecka, 2008), emphasize the importance of undertaking decommissioning with the assistance of professional experts due to the complicated nature of the process. Survey participants are asked to indicate which third-party professionals, in their opinion, should be involved in decommissioning. Participants could select more than one third-party professional. Though not in the same order for each group of respondents, the highest percentages of selections are for the facility manager, environmental consultant, civil/structural engineer, and mechanical engineer, as highlighted in Figure 8.

4.3 Analysis Regarding Condition Assessments on Unoccupied Buildings

The second aim of this paper was to identify whether condition assessments should be part of the decommissioning process and, if so, which assets should be considered when vacating a building.

4.3.1 Condition assessment frequency: When asked how often condition assessments should be carried out on unoccupied commercial buildings, most respondents across the three groups support yearly condition assessments (Figure 9). Some participants did select the option "other," commenting that the reason behind that selection is that annual condition assessments should include quarterly localized inspections (roof inspections, security, and vandalism checks).

4.3.2 Assets considered when vacating a building: In requesting that participants indicate which assets should be considered when vacating a building, respondents are able to select more than one asset. Shared responses across all groups are sprinklers and fire alarms, HVAC systems, roofing, and electrical systems. Respondents from Group II (facility managers and building owners) and Group III (construction managers, project managers, and engineers) also select security and access control systems as assets they deem essential to consider when vacating a facility (Figure 10).

4.4 Evaluating Current Awareness of Procedures and Guidelines

The nuclear and oil & gas industry is one of the few industries with already established decommissioning procedures. The survey questions, in this section, regarding

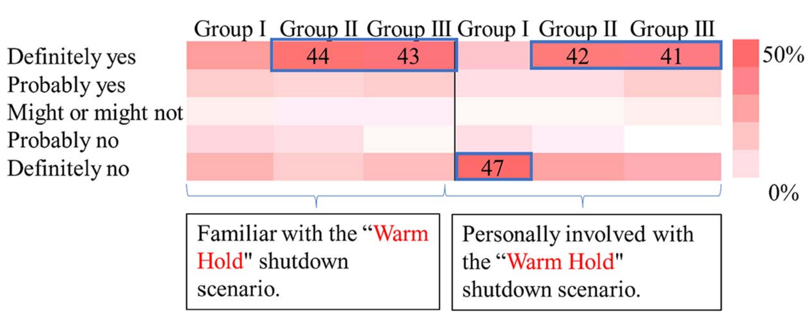


FIGURE 7.—Descriptive Statistics Regarding the Warm Hold Shutdown Scenario.

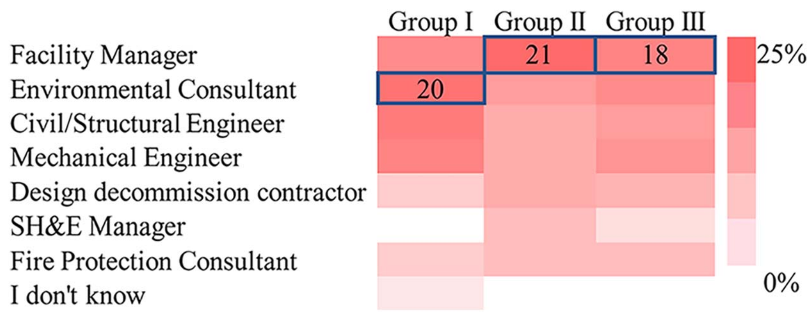


FIGURE 8.—Third-party Professionals Involved in Decommissioning.

procedures and guidelines are influenced by the current guidelines set out by this industry. The participants are queried on safety, health, and environmental considerations currently required for decommissioning commercial buildings and those that should be required for decommissioning commercial buildings, based on the oil & gas industry requirements. The respondents could select more than one regulation or guideline; their responses are shown in Figure 11.

Respondents' most frequently identified awareness of draining and removing all regulated substances from stationary tanks and lawfully disposing of selling or transferring regulated substances in the decommissioning process. The participants indicate less frequency in awareness and practice of ensuring that equipment or components containing lead dust or asbestos have been abated.

4.5 Inferential Statistics Summary

The results of the inferential statistics are summarized in Table 4. The calculated Chi-Square Test for Independence statistics results range from 17.2 to 129.7 for each test with degrees of freedom varying accordingly and result in p-values ranging between 0.043 to <0.001. Cramer's V values, which measure the strength of association between the variables, range from 0.100 to 0.372.

Upon applying a Bonferroni correction and considering the Cramer's V results, this study reveals significant associations between the respondents' current role in the industry and all other study variables shown in Table 2, except for decommissioning as part of an owner's strategic plan for a facility, involvement of professionals during decommissioning, and the frequency of condition assessments on unoccupied buildings. In these cases, respondents across all roles provided similar responses leading to a moderate association. These comprehensive findings emphasize the interrelationships, by industry, that influence practices in commercial building decommissioning, as evidenced by the descriptive analysis.

5. DISCUSSION

This study investigates current trends in decommissioning procedures and the relationship between such trends and the professionals' roles in the industry. The literature asserts that planning for decommissioning should occur ***before*** vacating the building and as early as during the design stage of the facility (Bailey & Galecka, 2008), in which decommissioning should also be part of the long-term facility plan. Best practices point to planning decommissioning at either the design stage for new construction or at the purchase of the building and should be part of long-term facility planning.

However, this study's results indicate that almost half of the participants, regardless of their role in the industry, have been involved in planning for decommissioning at reactive stages ***after*** a building was vacated or in an attempt to save a building for reuse. Therefore, this study surmises that decommissioning has not historically been

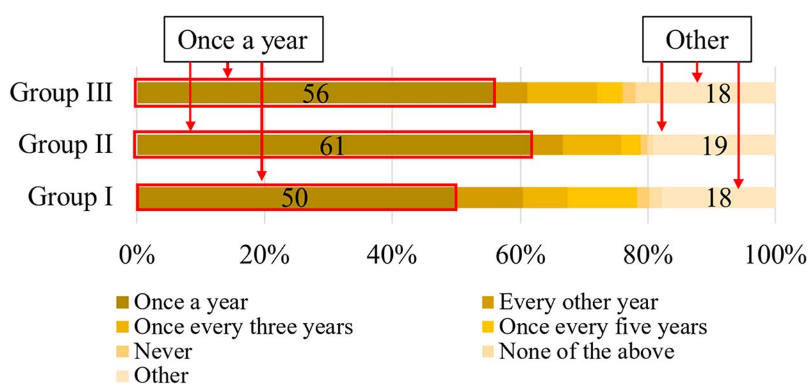


FIGURE 9.—Suggested Frequency of Condition Assessments on Unoccupied Commercial Buildings.

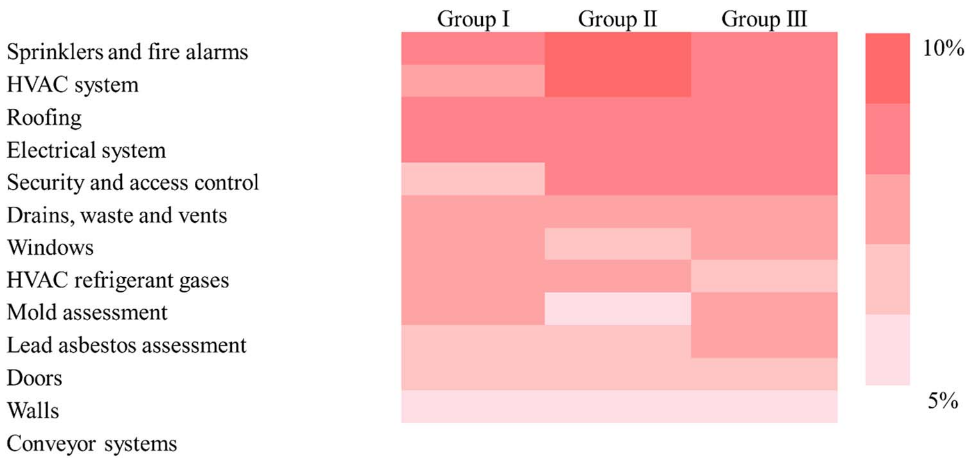


FIGURE 10.—Assets for Which Condition Assessments Should be Carried Out When Vacating a Building.

part of the long-term plan for the facility. The authors suggest that this may be due to the general perception in the industry, as suggested Life Cycle Assessments guidelines discussed herein in the Literature Review section, that the decommissioning phase is comparatively less significant than the construction and operations phase, as it makes a lower economic contribution to the owner. The results indicate a consensus among respondents that decommissioning ***should*** be a part of the long-term facility plan and, therefore, part of an organization's long-term plan for a facility.

A critical factor in planning for decommissioning is shutting the building down for the purposes of vacating. As discussed previously, the **cold hold** scenario entails turning off the lights and locking the doors. The results show facility managers and building owners are familiar with this shutdown scenario. However, the construction managers, project managers, & engineers have the highest percentage of those who have personally been involved in or initiated the cold hold shutdown scenario. Architects may not be as likely to have been personally involved in or prompt a cold hold shutdown scenario, but they may be familiar with the scenario since architects are more likely to be involved in the design stage than with tasks at the end of a building's useful life. This sentiment is also reflected in the **warm hold** shutdown scenario, which entails a minimal supply of the facility's water and heat to keep pipes from bursting during the cold season and maintain fire protection systems.

Although the literature indicates that the warm hold shutdown scenario is the recommended scenario but is not often observed (Bailey & Galecka, 2008), the survey results reflect a different sentiment, with nearly half of the professionals, even more so the facility managers, construction managers, and engineers, indicating involvement in cold hold shutdown scenarios. The cold hold shutdown scenario is highlighted in the literature as not always legal (Bailey & Galecka, 2008). Best practice suggests that the warm hold shutdown scenario is preferred. This study highlights that although there is some awareness and practice of the recommended shutdown scenario (warm hold) when vacating a commercial building, buildings are often vacated using the less prudent cold hold shutdown scenario. The authors suggest that standardized decommissioning procedures and guidelines for commercial buildings may lead to facility managers planning for warm

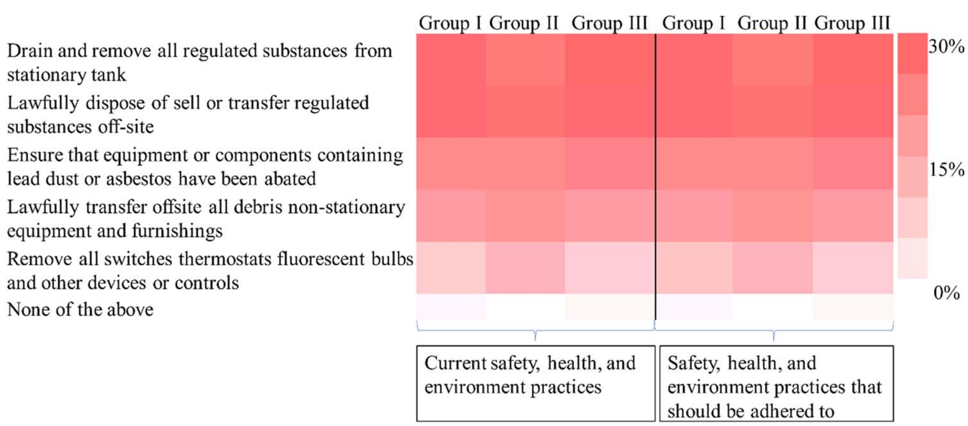


FIGURE 11.—Guidelines Used in the Nuclear Energy and Oil & Gas Industries.

TABLE 4.—Association Between Respondent's Current Role and Survey Responses and Their Strength.

	Parameter	Valid cases	Degrees of freedom[a]	Chi-square statistic[b]	p-value	Cramer's V[c]	Effect size
Planning	Involvement	656	10	20.435	0.025	0.252	High association
	Strategic Plan	506	8	30.866	<0.001	0.175	Moderate association
	Familiar with cold hold scenario	490	8	17.216	<0.001	0.133	High association
	Personally involved in cold scenario	480	8	53.56	<0.001	0.236	High association
	Familiar with warm hold scenario	456	8	10.052	0.026	0.372	High association
	Personally involved in warm hold scenario	444	8	34.402	<0.001	0.197	High association
	Third-party Involvement	720	18	129.667	0.000	0.100	Moderate association
Condition Assessments	Frequency of condition assessments	507	21	21.561	0.043	0.146	Moderate association
	Assets	530	26	58.363	<0.001	0.250	High association
Guidelines	Guideline awareness	509	12	28.011	0.006	0.358	High association

[a,b,c]Defined previously in the analysis section

hold shutdowns and therefore alleviate risks to the facility, residents, and the environment often associated with cold hold shutdowns.

The literature underlines the need for direction from qualified professionals when planning and executing decommissioning. This is emphasized by the survey results herein, which finds that the professional groups agree on the importance of involving a facility manager, an environmental consultant, a civil/structural engineer, and a mechanical engineer. However, the literature also indicates the need for a design decommission contractor who is an expert in decommissioning and abatement, a safety and health manager, and a fire protection consultant. Although there are those facility managers and building owners who indicate a need for a safety and health manager as part of the decommissioning team, these professionals (design decommissioned contractor who is an expert in decommissioning and abatement, a safety and health manager, and a fire protection consultant) did not rank high among the survey responses despite being equally critical to the decommissioning process, as highlighted in the literature.

Previous studies on condition assessments for occupied buildings indicate that these should be carried out yearly (Ahluwalia, 2008; Mayo & Karanja, 2018). The study discussed herein could not identify literature on requirements for condition assessments for unoccupied buildings. Still, the respondents agree with the concept of yearly condition assessments for unoccupied buildings, with over half of the respondents indicating as such, while also including a suggestion of quarterly localized inspections (roof inspections, security, and vandalism checks) since these buildings are vacant and therefore vulnerable to vandalism and deterioration. Additionally, this study's results indicate that roofing and sprinklers & fire alarm systems are critical assets to assess before vacating a building, coupled with windows, HVAC systems, HVAC refrigerant gases, and electrical systems. Interestingly, the respondents from all professional disciplines did not rate walls and doors high despite the literature underscoring that assessing these building components is necessary for security, i.e., ensuring doors are securely shut to avoid vandalism and squatters, health & safety, and evaluating the structural integrity of walls to ensure safety.

The respondents from all professional disciplines expressed awareness and a procedural need for draining and removing all regulated substances from stationary tanks, should these be present. The same is also indicated for lawfully disposing of, selling, or transferring regulated substances offsite as being essential. Abatement of equipment or components containing lead dust or asbestos; removal of all switches, thermostats, fluorescent bulbs, and other devices; and transferring all debris non-stationary equipment and furnishings offsite have all been highlighted as essential practices when vacating a facility both in the literature and existing guidelines, such as those from the nuclear energy and oil & gas industry. However, most of the respondents did indicate an awareness or practice of these procedures, particularly the abatement of lead equipment or building components containing lead dust or asbestos, which is necessary as it poses an environmental hazard if left unattended.

6. CONCLUSIONS

Proper decommissioning of commercial buildings should include prior planning, continued assessment of the building's condition, and following set guidelines and procedures. This study's results establish that professionals in the built environment recognize the need to conduct decommissioning using best practices. Despite professionals in the built environment being involved in planning for decommissioning, this study shows that most planning activities primarily occur reactively, once a building has been vacated, or as a result of reactionary planning in an attempt to save a facility for reuse. Notably, decommissioning may not often be a part of a facility's long-term plan.

Ideally, decommissioning should be included as early as the design stage, as part of a facility manager's long-term facility plan, and as part of the owner's total cost of ownership. A decommissioning plan should include professional services from facility managers, environmental consultants, engineers (structural and mechanical), and asbestos abatement specialists should the need arise. Once a facility has been vacated, the facility management team should carry out annual condition assessments with regular walkabouts to ensure the facility is maintained in its pre-decommissioning condition for as long as it is dormant.

Facility management involves the management of an organization's facility resources and support services not only at an operational level but also on a strategic level. Decommissioning is part of property asset portfolio management. It involves strategic property decisions, risk management, and facility planning and development, which are related to the organization's policy and strategic plan (Chotipanich, 2004). For a decommissioning project to be successful, a plan needs to be in place, and procedures and guidelines such as those used for federal buildings, some state governments such as Ohio and Nevada, and the oil & gas and nuclear energy industries put in place. Procedures and guidelines for commercial buildings are necessary to avoid being left dormant, leading to vandalism, damaging financial and legal consequences, and therefore causing negative public exposure to an organization.

The findings of this study not only contribute to a comprehensive understanding of current trends but also provide a foundation for informed decision-making by building owners and facility managers. While the study discussed herein aims to identify relationships between industries and decommissioning knowledge and current practices, future research is recommended to further highlight how some of the discussed variables may *influence* each other. Future research could also advise in incorporating predictive modeling techniques to offer projections that facilitate more efficient, environmentally conscious, and economically viable approaches for commercial building decommissioning. Additionally, developing a framework with proposed decommissioning guidelines and procedures will aid facility managers in creating safe, timely, and cost-effective decommissioning plans, ensuring the sustainable and responsible transition of commercial buildings.

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