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FINAL PROJECT REPORT

The Decarbonizing Healthcare Guidebook
A Living Resource for Emerging Energy Efficiency Equipment and Systems

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division manages the Gas Research and Development Program, which supports energy-related research, development, and demonstration not adequately provided by competitive and regulated markets. These natural gas research investments spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

The Energy Research and Development Division conducts this public interest natural gas-related energy research by partnering with RD&D entities, including individuals, businesses, utilities and public and private research institutions. This program promotes greater gas reliability, lower costs and increases safety for Californians and is focused in these areas:

- Buildings End-Use Energy Efficiency
- Industrial, Agriculture and Water Efficiency
- Renewable Energy and Advanced Generation
- Natural Gas Infrastructure Safety and Integrity
- Energy-Related Environmental Research
- Natural Gas-Related Transportation

The Decarbonizing Healthcare Guidebook: *A Living Resource for Emerging Energy Efficiency Equipment and Systems* is the final report for Agreement Number PIR-19-016, conducted by Mazzetti. The information from this project contributes to the Energy Research and Development Division's Gas Research and Development Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

This project conducted research on decarbonization technologies that reduce natural gas consumption in heating, ventilation, and air conditioning applications for space and water heating in healthcare buildings and other large commercial buildings for the purpose of reducing operational carbon emissions. Operational carbon emissions are a result of the consumption of energy to operate a facility, including natural gas, electricity, propane, diesel fuel, fuel oil, etc. In the United States, inpatient hospitals have the second largest energy use intensity of any building type, mainly due to constant 24/7 operation and the energy demand to operate critical life-saving systems. Globally, the healthcare industry is responsible for nearly 5 percent of total net emissions. The California Global Warming Solutions Act of 2006 mandates that statewide emission must decrease to 40 percent of 1990 emissions, and California Assembly Bill 3232 targets a 40 percent reduction in greenhouse gas emissions from all residential and commercial buildings by 2030.

This information has been written and assembled into a guidebook to serve as a resource for healthcare facility owners, design engineers, architects, and other stakeholders to decarbonize their buildings. A team of engineering experts researched and collected information on the background, technical description, implementation strategies, and potential barriers to implementation of various decarbonization technologies and compiled a narrative on how each technology helps to decarbonize a healthcare building when compared to the current design methods for a healthcare building. The research and report are presented on a website as a living resource that can constantly be updated to include the most relevant information available.

Please use the following citation for this report:

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Executive Summary

Background

Healthcare buildings, including hospitals, are the second largest consumer of energy per floor area of all building types. Large, sophisticated heating, ventilation, and air conditioning systems and water heating systems are required to satisfy the demand of these facilities that have 24/7 operations and are occupied by thousands of patients, employees, and visitors every day. These systems consume a substantial amount of natural gas statewide. Unlike other sectors in the United States that have reduced greenhouse gas emissions, healthcare-related greenhouse gas emissions increased 30 percent between 2006 and 2016. The California Global Warming Solutions Act of 2006 mandates that statewide emission must decrease to 40 percent of 1990 emissions, and California Assembly Bill 3232 targets a 40 percent reduction in greenhouse gas emissions from all residential and commercial buildings by 2030. To help achieve California's important climate change policies and mandates, there is an immediate need to identify advanced energy efficiency solutions for hospitals that will reduce natural gas use, increase efficiency, and reduce energy costs, while maintaining or improving patient safety and hospital operations. Achieving these goals will require developing clear guidance for key stakeholders — engineers, designers, hospital operators, and regulatory agencies — so they can deploy state-of-the-art energy efficiency approaches that will minimize natural gas use and decarbonize hospitals.

On Earth Day 2022, the White House and the U.S. Department of Health and Human Services launched the Health Sector Climate Pledge, a voluntary commitment to climate resilience and emissions reduction that includes cutting greenhouse gas emissions by 50 percent by 2030 and achieving net zero emissions by 2050. A group of 116 organizations representing 872 hospitals signed the pledge as of April 12, 2023. In addition to hospitals, these stakeholders include health centers, suppliers, insurance companies, group purchasing organizations, pharmaceutical companies, and more. Federal systems like the Indian Health Service, Veterans Health Administration, and Military Health System are coordinating to meet goals similar to those the private sector organizations have embraced. Combined, this means that more than 1,120 federal and private sector hospitals have made such commitments, together representing more than 15 percent of United States hospitals.

To meet the state of California's goals and the Health Sector Climate Pledge goals, the design of buildings must be changed so that by 2030 every new building has net-zero carbon emissions while also reducing the emissions from all existing buildings by half. It became clear that a technical resource, or guidebook, was necessary to help healthcare organizations and their partners decarbonize their existing building stock.

Project Purpose and Approach

To meet that need, the project team from Mazzetti produced *Decarbonizing Healthcare Guidebook: A Living Resource for Emerging Energy Efficiency Equipment and Systems* (Guidebook)*,* a comprehensive and interactive guidebook on existing and emerging energy

efficiency equipment and systems and design improvements to help substantially reduce natural gas use, increase efficiency, and provide a clear path to decarbonizing the entire healthcare industry. In partnership with hospital engineers and designers, and state regulatory agencies, the project team used its extensive experience in technology and design for the healthcare industry to create a publishable and interactive online version — a living resource — of the Guidebook that will help ensure that this Guidebook maintains its relevance for many years and is updated with the new, innovative technologies. The Guidebook is housed in an online platform, called Decarb Healthcare, (Website), which enables stakeholders to post new knowledge, ask questions, and report on progress, as well as enable continuous updates of the Guidebook with leading technologies and lessons learned from real world applications. This important feature allows hospitals to work according to their own schedules for retrofitting their facilities. The Website can be accessed at www.decarbhealthcare.com.

The Decarb Healthcare website will encourage the growth of a community of engineers, architects, and other healthcare design and operations professionals to share knowledge and experiences with one another, while working toward the same goals to minimize natural gas use and decarbonize their facilities.

Key Results

The project team publicly launched the Decarb Healthcare website through a virtual workshop in July 2023. As of August 2023, there were 156 registered users including members from 15 healthcare organizations around the nation. Since the launch, Decarb Healthcare website has received high praise from the California Energy Commission, healthcare organizations, and members of the healthcare design community across the country.

The Guidebook is now publicly available and serves as a critical resource for healthcare organizations to leverage as they navigate through their journey towards decarbonization and meeting statewide and health sector goals. *Decarbonizing Healthcare Guidebook* is found at https://www.decarbhealthcare.com/guidebook/506.

Knowledge Transfer and Next Steps

The Website, (https://decarbhealthcare.com), and Guidebook are free online resources available to the public. The project team held a public launch workshop in July 2023 to share the Guidebook and promote its use among the healthcare design community. The well-attended launch workshop had more than 70 attendees and featured two keynote speakers, Dr. Richard Jackson, professor at the Fielding School of Public Health at University of California, Los Angeles, and Dr. Victor Dzau, president of the National Academy of Medicine, who set the stage on the current state of the climate and decarbonization throughout the healthcare industry. The launch also featured Mazzetti Chief Executive Officer, Walt Vernon, and Cecilia Deloach Lynn, Director of Sector Performance and Recognition at Practice Greenhealth.

The project team is developing a marketing campaign plan to share the Decarb Healthcare website with its entire network through email blasts and various marketing communications.

The project team also plans to share the Guidebook and its updates during Mazzetti's *Bending the Climate Curve* monthly workshop series running into 2024.

Since 2022, Mazzetti has presented the Decarb Healthcare website and Guidebook content at various industry conferences. Past conference presentations include the American Council for an Energy Efficient Economy Hot Air Forum 2023 in San Diego, California, in March 2023, where Mazzetti presented a list of technologies that are included in the Guidebook. The project team did a deeper dive into a few select technologies such as variable air volume ventilation and the California Energy Commission's indoor air quality-based ventilation study, as well as dehumidification technologies like desiccant systems and dedicated outdoor air systems. More presentations were made at the CleanMed 2023 Conference in Pittsburgh, Pennsylvania in May 2023, where Mazzetti presented a list of technologies that the Guidebook will detail and other features such as potential code changes and the Global Carbon Challenge.

Mazzetti presented the Guidebook and Decarb Healthcare website at other conferences including Pennsylvania State Healthcare Facility Engineers in September 2023 and the Healthcare Design Conference in New Orleans, Louisiana in November 2023.

CHAPTER 1:
Introduction

Healthcare buildings, including hospitals, are the second largest consumer of energy per unit of floor area of all building types. Large, sophisticated heating, ventilation, and air conditioning (HVAC) systems and water heating systems are required to satisfy the demand of these facilities that have 24/7 operations and are occupied by thousands of patients, employees, and visitors every day. These systems consume a substantial amount of natural gas statewide. Healthcare-related greenhouse gas (GHG) emissions in the United States unfortunately increased 30 percent between 2006 and 2016, while other sectors have made progress to reduce GHG emissions.

To meet California's decarbonization mandates intended to mitigate the effects of global climate change, building owners, architects, design engineers, and others must change the way buildings have been designed and operated. They must design new net-zero emissions buildings and decarbonize their existing buildings through retrofit projects. There was a need for a guidebook to educate those building owners and design professionals on the best and most cost-effective ways to achieve building decarbonization for both new and existing buildings. California Energy Commission's grant funding of the *Decarbonizing Healthcare Guidebook: A Living Resource for Emerging Energy Efficiency Equipment and Systems Project* (Guidebook) has supported the creation of that resource, which is free to California ratepayers and the general public.

Mazzetti, an engineering company focused on creating healthier environments with experts in climate action consulting, building commissioning and retro commissioning, and lighting design, is the prime grant recipient and project manager for this grant agreement. Mazzetti's project team developed the Guidebook, a comprehensive and interactive guidebook on existing and emerging energy efficiency equipment and systems, housed on an online platform called Decarb Healthcare (Website). The Guidebook includes customized design improvements to help substantially reduce natural gas use, increase efficiency, and provide a clear path to decarbonizing hospitals. The project team collaborated with hospital engineers and designers, as well as state regulatory agencies and healthcare nonprofits and organizations, to develop this design guide. This online interactive tool is intended to aid hospitals in the planning and design of retrofit projects to substantially reduce operating costs and meet the state's decarbonization goals. The Guidebook will serve as a reference tool for hospital owners, operators, designers, architects, engineers, and regulators to understand the benefits of using advanced technologies and designs to minimize natural gas use, reduce GHG emissions, reduce healthcare costs, and provide benefits for investor-owned utility ratepayers. To accommodate new and future technologies and to maintain the Guidebook's relevance beyond the grant agreement, Mazzetti's Sustainability Practice has agreed to continue to manage and update the interactive online platform of the Guidebook.

# CHAPTER 2:
Project Approach

Creating the Guidebook

Designing the Guidebook

When designing the Guidebook, the project team thought about what such a resource would look like and how it could stay relevant in such a fast-changing environment. A hardcopy guidebook may quickly lose relevance and exclude the valuable resource of crowd-sourced input. The project team sought to develop something different, a living resource to change and grow alongside the industry and technology.

The Decarb Healthcare website has two primary features: one behind the scenes where the project team's research and main content is available to the public in the first released version of the Guidebook. The other side allows the public's input through comments on each chapter of the Guidebook as well as allows the capability for any registered users of the site to submit their own topics and content to be added to the Guidebook, after review from the project team Website moderators.

Lastly, the project team wanted to incorporate a tool that would help provide some context to the Guidebook content for the user. This tool generates a custom approach and strategy and puts the Guidebook chapters in perspective based on whether the facility is an existing building or new construction, the type of installed heating equipment (steam, hot water, or other), and the climate zone in which the facility is located. Figure 1 shows the project team's whiteboard mockup of the Guidebook during the beginning of the brainstorming process.

Figure 1: Guidebook Vision Board
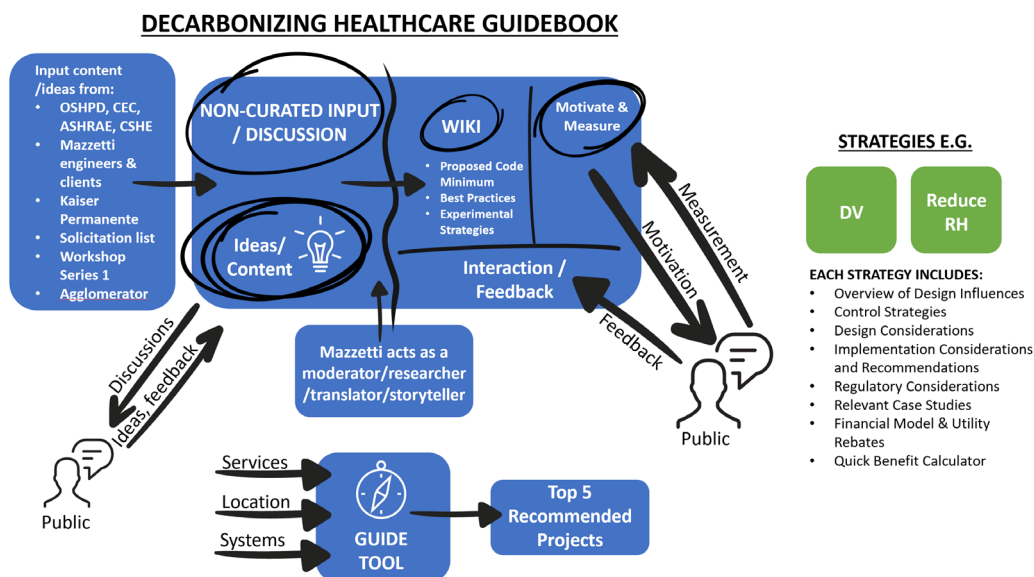
Source: Mazzetti, 2020

The project team was aided in the design of the Decarb Healthcare website by a subcontractor Swenson He, a Los Angeles, California-based software developer with expertise in user experience and user interface front- and back-end development. Swenson He helped turn the project team's vision board into reality with thoughtful features and functionality and helped incorporate Mazzetti's internal knowledge management system, called Guru, into the Guidebook to enable a fast and easy editing of the Guidebook content, without needing a software engineer or Website designer to perform the edits. This system was already familiar to the project team and using it for the Guidebook made for a very efficient content uploading and editing process, the behind-the-scenes aspect of the Guidebook that is critical to its ongoing success.

Developing the Content

With the Guidebook framework in progress, the project team began to research and write the Guidebook content. The project team planned and conducted the first of a series of virtual workshops, eight in total, in early 2021 that focused on specific decarbonization technologies within a hospital building. These workshops encouraged discussions from the "decarb community" — those members who registered on the Website — and provided the project team with a framework in which to conduct further research and develop content for each chapter.

Sixty to one hundred participants from across the globe attended each workshop. At these workshops, invited special guest speakers presented information to provide context and background information about the topic, followed by an interactive breakout session in which all participants were divided up into smaller working groups to answer questions that were posed by the host.

The workshops covered decarbonization technology strategies to reduce building loads and minimize reheat through redesigning ventilation setpoints and implementing smart building controls; electrify central utility plant equipment by replacing fossil fuel-fired boilers with a combination of air-source heat pumps, ground-source heat pumps, heat recovery chillers, and renewable thermal energy generation equipment; redesign domestic hot water systems by using heat pumps and solar thermal; determine new ways to handle process steam and humidification loads through electric steam generators or alternative non-steam approaches such as adiabatic humidification; and store heat and shift peak loads through thermal energy storage methods. Another workshop explored various financing methods and strategies to pay for decarbonization. A later workshop was held to share stories of actual healthcare organization's decarbonization journeys.

Table 1 lists workshops with a summary for each.

Table 1: Workshop Series 1 Summary

Workshop Number	Workshop Title	Date Held	Number of attendees	Link to workshop details
0	Kickoff to the Decarbonizing Healthcare Guidebook Workshop Series 1	02/09/2021	105	https://decarbhealthcare.com/guidebook/553
1	Reduce Loads Through building Optimization / The First R: Reduce	02/23/2021	98	https://decarbhealthcare.com/guidebook/554

Workshop Number	Workshop Title	Date Held	Number of attendees	Link to workshop details
2	Natural Gas Boilers: 20th Century Marvel	03/09/2021	81	https://decarbhealthcare.com/guidebook/555
3	Smart Water: Redesigning Domestic Hot Water systems	03/24/2021	32	https://decarbhealthcare.com/guidebook/556
4	Let off Some Steam: Decarbonizing Humidification and Sterilization Systems	04/06/2021	75	https://decarbhealthcare.com/guidebook/557
5	Thinking Outside the Grid	04/20/2021	75	https://decarbhealthcare.com/guidebook/558
6	Codeword: Decarbonize	05/04/2021	57	https://decarbhealthcare.com/guidebook/559
7	Show Me the Money: Funding Decarbonization	05/25/2021	68	https://decarbhealthcare.com/guidebook/560
8	Our REAL Decarb Journey	11/17/2021	82	https://decarbhealthcare.com/guidebook/561

Source: Mazzetti, 2023

These workshops led to the identification of many decarbonization technologies and strategies that were researched for use in the Guidebook. The approved list included technologies that could be implemented today to decarbonize a healthcare building. These technologies have been proven in various installations around the world, if not specifically in hospitals in the United States. Other emerging technologies or other concept technologies have been added or will be added in the future as more research is done and as the technology advances. Another benefit of having a living resource is that the Guidebook will always have the most updated information and will not become dated or obsolete.

Table 2 is a list of technologies that were identified and approved for research and writing following Workshop Series 1.

Table 2: List of Decarbonization Technologies

Section	Technologies
Load Reduction	• Variable Air Volume Ventilation • Retro commissioning of Building Controls • Displacement Ventilation • Better Zoning and Unoccupied Mode Strategy • Building Envelope Improvements • Improving Accuracy of Load and Energy Modeling
Dehumidification	• Dedicated Outdoor Air Systems • Desiccant Systems • Dehumidification Using Chilled Water Return Based Reheat

Section	Technologies
If You Must Have a Gas-fired Boiler	• Condensing Boilers • Boiler Temperature Reset • Right-sized Boilers • Stack Gas Economizers
Central Plant	• Heat Recovery Chillers • Heat Pumps • Solar Thermal Water Heating • Ground Source Heat Pumps and Geothermal • Local Heating Systems
Domestic Hot Water	• Domestic Hot Water Heat Pumps • Single Temperature Handwashing • Waste to Energy
Steam	• Electric Steam Generators • Concentrating Solar Thermal Collectors • Adiabatic Humidification • Chemical Sterilization
Load Shifting and Energy Storage	• Sensible Heat Thermal Storage • Latent Heat Thermal Storage aka Phase Change Material Energy Storage • Compressed Air Energy Storage • Large Thermal Mass in Buildings

Source: Mazzetti, 2023

Who Can Use the Guidebook?

The Guidebook was developed with a few perspectives in mind. First, the project team sought to develop a resource for healthcare building owners to leverage when creating their sustainability and carbon neutrality plans. Understanding the available technologies and how they could be integrated in an organization's existing facilities and also be designed into future new construction projects will help the facility directly influence their scope 1 emissions from the on-site combustion of fossil fuels. Scope 1 emissions are direct greenhouse gas emissions that occur from sources that are controlled or owned by an entity (for example, emissions associated with fuel combustion in boilers and furnaces).

Second, meeting the state's carbon neutrality goals will be challenging if facilities continue to be built the same way they have historically been built. This Guidebook is not intended to serve as a design manual for the building, but it should help engineers understand how to use these technologies in a decarbonized hospital. The status quo must be changed to create a new building standard without any fossil fuel-fired equipment installed in new construction. This responsibility largely falls on the architects and engineers to design facilities using new low- or no-carbon technologies. Heat pumps and heat recovery chillers must be the cornerstone of every facility moving forward, and architects and engineers must not allow

these technologies to be "value engineered" out of designs and the building design to proceed with cheaper gas-fired boilers or because "that's the way it's always done."

Architects and engineers must be promoters and shepherds of decarbonized building design strategies. Architects can take these ideas back to the design team and inspire the designers to decarbonize the building and push the engineers to do things they weren't planning to do. And engineers can use this to look for alternative, carbon-neutral ways to do what the client is asking them to do. Engineers who are self-motivated can use this resource to determine innovative ways to design a building.

Navigating the Website and Using the Guidebook

The resulting product of the project approach is a user-friendly, well thought out, and easy to access resource publicly available online at https://www.decarbhealthcare.com. The Website houses the Guidebook along with some other features the project team thought would provide value to the reader, including a motivation plan page to help mobilize and promote decarbonization within an organization. This motivation page also provides details on a global carbon challenge, where healthcare organizations can win awards and gain recognition for their decarbonization progress. Other features include a custom strategy tool to help any reader put this information into the context of their own facility type and climate.

Navigation

To navigate through the Website, the visitor can view the menu located at the top of each page and links to each of the different sections of the Website as well as the user log in and sign up (Figure 2).

Figure 2: Decarb Healthcare Website Tool Bar
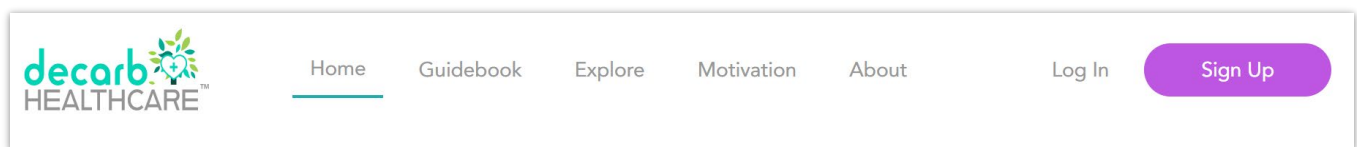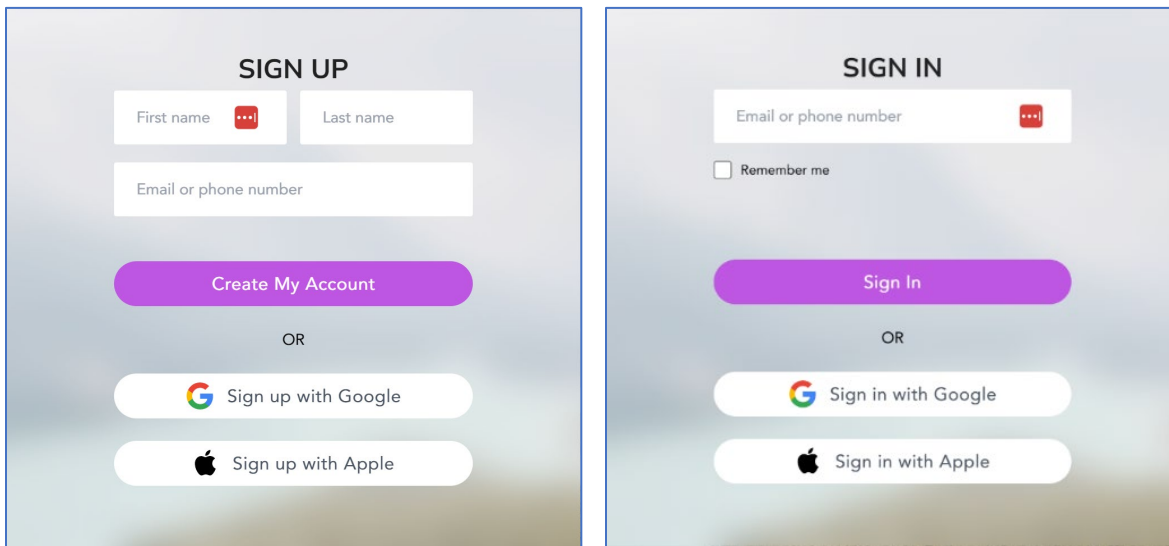

Source: Mazzetti

User Login and Sign Up

https://decarbhealthcare.com/signup
https://decarbhealthcare.com/login

The top right corner of the Website has a button to log in or sign up to the platform. The visitor is prompted to create an account to enable additional features such as content customization, commenting, liking content, and receiving notifications (Figure 3).

**Figure 3: Decarb Healthcare Sign In**

Source: Mazzetti

Homepage

https://decarbhealthcare.com/

When the visitor first arrives on the homepage of decarbhealthcare.com, the title of the Guidebook and background image are shown along with a call to action. Scrolling down reveals some paths for engaging with the Guidebook such as How [do we decarbonize healthcare]?... Reduce, Electrify, and Advocate. Further down the page is introductory content on Current Climate and Decarbonization, which explain the global problem. Finally, visitors are invited to register for the platform and join the Decarb Community (Figure 4).

Figure 4: Decarb Healthcare Home Page
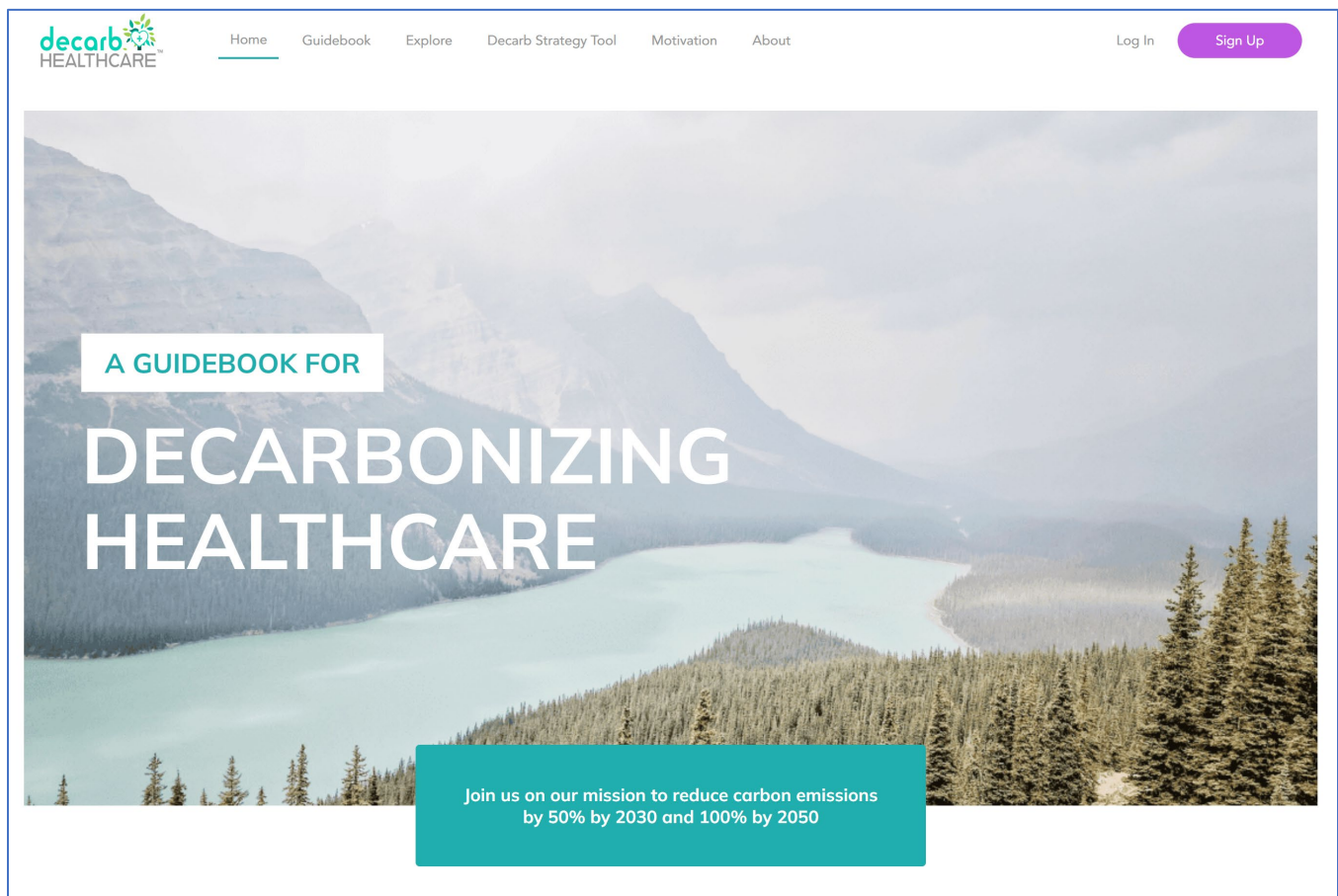
Source: Mazzetti

Guidebook: https://decarbhealthcare.com/guidebook/506

The Guidebook tab is where the visitor finds the main resource of this Website: the Guidebook itself. Navigating to this tab takes visitors to a directory page where they can access the content in the Guidebook in its entirety (Figure 5).
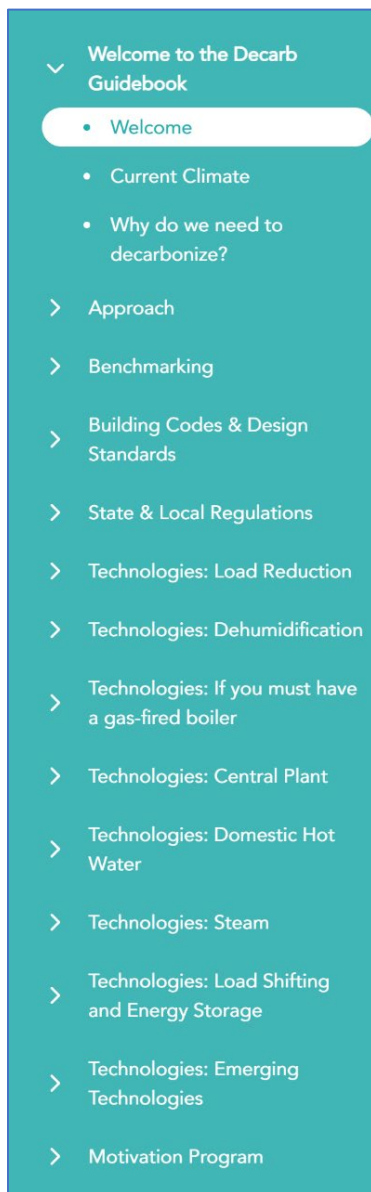
Figure 5: Decarb Healthcare Directory Page
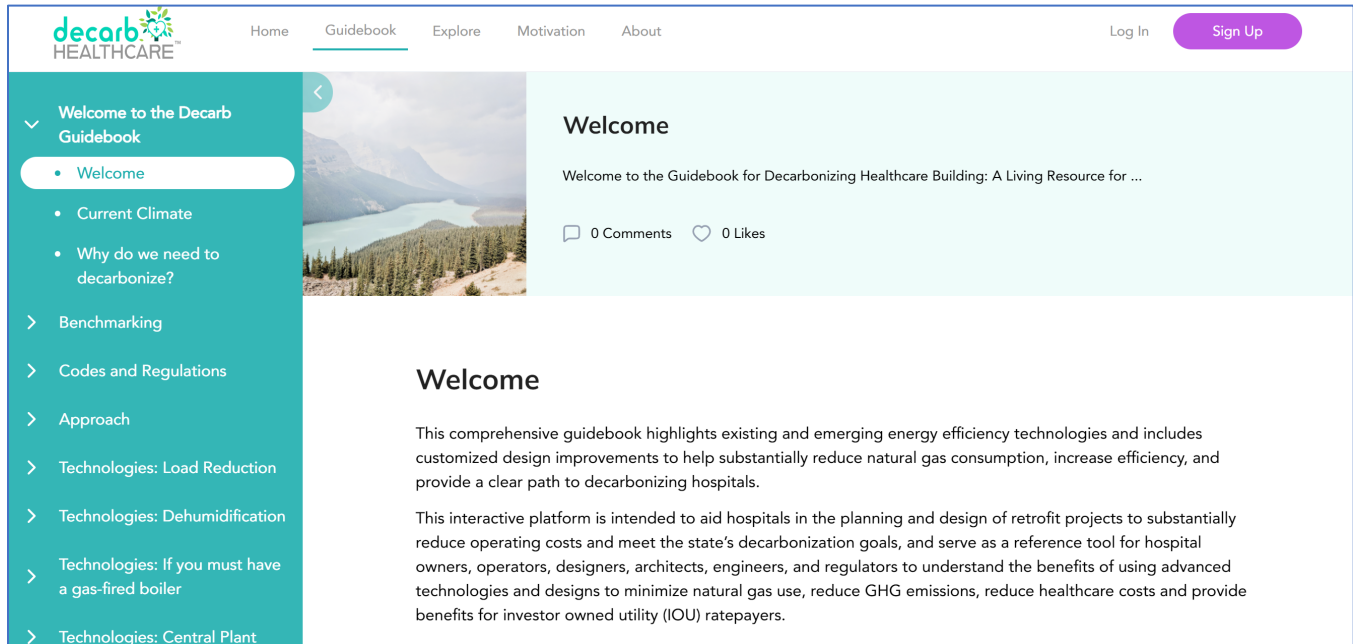
Source: Mazzetti

Table of Contents

The table of contents (Figure 6) is shown as the green bar and will help the user navigate to each of the Guidebook chapters. The menu features expanding and collapsing titles that reveal subheadings under each chapter.

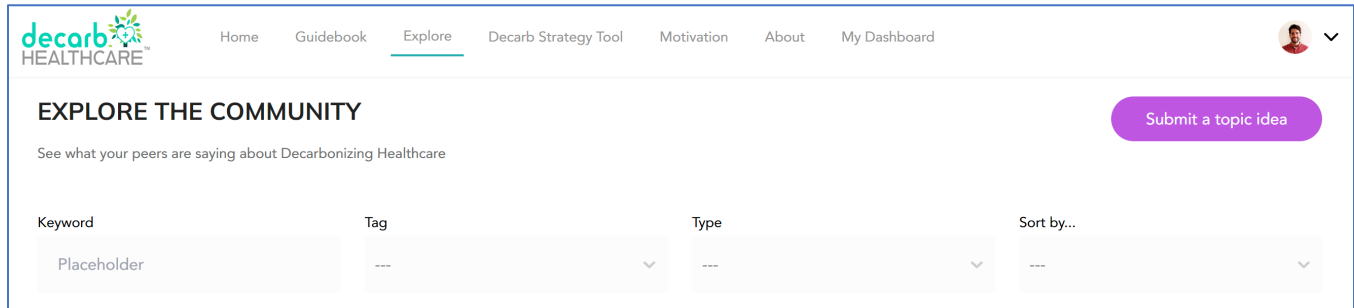**Figure 6: Decarb Healthcare Table of Contents**

Source: Mazzetti

Explore

The search bar allows the user to search and filter the Guidebook for specific content. There are four ways to filter the Guidebook content: keyword search, tag filter, type filter, and sort by (Figure 7)

Figure 7: Decarb Healthcare Search

Source: Mazzetti

- **Keyword:** By typing the query into the keyword search bar, search results will display all Guidebook content with that keyword in the article or title.

- **Tag:** Filtering via tags will return all chapters and sections that have been labeled with the same tag. The project team tagged each chapter and section with various labels related to the content. By clicking on the dropdown menu and selecting a tag, results will display all content with that tag. Example tags include new construction or retrofits, capital projects or low hanging fruit, electrification technologies or domestic hot water technologies.

- **Type:** Filtering via type will return all content of a certain type. Types of content include technology, executive summary, case studies, motivational, and workshops.

- **Sort by:** Sorting will allow the user to view the results in different orders, such as most recently posted topics, most liked topics, most commented topics, and latest commented topic.

Decarb Strategy Tool

https://decarbhealthcare.com/tool

The Decarb Strategy Tool will provide the user with a custom strategy narrative based on their own facility and answers to a series of questions (Figure 8). These custom strategies detail a general guide to the process of decarbonizing a healthcare facility. The tool will generate a unique narrative for the user based on whether the user's facility is an existing building or new construction, whether it has steam heating equipment, water heating equipment, or other equipment, and depending on the climate zone in which the facility is located. Users must be registered and signed in to use this feature.

Figure 8: Decarb Healthcare Strategy Tool
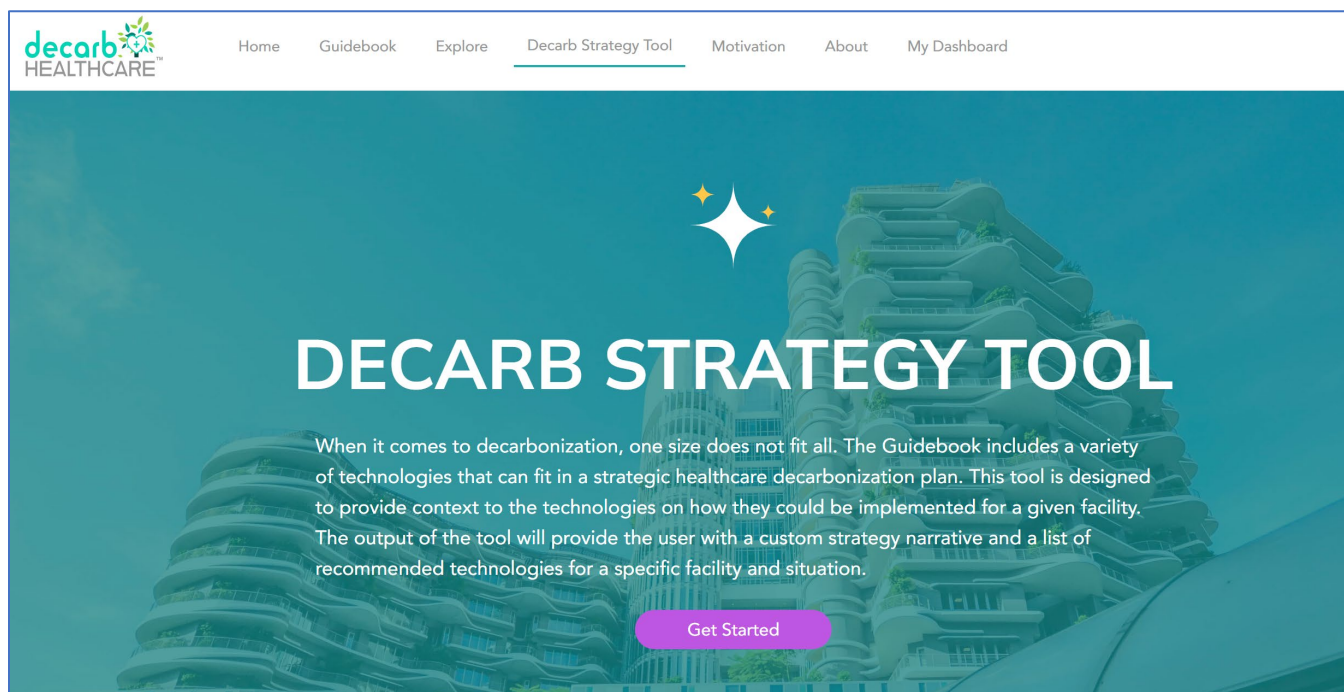
Source: Mazzetti

Motivation Program

https://decarbhealthcare.com/motivation

The Motivation tab is where users will find information about motivational programs, the White House's Health Sector Climate Pledge and information on Global Carbon Challenge, in partnership with the International Federation of Healthcare Engineering (Figure 9).

Figure 9: Decarb Healthcare Motivation Program

Source: Mazzetti

About

The About tab will take users to a page where they can learn more about the mission of this Website and its creators, including the experts that performed the research and wrote the content (Figure 10).

Figure 10: Decarb Healthcare About Project
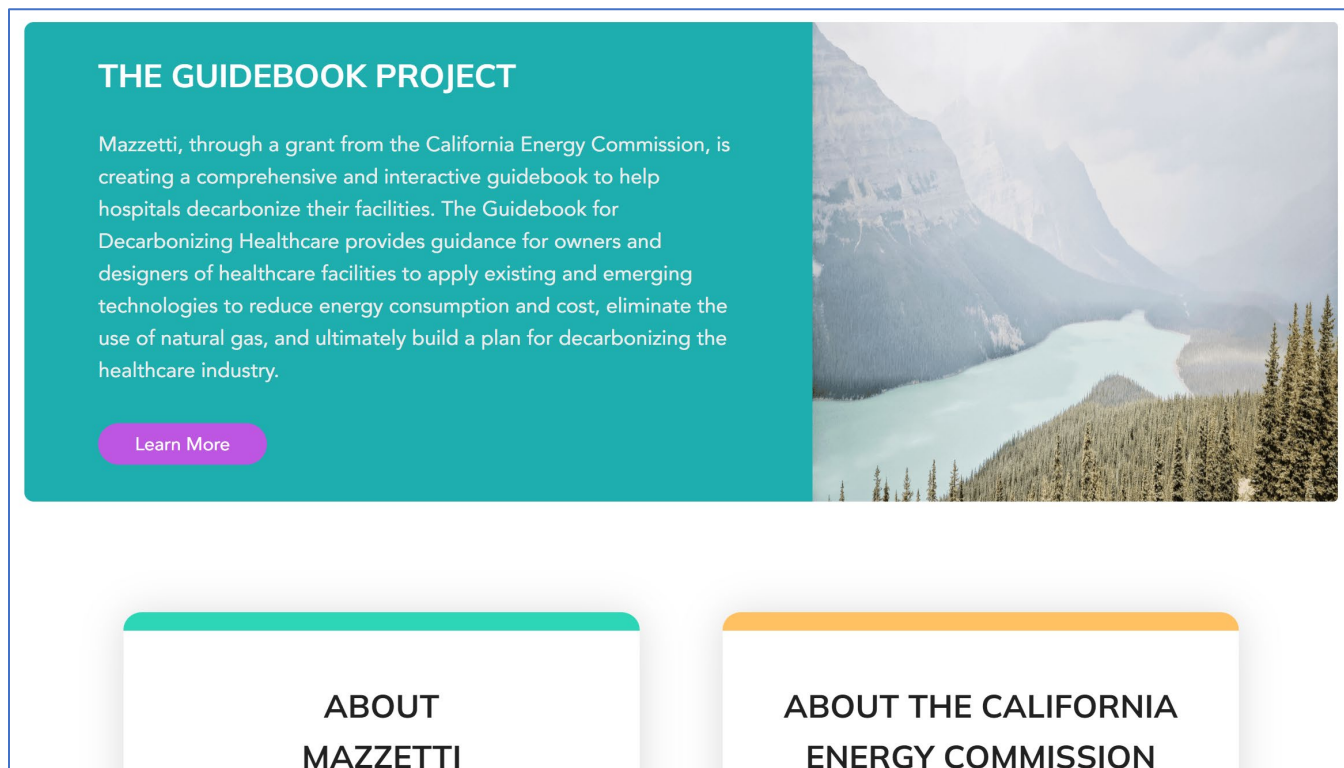
Source: Mazzetti

My Dashboard

https://decarbhealthcare.com/dashboard

The My Dashboard tab will appear when a user is registered and signed into the Website (Figure 11). The dashboard will organize all of the pages that a user likes so they can quickly reference if needed. It also includes a list of recommended articles that appear based on the user's preferences and topics of interest, which they are prompted to select upon registration. Lastly, there is a section for recommended readings, which are collections of articles that can provide an alternative way of reading and engaging with the content. For example, the recommended readings include numerous articles for users looking to take their first step towards decarbonization, other articles about designing an all-electric hospital, and one that explores the most detailed and effective case studies.

Figure 11: Decarb Healthcare Dashboard
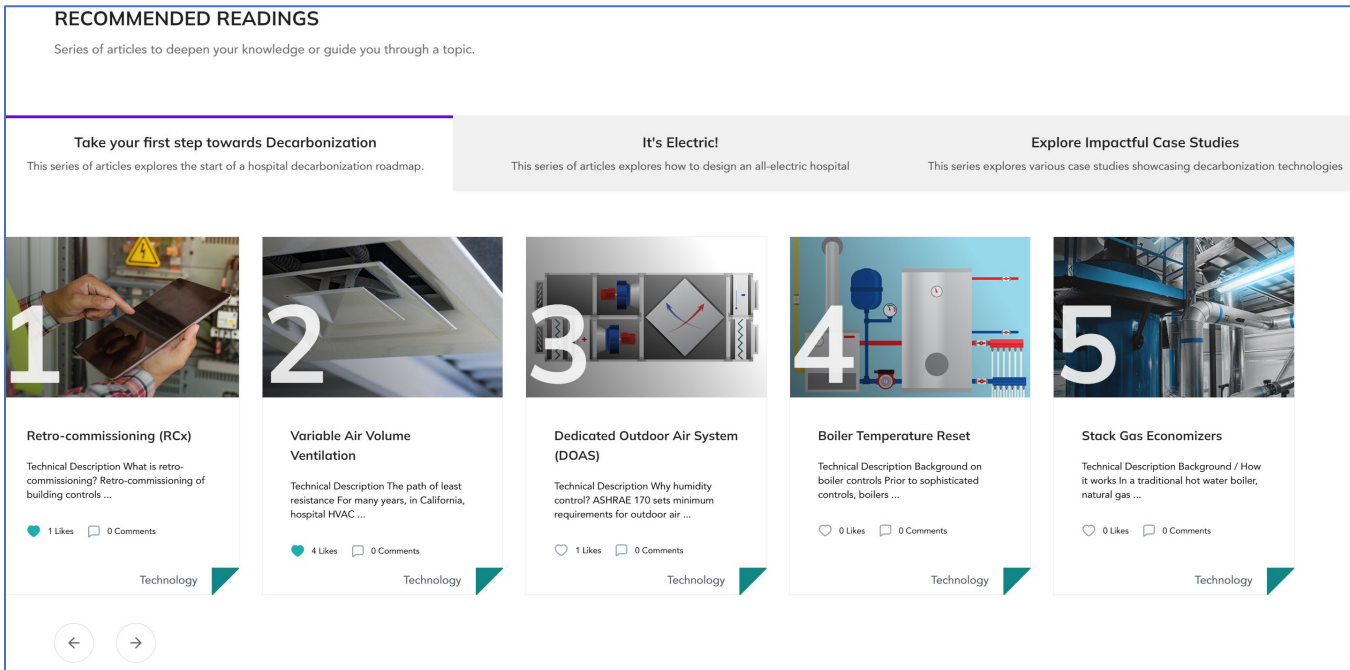
Source: Mazzetti

Automated Notification Emails

The community aspect of the platform is what makes the Guidebook a living resource. The user is encouraged to visit the platform often to explore the content and engage with other users and Mazzetti's experts to discuss implementing decarbonization technologies that have been presented in the Guidebook. Automated notification emails enable the platform to remind and notify users of new or updated content, replies to their comments, or other recent interactions to ensure they continue to visit the site, and that the conversation continues.

Call to Action

The Guidebook content will continue to grow and develop through the research done by the Mazzetti's experts and partners and through the growth of the Website's decarb community. The project team has a call to action for all visitors to join the community and the conversation around decarbonizing healthcare buildings (Figure 12).

Figure 12: Decarb Healthcare Call to Action

Source: Mazzetti

CHAPTER 3: Results

The Guidebook Content

The cumulative research and efforts from the project team along with Mazzetti experts and partners have resulted in a one-of-a-kind decarbonization resource that will have lasting impacts on healthcare facilities throughout California and the nation. The content of the Guidebook was a result of the cumulative research efforts of the project team. Following is a list of the Guidebook content sections with a short summary of what information and technology details can be found in each one. The finished product can be found at https://www.decarbhealthcare.com in its most current form.

Welcome to the Guidebook

The first page is a Welcome page with simple tips to describe the purpose of the Guidebook and how to navigate through it.

- Welcome provides tips on how to navigate the Guidebook.
- Current Climate describes the current state of the world in regard to climate change. Why Do We Need to Decarbonize? offers insight into the benefits of decarbonization.

Approach

This section describes the overall approach to decarbonizing a facility in general. It starts with the basic strategy and discusses how to integrate various decarbonization technologies into existing buildings and systems.

- Three Steps to Decarbonization
- New Construction and Major Renovation
- Integration to Existing Buildings
- Energy Resiliency
- Financing Decarbonization

An overall approach to decarbonization was developed in which all of the following technologies fit. This is described in the approach section of the Guidebook.[1] The three major steps to decarbonize buildings are minimizing loads, electrification, and transitioning to renewable energy sources.

Reduce Loads

Improving energy efficiency is perhaps the most straightforward and cost-effective way to decarbonize buildings. Reheat is the largest end use in most hospitals and often relies on on-site combustion of fossil fuels. There are a number of strategies for reducing reheat in both new and existing buildings, some of which may be low- or no-cost control measures. Other

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[1] https://decarbhealthcare.com/guidebook/512

reduction measures include lighting upgrades, use of energy-efficient heating and cooling equipment, and the use of advanced control strategies. These measures can significantly reduce the amount of energy needed to power a building, directly reducing carbon emissions.

In much of the United States, dehumidification is a primary function of cooling systems, especially in critical environments such as operating rooms, pharmacy clean rooms, and other spaces that require low temperatures for occupant comfort. But the traditional method of dehumidification is overcooling to wring out excess moisture, then reheating to maintain comfort. The Guidebook presents better ways to handle dehumidification.

Electrify What Remains

Burning fossil fuels is simply not compatible with decarbonization. In most hospitals, building heat, reheat, domestic hot water heating, sterilization, and humidification rely on natural gas combustion, using either steam boilers or hot water boilers, or a combination of the two. All of these loads can run on electricity, but some are easier than others to convert. It is also important to be careful about the load imposed on the hospital electrical system and the local and regional electrical grid. See Introduction: Central Plant[2] for more on electrifying these loads.

In addition to heating and domestic hot water, hospitals have traditionally relied on steam for sterilization and humidification. These needs have not gone away, but there are some alternatives to gas-fired boilers. See the Guidebook sections Alternative Steam Generation[3] and What If We Didn't Use Steam?[4]

One of the challenges in legacy hospitals is converting from steam distribution to hydronic heating and domestic hot water. The conversion can be disruptive and capital intensive. See Converting from Steam to Hydronic Heating.[5] But the choice is really when to convert, not if. Boilers that operate on fossil gas must be phased out — and for the planet's sake, sooner is better than later.

Some of the solutions for electrification of legacy buildings involve large capital projects, including the sections on financing options. However, if it is necessary to keep the boilers in service a little longer, there are some measures that can help. See If You Must Have a Gas-fired Boiler.[6]

Use Renewable Energy

Transitioning to renewable energy sources is another key strategy for decarbonizing buildings. Options for on-site renewable energy generation include solar photovoltaic panels, solar thermal collectors, and wind turbines. These systems can be capital intensive as described in the section on Financing Strategies[7] and include other challenges, such as limited land or roof

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[2] https://decarbhealthcare.com/guidebook/528#1508

[3] https://decarbhealthcare.com/guidebook/536

[4] https://decarbhealthcare.com/guidebook/537

[5] https://decarbhealthcare.com/guidebook/538#1547

[6] https://decarbhealthcare.com/guidebook/523#1494

[7] https://decarbhealthcare.com/guidebook/573

area for solar systems. Wind generation at a scale needed for a large urban hospital is difficult in an urban environment.

The Guidebook also has the user consider off-site renewable energy sources, such as purchasing grid-connected renewable energy through the user's power company or participating in a community solar program. If the building has access to landfill gas or other renewable fuels, they may be an alternative that achieves carbon reduction without capital investment in a new central plant system.

Looking forward, clean hydrogen is a possible solution. However, the Guidebook warns of greenwashing scams since most hydrogen produced relies on fossil fuels for production and transport, and there are technical and economic hurdles that are unlikely to be overcome in the near term. The project team suggests acting today to move away from combustion — waiting for the hydrogen economy could mean decades more carbon emissions.

Benchmarking

- This section is comprised of "Hospital Energy Use Breakdown" pages that show a chart of typical hospital energy use.

Building Codes and Design Standards

This section highlights local and state building and energy codes that play a role in the decarbonization of healthcare facilities.

- California Title 24 building codes
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) building codes

State and Local Regulations

This section describes various state and local regulations and codes that play a role in the decarbonization of healthcare facilities.

- California regulations
- Other state regulations

Technologies

The technology entries of the Guidebook share a similar structure. Each technology entry has a summary section called Executive Summary that identifies a problem or current course of action and presents the entry's technology as a solution. The technical description arms the reader with knowledge necessary to understand how builders arrived at the original design, how the alternative system works, and the relative cost and relative benefit. How It Decarbonizes is a brief section that highlights exactly where and to what magnitude carbon emissions are being reduced. Implementation barriers regarding finance, codes, technology, culture, as well as hospital operation are presented in the Implementation and Barriers section. There is a brief guide for entries that focus on practices rather than technology. Case studies either from the Mazzetti portfolio, partners and clients, or online resources can also be found within each technology entry.

The following is a list of technology chapters and a sample of the technologies that can be found within:

- Load Reduction

  - This section explores technologies that reduce internal loads and reheat such as variable air volume, retro-commissioning, displacement ventilation, better zoning, unoccupied mode strategy, building envelope improvements, and improving accuracy of load and energy modeling.

- Dehumidification

  - This section explores more efficient and low-carbon dehumidification methods such as desiccant systems, dehumidification using chilled water return-based reheat, and dedicated outdoor air systems.

- If You Must Have a Gas-fired Boiler

  - This section explores carbon reduction measures to make minor efficiency improvements to existing gas-fired boilers such as condensing boilers, stack gas economizers, right-sizing boilers, and boiler hot water temperature setpoint reset control strategy.

- Central Plant

  - This section explores fossil fuel combustion-free methods of generating heat within a facility's central plant such as heat recovery chillers, heat pumps, solar thermal water heating, ground source heat pumps, and local heating systems.

- Domestic Hot Water

  - This section explores methods of reducing energy consumption and electrifying the domestic hot water systems such as domestic hot water heat pumps, single-temperature handwashing, and waste-to-energy.

- Steam

  - This section explores alternative ways to produce steam without fossil fuel combustion such as electric steam generators and solar thermal collectors as well as other methods to rethink processes that traditionally rely on steam like humidification and sterilization by using adiabatic humidification or chemical sterilization.

- Load Shifting and Energy Storage

  - This section explores various ways of shifting heat generating loads to off hours to take advantage of renewable energy and various methods of thermal storage, such as sensible heat thermal storage, latent heat thermal storage otherwise known as phase change materials energy storage, compressed air energy storage, and large thermal mass in buildings.

- Emerging Technologies
  - This section explores unproven emerging technologies at a conceptual level, such as heat pumps using propane refrigerant. These technologies have not yet been tested in the market and do not have any hospital installations to analyze. However, there may be future considerations for these measures as technology progresses.

Motivation Program

This section details the motivation program, which will seek to encourage, enable, and support healthcare organizations and the rest of the decarb community as they explore implementing the decarbonization technologies described in this Guidebook. There are also details about the ongoing IFHE Global Carbon Challenge program.

Motivating People

Most of the Guidebook content addresses specific technologies and any related financing and regulatory measures or circumstances to consider. There is a missing piece with culture — people and people's behavior to implement these changes. This piece of the puzzle should not be underestimated.

People need little motivation to perform behaviors that are (or at least perceived as) easy. Alternatively, as the effort increases, the amount of necessary motivation increases. According to the book *Making Shift Happen*, motivation is driven by internal factors, such as perceptions of the positive or negative consequences of the behavior, perception of the social acceptability of the behavior, and the degree to which personal identities and value systems align with the behavior. The Motivation Program is rooted in this theory and shares the key points from that resource to lay out some tools for organizations to use when trying to motivate their people to join this effort.

Carbon Challenge

To complement the Guidebook and to motivate its use to reduce carbon emissions, the Mazzetti organization, with the International Federation of Healthcare Engineering (IFHE), created the Carbon Challenge. The IFHE Carbon Challenge is a worldwide award program, recognizing hospitals that make significant carbon reductions.

Prizes are given for the following accomplishments:

- Greater than 5 percent carbon reduction (2021 baseline year, 2023 performance year)
- Greater than 10 percent carbon reduction
- Best Reduction in Country Award
- Best in World

Awards are categorized as hospitals (acute care facilities) versus non-hospital healthcare buildings. The award program measures performance based on facility types. Participants are given an award for the highest percentage reduction, not the highest net reduction, so everyone can participate and can take steps to reduce their carbon footprint.

Additionally, organizations that sign up for the IFHE Carbon Challenge will be given a state-of-the-art dashboard, enabling them to see and track energy or carbon emissions across their enterprise. The visually appealing tool will help inform rapid decision making to further decarbonization. In the future, this tool will also show the average emission metrics and average reduction for all award applicants.

Healthcare organizations can sign up for the IFHE Carbon Challenge through this link: https://ifhecarbonchallenge.com/

Health Sector Climate Pledge

In addition to the IFHE Carbon Challenge, the project team sees the White House's Health and Human Services Health Sector Climate Pledge (HHS Pledge), as a motivating step towards helping a healthcare organization reach carbon neutrality. The HHS Pledge states that an organization is committing itself to achieving a 50 percent reduction in carbon emissions by 2030 and achieving net zero emissions by 2050, from a baseline no earlier than 2008, and publicly accounting for progress on these goals every year. The pledge also commits signers to designate an executive-level lead for the emission reduction work by 2023 and perform a GHG inventory by the end of 2024, as well as developing and releasing a climate resilience plan for continuous operations by the end of 2023.

The Mazzetti organization has signed the pledge as a healthcare partner and encourages other healthcare partners and healthcare organizations to sign on. Mazzetti will keep the latest information from the HHS Pledge on Decarb Healthcare website and track any recent developments.

Pilot Projects

This section details potential pilot project opportunities. The project team intends for the Guidebook platform to serve as a matchmaking tool to pair hospitals with manufacturers of emerging decarbonization technologies.

Finance Strategies

This section provides answers to the question "How do we pay for decarbonization?" The strategies defined in this section go beyond simple payback with energy savings as a way to validate and pay for a project. It looks into various financial strategies that can help a healthcare organization's finance team fund decarbonization.

Community Discussions

This section organizes all of the decarbonization community member generated topics. The Add a Topic feature allows users to submit a topic and content of their own writing and after review from the project team's moderators, it can be posted in this section for further discussion.

Citations and Appendix

All sources that were used in the development of the Guidebook are listed in this section of the Guidebook.

CHAPTER 4: Conclusion

By August 2023, the Decarb Healthcare website had 156 registered users, including members from 15 different healthcare organizations around the country, with an average of 5-10 new users per month. These numbers reflected member registration after the Guidebook launch workshop but before the marketing plan was fully implemented. Mazzetti expects that the number of users and healthcare organizations that will register will increase as more content is added.

The Guidebook project will continue beyond the term of the grant with the California Energy Commission (CEC) since Mazzetti's Sustainability Practice has committed to keep the Website running and up to date with the latest research, technologies, and case studies. Mazzetti intends to continue to encourage engagement on the social side of the Guidebook and hold future workshops as well.

Mazzetti will seek recommendations for future Guidebook improvements as well as additional funding opportunities to add significant new features and tools to the Guidebook.

Ongoing Marketing Plan Ongoing

The Mazzetti organization plans to share the Decarb Healthcare website with its entire network through email blasts and various marketing communications. Mazzetti will also share the Guidebook and its updates during its Bending the Climate Curve workshop series that will run monthly into 2024.

Prong 0: Guidebook Ease of Access and Guidebook Launch

Because the Guidebook is easily accessible online and was designed to be attractive and engaging, it can reach a large audience including the general public. Any individual or organization, in California and beyond, can access the Guidebook and find it useful. The simplicity of the model the Guidebook shares (reduce load, electrify, advocate) provides an entry point for anyone or any organization considering a decarbonization journey.

The Project Team celebrated the launch of the Guidebook with a virtual webinar. This included introductory remarks from Healthcare Without Harm and keynotes from Dr. Victor Dzau — the president of the National Academy of Medicine and Dr. Richard Jackson — a California professor, pediatrician, and leading voice on climate change. Participation of the esteemed voices at the launch event signals to those who will use the Guidebook later both its importance and its ease of access.

Prong 1: Mazzetti Guidebook Amplification

Prong 1 involved Mazzetti's direct promotion of the Guidebook. This included an eBlast during the week of July 31, 2023 and continued social media engagement. It will also include posters and QR codes at future industry events.

Prong 2: Ecosystem Guidebook Amplification

As a key component of promoting the Guidebook, Mazzetti is developing a guide and press release toolkit to share with other key organizations. The kit and personal outreach will be used to encourage organizations to (1) share the Guidebook within their networks via eNewsletter/eBlast or the equivalent; (2) include the Guidebook in their resource page; (3) review and use the Guidebook and encourage their members to do the same. By doing this, the potential user community will be reminded of the Guidebook from multiple sources.

The public relations kit and personal outreach will be conducted with organizations such as the CEC, the American Society for Healthcare Engineering, the California Society for Hospital Engineering and other similar state-level hospital engineering organizations, Healthcare with Harm, Practice Green Health, the Center for Health Design, the International Federation of Healthcare Engineering, the American College of Healthcare Architects, the Academy of Architecture for Health, the Facilities Guidelines Institute, the National Academy of Medicine, and the Healthcare Facility Symposium and Expo.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CEC	California Energy Commission
GHG	greenhouse gas emissions
HHS Pledge	White House Health and Human Services Health Sector Climate Pledge
HVAC	heating, ventilation, and air-conditioning
IFHE	International Federation of Healthcare Engineering
TAC	Technical Advisory Committee

References

There are no direct references for this report, there is a reference and citation page in the Guidebook that includes the content sources, https://decarbhealthcare.com/guidebook/572.

Project Deliverables

Guidebook Deliverable: https://www.decarbhealthcare.com.