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ISO 50001-Based Energy Management Systems as a Practical Path for Decarbonization: Initial Findings from a Survey of Technical Assistance Cohort Participants

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Abstract: Organizations face rising pressure to take action to reduce their climate-affecting emissions (i.e., decarbonize). While many responses are possible, an essential approach—strategically managing their energy consumption as an essential business practice via an ISO 50001-based energy management system—is not yet widely recognized as a framework for decarbonization. This study analyzes interim survey results from 24 organizations (a 48% response rate) implementing a rigorous energy management system, one deployed by the U.S. Department of Energy as "50001 Ready", to test whether participating organizations perceive the energy management system under development as an essential aspect of their decarbonization efforts. The results are preliminary in nature, given the ongoing nature of the program and associated data collection; however, they are sufficient to refute our hypothesis that energy management systems are perceived by organizations participating in 50001 Ready cohorts to primarily affect energy performance with little-to-no connection regarding decarbonization efforts. Major findings include that participants' decarbonization targets and commitments are driven by market imperatives (highlighting the importance of ISO 50001 as a management system tool) and that they see energy efficiency as vital to decarbonizing. We conclude by suggesting future research directions to further establish the premise that energy management systems are an effective, efficient, and long-lasting decarbonization strategy.

Keywords: energy management systems; ISO 50001; decarbonization; technical assistance; organizational behavior

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1. Introduction

Amid increasing pressure from shareholders, regulators, and the public to mitigate climate change, organizations of all kinds face a pressing need to significantly and persistently lower their carbon footprints. Because more than two thirds of global greenhouse emissions stem from the direct use of energy [1], energy management and improving energy performance are essential to a successful reduction in emissions. Cutting carbon emissions quickly and deeply enough to mitigate the worst effects of climate disruption will require systematically managing energy over decades. The organizational use of an energy management system (EnMS) business practice is considered one of the most cost-effective ways to realize the large energy efficiency potential remaining in the industrial sector [2,3]. One way to conceive of an EnMS is to have an implementing organization manage energy as a business practice, just as it manages other important aspects of its operation. An EnMS is a continual improvement process that is intended to become part of the fabric of an organization in order to outlast employee turnover or short-term changes in direction [4]. This paper investigates whether participants in a U.S. government effort to promote energy management consider an EnMS to be part of their decarbonization efforts. It represents a mid-program opportunity to evaluate the research question of whether and how participating organizations view EnMSs as related to decarbonization. It does so

by investigating the hypothesis that participants see EnMSs as primarily affecting energy performance, with little-to-no connection to their efforts to decarbonize.

Methods to manage energy as a regular organizational activity over extended periods are well-established, with various procedures and processes for systematic energy management developed over the last two decades. National programs continue to evolve around the International Standards Organization (ISO) standard for EnMSs (ISO 50001), including:

- U.S. Department of Energy's 50001 Ready and Superior Energy Performance (SEP) programs;
- Germany's Eco tax cap for industry, special equalization scheme, and the Federal Office for Economic Affairs and Export Control (BAFA)'s program to support EnMSs in small- and medium-sized enterprises;
- China's Top 10,000 Enterprises Energy Efficiency and Low Carbon Action Plan;
- Brazil's National Plan for Energy Efficiency (PNef);
- Canada's Energy Efficiency Program for Industry and the Canadian Industry Program for Energy Conservation;
- Mexico's National Program of Energy Management Systems (PRONASGEn); and
- South Africa's Industrial Energy Efficiency (IEE) Project [5].

These and similar programs elsewhere have enormous potential to increase energy performance while cutting energy use, GHG emissions, and costs: if half of the projected energy use from the industrial and services sector globally were to be managed under ISO 50001 by 2030, cumulative savings from 2011 through to 2030 are estimated at 105 EJ of primary energy, 6500 million tonnes of CO_2 ($MtCO_2$), and almost USD 700 billion [5]. In the U.S., SEP 50001 facilities, with a third-party-verified energy performance improvement from an ISO 50001-certified EnMS, have achieved persistent energy efficiency gains of more than 3% annually, exceeding the needed annual efficiency gains of 1.3 to 1.7% modeled to limit anthropogenic global warming to 1.5 °C [6]. Within North America, some strategic energy management (SEM) programs offered by utilities and states/provinces in North America incorporate elements of ISO 50001 but many are less rigorous than a 50001-based EnMS approach [7]. Nevertheless, SEM could provide nearly one fifth of Canada's emissions reductions goals for the industrial sector by 2030 [8].

At the same time, the adoption of an energy management system (EnMS) remains relatively low in most countries. In 2021, 22,575 valid certificates for 57,019 sites were reported—at least an order of magnitude lower than ISO 9001 (Quality Management) and 14001 (Environmental Management), with 1,077,884 and 420,433 certificates, respectively [9]. The literature on barriers to energy management system adoption is nascent, but recent papers provide some clues. A systematic literature review finds that scholarship on organizational culture has focused chiefly on enhancing productivity instead of sustainability [10]. A content analysis of 72 case studies of successful ISO 50001 implementation underlines that organizations typically do not prioritize improving overall system efficiency via implementing an energy management system, in that three frequent barriers were: energy management being neither integrated nor rewarded within organizational culture, difficulties in educating personnel at various levels within the organization, and sustaining commitment from top management [11]. Other works have identified challenges within the manufacturing sector, including limited access to capital, the complexity of production processes, thin organizational structures, and non-energy-related issues being of higher priority [12,13]. In addition, a recent paper indicates that while participants in a 50001 Ready virtual in-plant training understood the benefits of establishing an energy management system, about half underestimated the time and resources ultimately required for successful implementation [14].

Moreover, the scant literature explicitly links energy management systems to decarbonization. Several recent papers discuss models and program evaluation methodology for EnMSs in the context of decarbonizing industries, but are limited to specific sectors and countries [15,16]. A 2022 U.S. Climate Alliance handbook on enabling industrial decarbonization mentions energy management systems only twice: raising capital for

decarbonization via the German policy of reducing energy taxes by 90 percent for large energy users that are ISO 50001 certified, and a policy opportunity for the refining sector to reduce emissions [17]. In addition, the authors recently conducted in-depth interviews with 24 strategic energy management (SEM) programs throughout North America [7]. Just two of these programs mentioned progression toward carbon targets as a key value proposition that they market to customers, and only one stated that customers report achieving sustainability goals as a main benefit of SEM.

However, recent policy decisions related to the climate crisis hold the potential to markedly increase the adoption of ISO 50001-based energy management systems. The U.S. Security and Exchange Commission has proposed a regulation obliging all publicly traded companies to report their greenhouse gas emissions and climate-related risks. Emissions reporting would be standardized, with larger organizations required to undergo independent audits [18]. Such action mandating climate risk reporting significantly trails this elsewhere, including in the European Union (EU), Britain, Japan, Brazil, Switzerland, Singapore, Hong Kong, and New Zealand [19]. In the EU, the Carbon Border Adjustment Mechanism (CBAM) will be phased in between 2026 and 2034, with importers of steel, iron, cement, electricity, hydrogen, and fertilizers required to pay the difference between the price of carbon allowances in the EU Emissions Trading System and the carbon price where goods were manufactured [20]. Climate financial risk disclosures will create strong financial drivers for companies to decarbonize.

For its part, the EU has more closely linked climate change and energy management in its recent revision to the Energy Efficiency Directive (EED), undertaken to align the EED with the EU's "Fit for 55" climate transition package, with a near-term goal of reducing EU final energy consumption by 11.7% by 2030 [21]. Relevant changes include requiring every company in the EU: (1) with an annual energy consumption higher than 85 TJ to implement an ISO 50001 energy management system; (2) with an annual energy consumption above 10 TJ to audit their energy use according to EN 16247-1 [22], similar to ISO 50002-1: Energy Audits—Requirements with Guidance for Use [23] developed by ISO technical committee 301, which oversees ISO 50001. One expert estimates that EU companies will obtain 15,000 to 30,000 new ISO 50001 certificates in the two years after this revision becomes law [24]. Also in Europe, the EU Strategy for Sustainable and Circular Textiles will require manufacturers who wish to import textiles into the EU to establish an energy management system for each dyeing, printing, and finishing production site; "ISO 50001 or equivalent systems for energy or carbon dioxide emissions shall be accepted as evidence for the energy management system" [25–27]. Similar initiatives aimed at achieving circularity in other manufacturing sectors may follow.

The speed and scale with which decarbonization must occur is becoming ever more clear. Considering that there are a multitude of organizations that have made public climate commitments but are faltering in their progress, investigating the connections between energy management systems as a systematic process and driver of decarbonization is imperative. While energy management practitioners may believe that some implementing organizations are pursuing EnMSs at least in part for decarbonization purposes, to our knowledge, this paper is the first that analyzes real-world data in light of this commonly held belief. While the sample size is small, given that the program is ongoing, it is a first step in testing whether and how EnMS users connect 50001-based EnMSs to their decarbonization efforts. After developing the current context around EnMSs and outlining the research methodology, this paper presents and discusses initial findings from an online survey of participants in a cohort-based technical assistance program for 50001 Ready EnMS implementation led by the U.S. Department of Energy. Finally, we conclude the paper with a discussion of future program and research opportunities.

2. Materials and Methods

In 2020, the U.S. Department of Energy began offering free technical assistance to U.S.-based sites to implement a 50001 Ready energy management system using a cohort training

model [28]. The program is designed as follows. Organizations enroll in a cohort designed for a particular sector or subsector (e.g., universities). Participating organizations can include one or multiple sites in the cohort program, usually of the same type (e.g., campus buildings). An organization can have one or more individuals participate in a cohort, with these individuals usually based at the organization's sites or corporate/headquarters offices. No participating organization had individuals that were only from corporate offices. Trainers are coaches from third-party companies that have previous experience in implementing ISO 50001, 50001 Ready, and/or strategic energy management at client organizations. Additionally, 484 individual participants from 274 sites and 64 organizations in commercial, industrial, and institutional sectors have taken part in 18 separate cohorts, with 187 sites from 50 organizations focused on actual implementation (starting in late 2021) and 87 sites receiving training only. Participant sites have been geographically diverse, as seen in Figure 1. Sectoral participation has also been diverse, with a plurality of sites coming from the public administration sector, followed by manufacturing, utilities, and hotels.

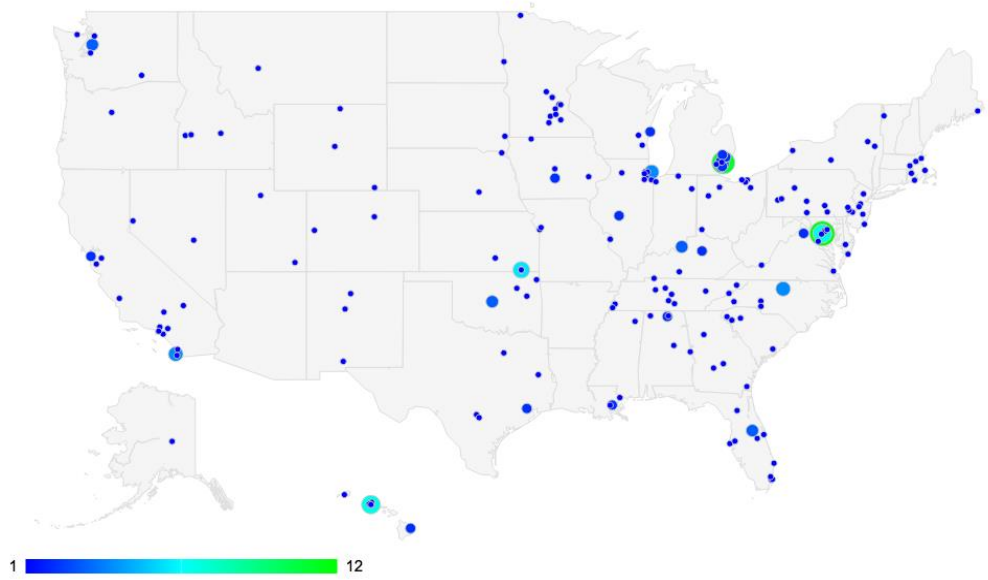

Figure 1. Location of all sites engaged in 50001 Ready Technical Assistance Cohort Program to date, with color and size of circles indicating the number of sites in a particular location.

One key aspect of running this program is an integrated data collection effort, with coaches sending five online surveys to participants over the course of the program engagement, which typically lasts from 10 to 12 months. These surveys are completed by the individual(s) from participating organizations. The Human Subjects Committee at Lawrence Berkeley National Laboratory approved an exempt protocol for these surveys (protocol 00023247 and approval number 382NR001-31JA23). Under the terms of this human subject research protocol, which assures confidentiality for participants, we cannot make public the survey response data. The program and data collection are ongoing, and we expect that the complete data set will yield a wealth of quantitative and qualitative insights when analyzed.

The results in this paper are drawn from the mid-program survey on energy management and sustainability sent to two types of respondents: (1) if part of a multi-site cohort, the corporate/headquarters representative; and (2) if part of a non-multi-site cohort, one representative per site (the site lead). The intention of the survey was to gather data on each organization's approach to sustainability, energy and decarbonization targets and goals, energy governance, and specific energy-related issues such as existing projects, renewables, electrification, integration of energy goals into the value chain, and existing measurement, management, and reporting initiatives. A total of 46 respondents had pro-

vided their opinions by March 2023; data cleaning resulted in 24 usable responses from intended respondents—from 24 different organizations—and 22 responses from additional site personnel, which will not be analyzed here. This results in an effective survey response rate of 48%, considering the 50 implementation-focused organizations taking part by this time. The median response time was around 18 min. Because taking the survey is voluntary and almost every question (aside from those related to identifying participants) did not require an answer, some respondents skipped questions at times.

The 24 organizations represented by respondents are diverse in terms of sector and size. A plurality of organizations (46%) was in the manufacturing sector, 21% in public administration, 17% in utilities, and the remaining 12% split between the following sectors with one respondent each: transportation and warehousing, technical services, educational services, and health care. Represented manufacturing subsectors included transportation equipment, fabricated metal product, wood product, chemical, nonmetallic mineral, and miscellaneous manufacturing. In total, 14 of 24 respondents (58%) were participating in a multi-site cohort led by a higher organizational office, such as the corporate or headquarters office, while 42% were site leads responding on behalf of single sites without further organizational involvement. In terms of size, Figure 2 displays a box plot of participant organization sizes (excluding one organization) by number of employees, where the minimum is 23 employees, the median 2500, the mean 23,852, and the maximum 402,600. Four (17%) qualify as small- and medium-size enterprises as defined by the EU, with fewer than 250 employees [29], while five (23%) have fewer than 500 employees.

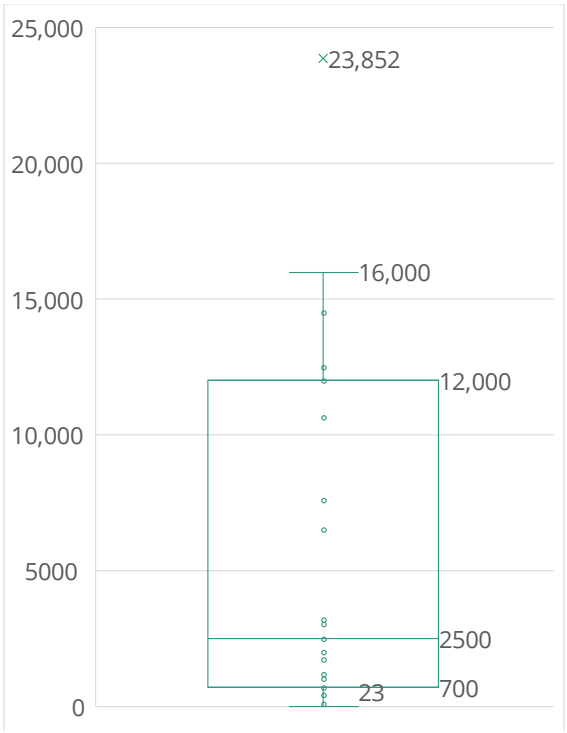

Figure 2. Box plot of participant organization size, excluding outliers and with exclusive interquartile range (n = 23).

Finally, respondents themselves had a range of job titles, with the most common being Energy Manager (25%), Energy or Environmental Engineer (12.5%), and Environmental, Health and Safety Manager (12.5%). In total, 15 of 24 respondents had the word "Manager" in their title, while 2 respondents were at the VP or Executive Director level and others tended to be individual contributors with titles containing terms such as "Analyst", "Specialist", or "Engineer". The most common words among job titles were, in descending order of prevalence, "manager", "energy", "environmental", "engineer", "safety", "senior",

"health", and "sustainability". Note that individual respondents, depending on context, may not be aware of all issues connected to questions asked in the survey; the results below necessarily reflect their own understanding of site or corporate views.

3. Results

This section presents descriptive statistics from analyzing responses to the energy management and sustainability survey representing 24 organizations. Given the small sample size, responses are not expected to provide unquestionable conclusions, but still can provide an initial snapshot of participants' perceptions of how an ISO 50001-based energy management system affects decarbonization. Taken together, these provide insights invalidating the proposition that energy management systems have little relevance for reducing carbon emissions and point to opportunities to consider adjusting program outreach or implementation. The results demonstrate the definitive value of 50001 Ready to decarbonization efforts, with pending further data collection that will enable deeper and more nuanced analysis.

3.1. EnMSs in Relation to Sustainability

Cohort participants responded to several questions regarding aspects of sustainability their organization was interested and/or engaged in; has any goals, targets, and/or commitments for; and whether they see a 50001 Ready EnMS potentially helping to address any of these aspects. As shown in Figure 3, more than 70% of cohort participant organizations are interested/engaged in greenhouse gas (GHG) emissions as an aspect of sustainability, second to energy and water. Half already have goals/targets/commitments for GHG emissions, as they do for water and waste. However, while an ISO-based energy management system could theoretically be adapted to manage any resource along with energy, more than half (54%) of responding organizations see using a 50001 Ready EnMS to help manage GHG emissions—far higher than for other resources like water or waste. In other words, the smallest gap between the share of respondents who are engaged in managing a resource and those who see 50001 Ready as helping to do so is for GHG emissions (after energy itself).

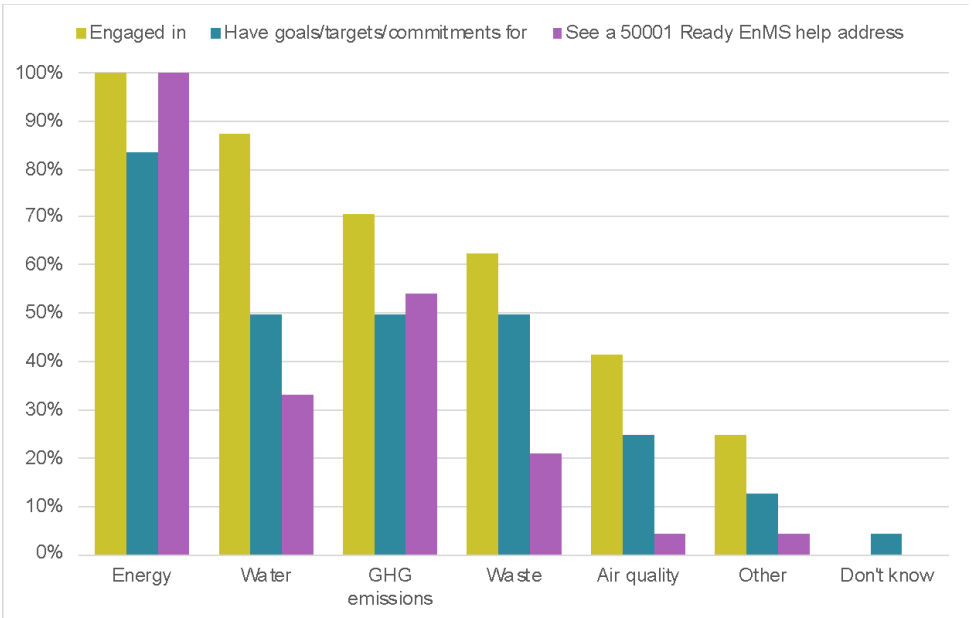

Figure 3. How participants' organizations are engaging in different aspects of sustainability (n = 24).

"Other" responses for organizations related to engaging in aspects of sustainability include "inclusive/collaborative engagement", "corporate citizenship", "social impact",

and "environmental compliance and transportation". "Other" responses with respect to goals, targets, and commitments comprised specific commitments and targets, and the one related to having a 50001 Ready EnMS help address various aspects of sustainability read: "complementing and alignment with ISO 14001 certification" for a respondent that sees such an EnMS helping address energy, GHG emissions, and air quality.

3.2. Energy and Decarbonization-Related Goals, Targets, and Commitments

3.2.1. The Nature of Such Goals

Next, the survey asked participants whether energy- and decarbonization-related goals at their organizations were public/external, internal only, or both public and internal (see Table 1). Overall, energy-related goals were more likely to be internal only than decarbonization ones—a majority of which were both public and internal.

Table 1. Whether energy and decarbonization-related goals/targets/commitments are internal, external, or both (n = 22).

Type of Goal	Energy-Related	Decarbonization-Related
Public/external	18%	23%
Internal	45%	14%
Both public and internal	36%	55%
Unknown	0%	9%

When asked to share existing energy- and decarbonization-specific goals, targets, and commitments via an open-ended question, respondents gave a range of answers, from the vague "reduction" or "improve EUI [energy use intensity]" to specific percentage reductions year-over-year or by a particular year. Others stated commitments such as the U.S. Department of Energy's Better Plants program or U.S. Environmental Protection Agency's ENERGY STAR's Challenge for Industry, which encompass specific targets and timeframes. Table 2 below displays a classification of these goals, showing the share of responding organizations that mentioned an existing goal. In general, respondents representing organizations shared corporate-level commitments more often than facility-level goals, with a marked lack of decarbonization targets at the facility level. Also noteworthy is that specific decarbonization-related targets at the corporate/headquarters level were more often tied to a specific timeframe than corporate/headquarters goals for energy. In addition, those organizations with only internal goals/targets/commitments were more likely to not specify any.

Table 2. Classification of energy- and decarbonization-related goals/targets/commitments (n = 22).

Type of Goal	Goal Exists	Goal Is Quantified *	Time Frame Is Specified
Energy, corporate	75%	41%	27%
Energy, facility	63%	32%	14%
Decarbonization, corporate	71%	41%	36%
Decarbonization, facility	17%	0%	0%

* We consider the two responses stating only "net zero" to be not quantified, given varying definitions for this term.

3.2.2. Drivers for and Context of Setting Goals

The survey also explored the main internal and external drivers compelling participant organizations to set energy- and decarbonization-related goals, targets, and commitments, as well as whether these goals are connected to broader organizational priorities. Responses

to these open-ended questions ranged widely, so we analyzed them by grouping responses into categories and via word frequency analysis.

Taken as a whole, responding organizations cited a wider range of drivers for energy-related targets than they did for decarbonization-related commitments. The single biggest driver of setting energy-related goals was cost savings (11 of 21 responses, or 52%), followed by organizational directives, customer pressure, and regulatory requirements at 19% each, as well as investor pressure at 10%. Responses given by only one respondent were: a changing market, operational efficiency, monetary incentives, building occupants, environmental impacts, increasing resiliency, a culture of excellence, energy efficiency, and "community". In contrast, decarbonization-related commitments were most commonly motivated by regulatory requirements (24%), followed by customer and investor pressure, each at 19%, as well as organizational directives and reducing GHG emissions, each at 14%. A total of 10% of respondents cited cost savings and environmental impacts, with responses from one respondent each as follows: "to be determined" and "community". Broadly, we interpret this as a key finding: GHG targets are motivated chiefly by market imperatives (meeting regulations and satisfying shareholders), while operational excellence goals drive setting energy targets, which can be weakened given other pressures.

Regarding how these targets and goals are connected to broader organizational priorities, responding organizations were asked to give open-ended responses for energy and decarbonization separately. Generally, those related to energy goals were longer than those for decarbonization. Comparing response sets to one another, 8 of the 21 responding organizations (38%) used substantively similar or identical language to describe broader priorities linked to both energy and decarbonization goals. These tended to be sustainability plans, ESG targets, regulatory requirements, or the company's vision. Next, we categorized each response set by assigning inductive codes capturing meaning, using codes developed from the ground up [30]. For organizational priorities related to energy goals, we assigned 27 code references, with the highest number (6 of 27, or 22%) going to cost savings, followed by reducing energy intensity, renewable energy targets, and sustainability plans at 11% each. Also coded more than once were ESG targets and strategic plans. For decarbonization goals, we assigned 23 code references. GHG reduction targets and sustainability plans were the most common codes (4 of 23, or 17%) for responding organizations, after which came ESG targets and regulatory requirements at 8.5% of assigned codes each. This provides some further evidence supporting the key finding in the previous paragraph: broader organizational priorities driving energy management are optional relative to managing carbon.

3.3. Participation in Other Management, Measurement, and Reporting Initiatives and Programs

To understand more about other sustainability initiatives centered on management, measurement, and/or reporting, the survey asked respondents to indicate in which, if any, of 23 specific programs their organization participates, some of which are U.S.-specific. Figure 4 presents these in descending order, showing that at least one quarter of responding organizations were also involved in Leadership in Energy & Environmental Design (LEED) (which typically does not apply to existing buildings' operations or energy performance). ISO 14001 (Environmental Management), and ISO 9001 (Quality Management)—as well as other programs not defined by the survey. "Other" responses include: strategic energy management programs, the U.S. DOE's Better Climate Challenge, utility incentives for energy efficiency, the Association for the Advancement of Sustainability in Higher Education Sustainability Tracking Assessment & Rating System (AASHE STARS), Second Nature Presidents' Climate Commitment, community choice aggregation, "varies at plant level", and "using the 50001 Ready program to organize objectives and actions". These results suggest that 50001-based EnMSs are complementary to a wide array of existing initiatives focused on sustainability, and could be interpreted relative to the research hypothesis that 50001 does not conflict with other decarbonization or GHG-centered programs.

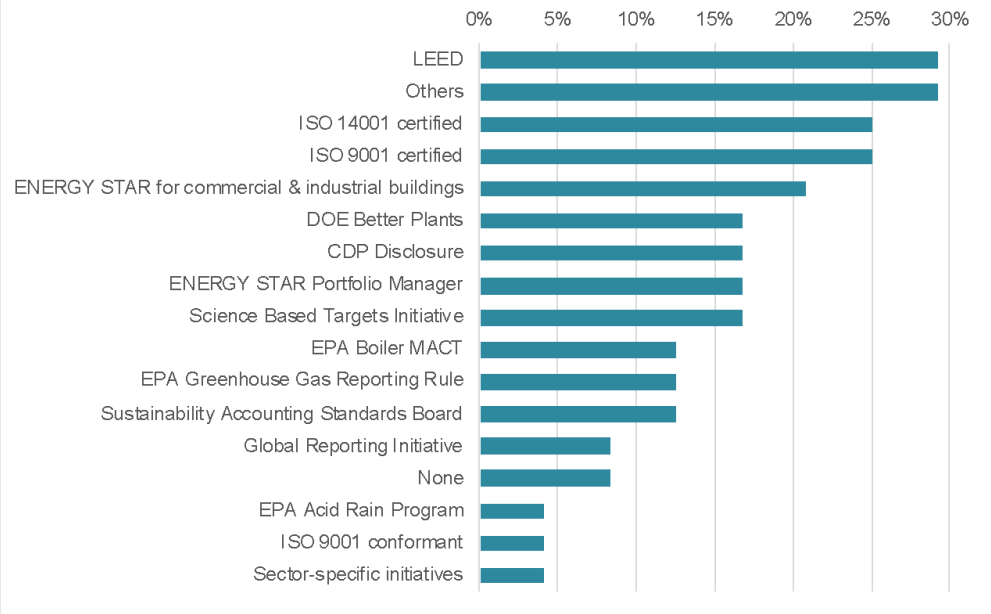

Figure 4. Participants' involvement in other management, measurement, and reporting initiatives and programs (n = 24).

3.4. Scope of Decarbonization Efforts

In order to understand more about cohort participants' approaches to meeting their organizations' decarbonization targets, several survey questions were designed to elicit insight on specific actions participating organizations will take and whether they have any initiatives to influence the energy use and/or carbon emissions of their supply chains. There was also an open-ended question on the organization's overall approach to managing decarbonization. Employing survey display logic for these questions means that only those respondents who answered that their organizations have decarbonization goals/targets/commitments saw the first question, and that the display of the third question was dependent on answering affirmatively to the second question.

Table 3 demonstrates that 9 of 10 respondents—all of those who did not select "don't know"—see a role for energy efficiency in meeting their decarbonization commitments, more than any of the other response options. In addition, almost all respondents stated their organization will rely upon multiple strategies, with only one respondent selecting only one action choosing energy efficiency. This finding gives some assurance that while achieving carbon targets will necessitate a variety of actions, program participants remain focused on improving energy performance.

Table 3. Specific actions participant organizations will take to meet their decarbonization targets.

Action	Share of Respondents (n = 10)
Energy efficiency	90%
Installation of on-site carbon-free energy generation	60%
Procurement of carbon-free energy credits (RECs)	60%
Switching to carbon-free energy	30%
Other *	30%
Procurement of carbon-free energy via green tariffs	20%
Unknown	10%

* "Other" responses included: "Using renewable natural gas for approximately 20% of our fleet", "Engineering solutions such as substitution of more environmentally friendly processes", and "Strategy being developed".

In terms of whether participant organizations consider energy and/or carbon embedded in their supply chains as part of their sustainability commitments, Figure 5 displays that a minority of participant organizations' energy and climate targets include supply chain initiatives. It stands to reason that larger organizations have more influence on their suppliers. Figure 2 demonstrates that most participant organizations are large, yet many are still focused internally at this stage. The survey also contains a question asking whether participants focus on Scope 1, Scope 2, and/or Scope 3 emissions [31]; most targets include Scope 1 and Scope 2 emissions, with a few encompassing Scope 3 emissions as well. The results are not presented here as we have some questions about how participants are interpreting the question, which will be revised for clarity going forward.

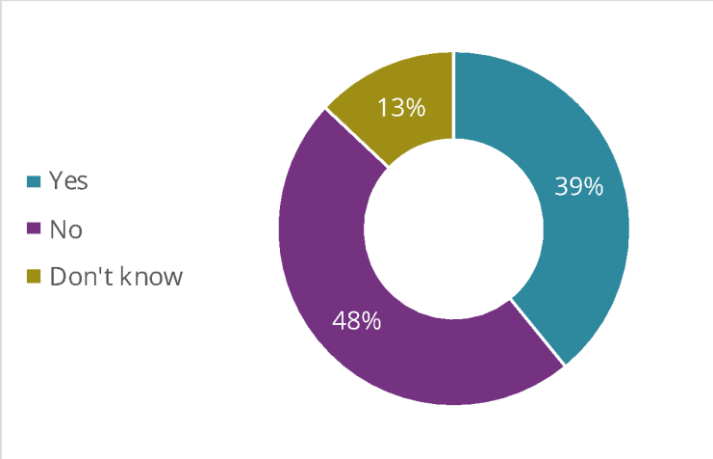

Figure 5. Whether participant organizations have initiatives to influence energy and carbon impacts of supply chains (n = 23).

Turning to how responding organizations are managing decarbonization, we find that most of those organizations with a decarbonization strategy are centering energy management in their approach, providing additional evidence to refute the research hypothesis. To analyze the open-ended responses, we categorized them using inductive coding. In total, 8 of 23 respondents (35%) indicated that their organization is still formulating specific strategies, 1 responded "unknown", and another stated they were unable to disclose. In total, 2 of 23 (9%) asserted that their organization does not have a decarbonization target, with no further detail provided. Of the remaining 11 respondents that briefly described an existing approach, 8 (73%) affirmed that managing energy by increasing efficiency, reducing consumption, and/or implementing a 50001-based EnMS was at the center of their organization's decarbonization strategy. Another respondent whose organization was still determining its approach stated: "We are just getting started. I would say that 50001 Ready is driving the establishment of a decarbonization strategy". In total, 5 of these 11 will rely on renewable energy, both on-site renewables and purchasing carbon-free electricity, while 3 mentioned renewable energy credits (RECs). The same number of respondents stated that they will reduce GHG emissions by replacing processes or technologies where possible.

In exploring relationships between variables, no clear pattern emerged between responding organizations with and without corporate involvement with respect to how they plan to manage decarbonization. When comparing responses for those organizations the program has categorized based on their progress as "close to 50001 Ready recognition" (11 organizations) and "struggling but still committed" (12 organizations), 7 of the 12 "struggling but committed" responses (58%) were still formulating an approach to decarbonization or did not have nor know of one. Figure 6 depicts the connection between individual codes and the program's assessment of progress toward recognition. Those orga-

nizations close to recognition (having made more progress) cited more concrete, substantive actions than the others, while the overlap is in line with what one might expect.

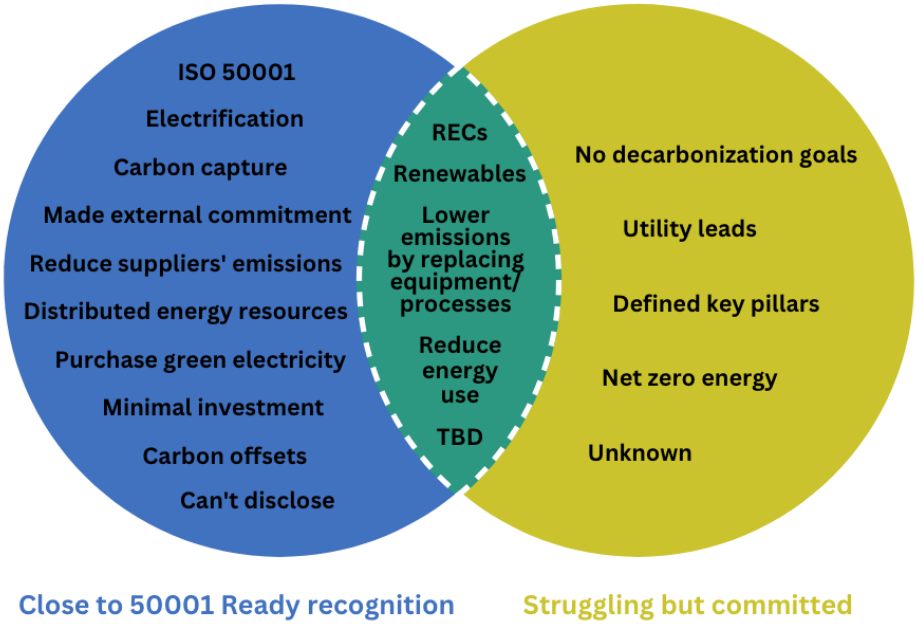

Figure 6. Venn diagram showing a connection between individual codes related to decarbonization approaches and progress toward 50001 Ready recognition.

3.5. Linkages between a 50001 Ready Energy Management System and Decarbonizing

Finally, the survey posed two open-ended questions to cohort participants asking whether and—if yes—they see using a 50001 Ready EnMS to also manage their decarbonization efforts, as well as the single biggest decarbonization-related benefit, if any, that implementation of a 50001 Ready EnMS has brought or will bring to participating organizations. In total, 17 of 22 (77%) responding organizations confirmed that they plan to use 50001 Ready to manage or support the process of decarbonizing. Seven of these explicitly linked reductions in energy consumption to cutting emissions in their responses, with one affirming that "energy efficiency will be our biggest driver for decarbonization"; three respondents see a 50001-based EnMS as a framework or guide to "manage the steps needed to accomplish our goals". One of the three stated: "An EnMS across the company has proven extremely beneficial to begin assessments for decarbonization opportunities across our facilities".

It is initially puzzling to compare the earlier 54% of organizations who see a 50001 Ready EnMS potentially helping to address GHG emissions as an aspect of sustainability to the 77% in the previous paragraph. The earlier question had 24 instead of 22 responses, with 2 who answered "no" to not responding to the latter question. Respondents might also perceive a difference between addressing GHG emissions and decarbonization efforts. Alternatively, taking the survey itself may have led a few respondents to think differently about the potential of 50001 Ready to manage decarbonization/GHG emissions, given that the earlier question was one of the first questions posed while the other was the third-to-last. The survey responses did not suffice to allow for us to determine which of these factors led to this difference. But taken together, responses to both questions support the conclusion that a majority of participating organizations consider 50001 Ready as benefiting their approach to managing decarbonization and/or GHG emissions, both theoretically and practically.

Regarding the single most important decarbonization-related benefit from the implementation of a 50001 Ready EnMS, responses can be split into several rough categories, in descending order of mentions: positive changes to organizational behavior, reduced en-

ergy consumption, and improved standardization and tracking of data and improvements (these latter two have an equal number of mentions). There is some overlap between these categories; for example, the most commonly mentioned behavioral benefit was a larger focus by management and others on reducing energy consumption, followed closely by a better awareness of energy consumption, of the EnMS itself, and of available opportunities. Other stated behavioral benefits include improved engagement, knowledge, collaboration, training, and peer-to-peer networking.

3.6. Nonparametric Tests of Significance for Categorical Data

Most of the data collected via the online survey were categorical in nature. Understanding whether relationships exist between variables such as organizational size and categorical data requires nonparametric statistics. Because differing opinions exist in the literature with respect to whether Pearson's chi-squared (χ^2) test should be employed with a small sample size [32,33], we applied a test that seems most appropriate for our sample: the '$N - 1$' chi-squared test [34].

Tables 4 and 5 below are frequency tables for two potential relationships between variables: whether participants see a 50001 Ready EnMS potentially helping to address GHG emissions (the same data as Figure 3) is correlated with their progress in the cohort program toward 50001 Ready recognition or whether it is correlated with organizational size. In both cases, the sample size is 23 organizations. One organization not shown in Table 4 had an equal number of sites split between "close to recognition" and "struggling, but committed" status, while one not shown in Table 5 did not disclose the number of employees.

Table 4. Comparison of whether cohort participant sees role for 50001 Ready in managing GHG emissions, split by extent of progress toward 50001 Ready recognition.

	Sees Role	Does Not See Role	Total
Close to 50001 Ready recognition	8	4	12
Struggling, but committed	4	7	11
Total	12	11	23

Table 5. Comparison of whether cohort participant sees role for 50001 Ready in managing GHG emissions, split by organization size.

	Sees Role	Does Not See Role	Total
SME (<250 employees)	3	1	4
Large organization (≥250 employees)	9	10	19
Total	12	11	23

The results from Table 4 for the '$N - 1$' chi-squared test are: $\chi^2 = 2.02$ and $p = 0.2$.

The results from Table 5 for the '$N - 1$' chi-squared test are: $\chi^2 = 0.97$ and $p = 0.3$. Taken together, neither of these results are significant at $p = 0.1$ or 0.05, meaning that associated implicit null hypotheses (that there is no relationship between cohort progress or organizational size and whether participants see a 50001 Ready EnMS helping to manage GHG emissions) cannot be rejected. Note that with small sample sizes, statistically significant results will typically not be attained unless effect sizes are large enough to be significant in practice [35]. As this project and the associated data collection continue, we anticipate being able to examine a large number of other potential relationships in a similar manner as additional data are gathered, as agreed upon with participants.

4. Discussion

This study of participants in the 50001 Ready technical assistance cohort program was carried out under the research hypothesis that EnMSs are seen by organizations to mainly affect energy performance, with scant linkages to decarbonization. The paper represented an opportunity to reflect mid-program on the collected evidence to test this hypothesis, as well as to understand which improvements to make to the program and associated data gathering efforts. While more data will continue to be collected, we can state from the evidence so far that the hypothesis is incorrect. Further data are likely to inform a revised hypothesis, or additional hypotheses, regarding the relationship between 50001 Ready and decarbonization efforts.

We reject the research hypothesis given the following evidence summarized from a mid-program survey of 24 organizations (48% response rate). Section 3.1 demonstrates that the majority of organizations participating in a cohort program focused on achieving 50001 Ready implementation are theoretically interested in using 50001 Ready to manage GHG emissions, second only to energy among other aspects of sustainability. Section 3.2.1 shows that decarbonization goals/commitments at participating organizations are more likely to be external than energy targets; it is reasonable to assume that organizations are more likely to be held accountable for, and likely achieve, external targets. Section 3.2.2 underlines this interpretation by demonstrating that the most common rationales for setting decarbonization targets are related to market forces and customer, investor, and regulatory pressure, while energy targets tend to be related to cost savings and other positive yet less essential organizational goals. The results presented in Section 3.4 confirm that participants consider energy efficiency as central to their decarbonization efforts—and that those organizations who made good progress in the cohort program tend to mention more specific and significant decarbonization strategies and actions than others. Finally, Section 3.5 substantiates that more than three quarters of responding organizations regard 50001 Ready as a way to manage and at least support their decarbonization processes, with several explicitly affirming its importance as a framework, especially to improve organizational behavior.

Next, we put some of these findings and their implications into a broader context, which also brings future research directions into sharper focus. As the connection between energy management systems and cutting GHG emissions becomes clearer, experts rightly do not wish to lose the focus on improving energy performance as a decarbonization strategy. The results presented in Section 3.4 affirm that program participants see energy efficiency as an essential pillar to decarbonizing. Based on Section 3.5 and in alignment with a recent white paper [36], we posit that 50001 enables a process for the consideration of many different types of actions required to reduce GHG emissions, including energy efficiency, demand-side energy management activities, fuel switching, on-site generation, and managing emissions embedded in supply chains, among others. In addition, Section 3.2 pertains to energy and decarbonization targets and commitments. According to the literature, specific, quantified, and time-bound targets are key drivers for action; science-based targets specifically must be theoretically achievable, continually quantified, and supported by a clear rationale as to why they are set at a particular level [37,38]. The finding relating decarbonization (and not energy) commitments to market forces in Section 3.2.2 holds significant meaning if regarded as providing a far stronger drive to achieve these targets. We also hope that our continued data collection efforts or future work by others will allow for 50001-based energy management systems to be better linked to improved decarbonization outcomes, which in turn would raise the profile of 50001 as a means to successfully meet the market imperatives of decarbonization.

Given that this paper represents the analysis of a survey in the middle of a cohort program that is still underway, further analysis of the data can give clues to what could be learned from a refined survey instrument administered to future participants. One question relates to Section 3.3, demonstrating the multitude of other programs in which participating organizations are also engaged. We are unsure what this means beyond there

being a large number of seemingly complementary programs. However, we are unaware that a map of such (and similar other) programs, their purview, and their overlap exists, meaning that confusion may be hindering progress. This highlights a potential research opportunity that would enable organizations to understand more about which suite of programs would suit their needs. In addition, this could be an opportunity for the cohort coaches or third-party experts to check with individual participating organizations whether 50001 Ready is a good fit with other programs in which they are involved, potentially yielding some lessons learned that other cohort members could emulate. Another question relates to understanding the difference between seeing 50001 Ready as potentially helping to address GHG emissions versus being leveraged to manage or support decarbonization. We will consider revising the survey questionnaire to clarify what is meant by each of these questions to reduce confusion for future respondents and/or reach out to those who responded for this analysis to discuss whether they perceive a difference. In addition, in hopes of ensuring that more responses survive the data-cleaning process (i.e., that only intended respondents based on their role in the cohort are receiving the survey link), we will refine the instructions for coaches on who is intended to respond to this and other cohort surveys in concert with improving data transparency for the program (e.g., ensuring rosters of participants are current). In any case, we anticipate that continued data collection for this cohort program will amass more data that will be used to deepen—either further confirming or complexifying—the initial findings this paper establishes.

Additional future research directions include providing evidence for the hypothesis that decarbonization outcomes are better if organizations successfully exploit energy management systems' rigor, structure, and continual improvement approach. If leaders of organizations understand the links between 50001-based EnMSs and meeting decarbonization objectives posed by market imperatives, and investors become aware that decarbonization is better managed with a 50001-based EnMS in place, the uptake of 50001 programs is likely to sharply increase.

5. Conclusions

The pressure to decarbonize presents an organization with many unfamiliar options; in this landscape characterized by uncertainty, making sound business decisions can be daunting. Pursuing an energy management system such as 50001 Ready means relying on a logical, tested approach to making good choices over an indefinite time period. Examining participants in the 50001 Ready cohort program indicated that 50001-based energy management systems hold real promise for being a mechanism that meaningfully leads diverse organizations toward meeting (or at least being on their way to achieving) their decarbonization targets. Perhaps interesting to policy makers is that, at least at this point in time, a suggestion that factors external to the organization were more supportive of their decarbonization efforts than internal considerations. Learning that diverse organizations can realize the value of 50001-based energy management systems, as evidenced by the initial results from this study, provides optimism that organizations of different types can successfully navigate the path to decarbonization.

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