Navigating the Energy Management and Control System (EMCS) Portal

EMCS Consumer Insights Team
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Problem Statement and Background

EMCS is an autonomous system that collects energy consumption and generation data from Cornell properties in Ithaca, including dormitories, central power plants, and solar panels. Three major types of energy are recorded: chilled water flow, electricity, and steam flow. Every 15 minutes, the software architecture collects these energy consumption data from field meters and uploads them in a database. Such data is of interest to groups of different users, including researchers who study energy systems, building coordinators who want to promote sustainability goals, and students who want to learn more about sustainability and make an impact on campus.

The current bridge between the users and the data is the EMCS dashboard. This portal consists of a landing page that contains meters that provide insight into the current state of energy consumption on campus as well as dashboard groups of related sub-dashboards including the Central Energy Plant (CEP) Generation dashboard, the Renewable Energy Generation dashboard, and the Building Utility Monitoring dashboard that provide more specific information about energy production and consumption at Cornell. Though all the collected data were present in the original version of the dashboard, some of the data visualizations were not intuitive without further documentation (Figure 1), and navigating through the dashboard homepage (Figure 2) was difficult. Furthermore, some of the plots contained legends with programming names, which were not user-friendly, particularly to users unfamiliar with the system and the data (see Fig. 3 as an example).

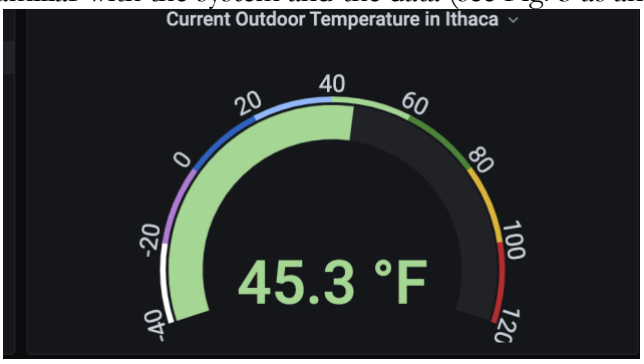


Fig. 1. Temperature of Ithaca area. This visual is located in the very center of the website, while its importance to the user groups relative to the other landing page meters is questionable.

Fig. 2. Main visualization with lack of explanation on the background trendlines or the outer circles and ratio.

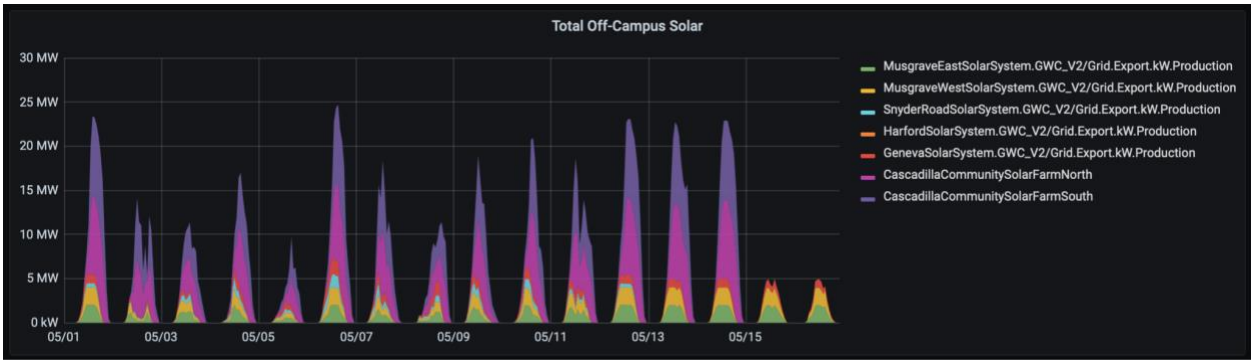


Fig. 3. A sample plot on the EMCS dashboard. Notice that the legend names come from the backend database, and it is difficult for users with no background knowledge to understand.

Our goals were based on previous conversations with the EMCS team and feedback from users [1]. We improved the dashboard in two areas:

(1) better visualizations of energy data using Grafana and

(2) better documentation that assists users of varying levels of knowledge about energy data.

After several demonstrations with Steve Mandl, the primary coordinator of the website, we decided that the user document could blend into the website visualizations for accessibility. Such improvements (a) make the dashboard more accessible to users with different levels of knowledge, and (b) fulfill user needs under various use cases (see Table 1 below for user groups and use cases).

To better understand how to increase the effectiveness of the previous dashboard visualizations and generate and embed effective user documentation, we reviewed previous work and research conducted in similar projects. A previous study showed various data visualization techniques that enhanced one's learning process [2]. For example, the combination of heat maps, map visualizations, and comparison visualizations can provide the users a holistic view of the data. This gave us ideas for how we could implement a building comparison visualization. Some articles discussed data visualizations that are specifically related to energy consumption [3, 4]. We optimized the energy consumption format so that the trendlines and maximum are much more intuitive to understand. We added extra explanations that pop up for those who do not understand the energy metrics.

In addition to practical techniques like common visualization types for energy consumption, the articles also discussed the need to consider the dimension of data and software/hardware limitations when creating visualizations. Energy dashboards were also shown to be successful at other universities [5-7], meaning that the EMCS dashboard should achieve a similar effect with appropriate modifications and improvements on the current status. Given our lack of previous experience in website optimization and visualization, our teammates went through a brief demo of grafana [8], in search of better graphics that can replace the current data visualization. Moreover, a basic introduction of website management and optimization [9, 10] was helpful throughout the entire process as we could prioritize accessibility to maximize the benefit for our user groups.

I. Project Scope and Constraints

We executed the following tasks to address the two main areas of improvement discussed in the section above. The first task entailed getting a better understanding of the dashboard users so that we can effectively address the two areas of improvement that we identified. The following two tasks were directly related to the areas of improvement, while the last task required looking to users for suggestions to guide further enhancements to our implemented improvements.

A. Task 1. Understand the variety of dashboard users and their user needs

To design a more user-friendly and accessible dashboard, we wanted to be aware of the various users that may visit the dashboard and their needs. Based on conversations with the senior leaders of the EMCS team and the user feedback collected and provided to us [1], we derived several user groups (see Table I). These user groups include:

(1) the Cornell community, which can be broken down into building users/ residents/ occupants, building managers, and general students,
(2) energy plant operators, and
(3) the general public.

We also identified estimated levels of knowledge and rudimentary use cases for each user group.

This information was fundamental to appropriately cater the data visualizations and user documents to the dashboard's multitude of users such that even those with little prior knowledge of energy data would be able to effectively understand and potentially utilize the dashboard. With this preliminary documentation of user groups, we sought guidance from the EMCS team to refine these definitions and ensure that we accurately understood our users. We then actively referred back to these user groups and user needs as we improved the visualizations and developed the user document to confirm that we accounted for each user group.

TABLE I.
SUMMARY OF IDENTIFIED USER GROUPS FOR THE EMCS DASHBOARD WITH ESTIMATED LEVELS OF KNOWLEDGE, USE CASES, AND RELEVANT DASHBOARD FEATURES

1. Cornell Community			
User Group	**Estimated Level of Knowledge**	**Use Cases**	**Relevant Dashboard Features**
Building Users, Residents, or Occupants	None Beginner	• Energy usage patterns in their buildings • Interested in implementing changes to their practices for sustainability	• Individual building dashboards • Energy smackdown

Building Managers	Intermediate Expert	• Track year-to-date usage • Forecast energy usage • Plan building strategies • "Verify operational consistency" (from provided user feedback spreadsheet)	Individual building dashboards
General Students	None Beginner	Energy generation and usage patterns in multiple buildings on-campus or off-campus as a whole	• Landing page overview meters • Individual building dashboards • Renewable energy generation dashboards
2. Energy Plant Operators			
User Group	**Estimated Level of Knowledge**	**Use Cases**	**Relevant Dashboard Features**
	Expert	Monitor electricity demand and plant generation	Central energy plant (CEP) dashboards
3. General Public			
User Group	**Estimated Level of Knowledge**	**Use Cases**	**Relevant Dashboard Features**
General Public	Beginner~Expert	Energy generation and usage patterns on campus as a whole	• Landing page overview meters • Individual building dashboards • Renewable energy generation dashboards

B. Task 2. Implement Improvements to Data Visualizations

Through communication with the EMCS team and our explorations of the previous version of the dashboard, we identified key areas of improvement in terms of data visualizations. We proposed three main subtasks to address them.

A. **Time series plots:** replace dataset titles with human-readable names and include explanations of units
B. **Landing page overview meters:** make overview meters more intuitive to understand
C. **Building comparisons:** add functionality to compare building energy usage data

Task 2A was to help users understand the visualizations and minimize confusion with the energy data. To accomplish this, we parsed through the names from the current datasets and extracted the useful information to display in a more user-friendly form, particularly for the Renewable Energy Generation Dashboards. We additionally included explanations of the meters and units of the energy data on the landing page to give the user a better understanding of what is being measured. The explanations of the units are also relevant to other time series plots throughout the various dashboards.

The landing page overview meters are intended to give the dashboard user a quick snapshot of the current state of energy usage on campus. However, this was not particularly apparent from the previous visualizations. Thus, for Task 2B, we modified the previous data visualizations by simplifying the visual to eliminate confusion about certain unexplained components.

The intention behind Task 2C was to provide users with data that would satisfy their user needs. Specifically, building comparison visualizations were a commonly requested feature from the user feedback form that would make the data itself more informative to users looking to explore how different buildings use energy relative to one another [1]. As such, we wanted to add a functionality that would compare building energy usage data to the building dashboards.

C. Task 3. Develop the User Document

With the various visualizations and dashboards in mind, we developed a user document composed of two aspects:

A. General portal help page
B. Dashboard-specific help panels and pages

The general portal help page is built upon the previous help page, giving in-depth information about the purpose of the site, which dashboards are included, how to navigate the site, and general information relevant to all dashboards such as how to select time ranges of interest on time series plots, and how to download energy usage data. This improved general portal help page is easily accessible and visible from the landing page as it is embedded into the landing page itself. This ensures that the dashboard users are able to figure out how to use the portal from the very start. The dashboard-specific help panels and pages contain information relevant to each specific dashboard, such as descriptions of the energy data and what they mean. This format allows users to easily access information about energy usage depending on what they would like to explore.

D. Task 4. Conduct usability testing and revise accordingly

Since one of our guiding principles was customer or user-centricity, we conducted usability testing once we developed our improved data visualizations and initial user document. This allowed us to gauge the effectiveness of our efforts and make revisions to best fit the needs of the various user groups before submitting our final visualization improvements and user document. Also, around May, all the team members had become familiar with the website graphics, and the usability testing gave us a fresher insight and perspective. The comments were very helpful in finalizing the design, and the data download task was performed by each member assigned to usability testing.

E. Constraints/Caveats

The scope of this project was limited by available Grafana features and time constraints. While we would have liked to customize some of the visualizations to make them even more intuitive (including the landing page meters) rather than using the default visualizations available in Grafana, doing this would require more time than we had. In addition, one usability testing participant suggested the idea of a visualization that can compare renewable energy generation and overall electricity consumption, yet this was difficult to implement in the remaining time.

II. Log of Implemented Changes

The following is a log of specific changes made to the original version of the EMCS portal to improve data visualizations and develop user documentation.

A. Improving Data Visualizations

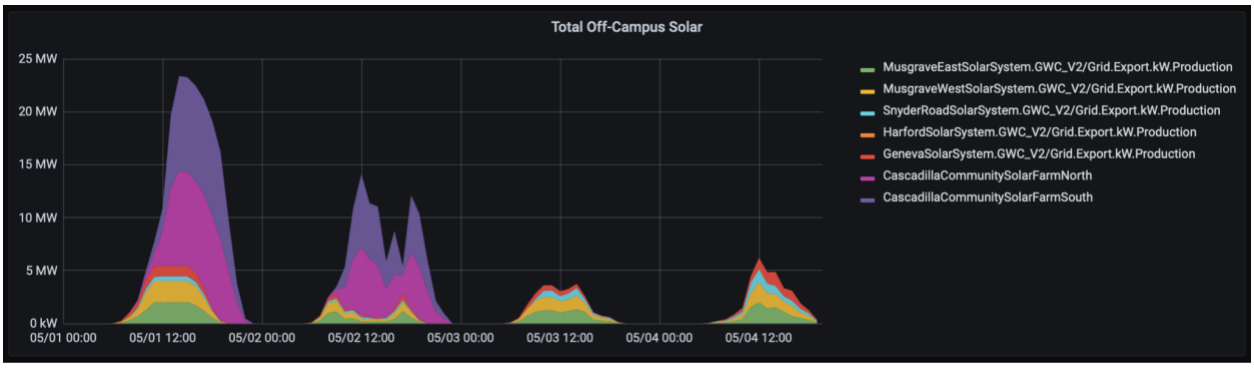
As discussed in the Project Scope and Constraints section, improvements made to the data visualizations included:

(1) making panels and labels more human-readable,
(2) making landing page meters more intuitive, and
(3) adding a building comparison dashboard.

1) Making Panels and Labels More Human-Readable

Previously, the portal contained visualizations and panels where the legend labels were difficult to interpret. Examples of these visualizations were specifically present on the Solar Production dashboard which is one of the Renewable Energy Generation dashboards. On the Solar Production dashboard, the legend entries of the Total Off-Campus Solar and Total On-Campus visualizations contained labels that were long strings directly derived from the backend database (see Fig. 4A). For ease of interpretation, the location of solar energy production was extracted from the strings and used to replace the strings in the legend (see Fig. 4B). This modification reduces the effort that a user without background knowledge of how the system works would need to exert to understand what the visualizations represent.

(A)



(B)

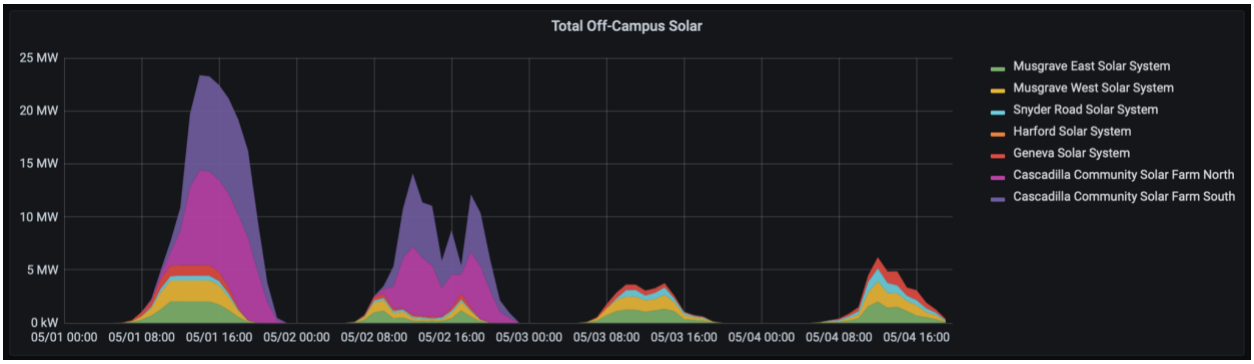


Fig. 4. Comparison of the (A) original and (B) modified versions of the Total Off-Campus Solar panel of the Solar Production dashboard, one of the Renewable Energy Generation dashboards. The modified version of the panel (B) has more human-readable labels compared to the original version of the panel (A).

Another change that was implemented to make the portal more user-friendly was modifying the Central Energy Plant (CEP) Generation dashboard panel on the landing page to be more informative and have more human-readable dashboard titles. The original version of the panel contained hyperlinks to a set of sub-dashboards, but it was difficult to immediately discern what the dashboards were from the list of dashboard names provided (see Fig. 5A). In order to remedy this issue, the panel was altered to provide a list of more human-readable dashboard names (see Fig. 5B). Again, this change lessens the burden on the user, especially a new user with little knowledge of the system, of having to figure out how to navigate through the dashboard to energy data of interest.

(A) (B)

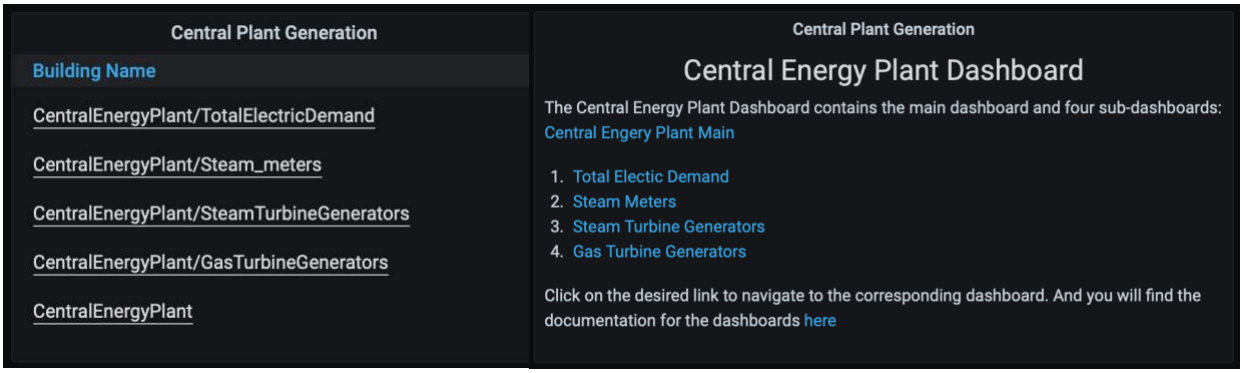


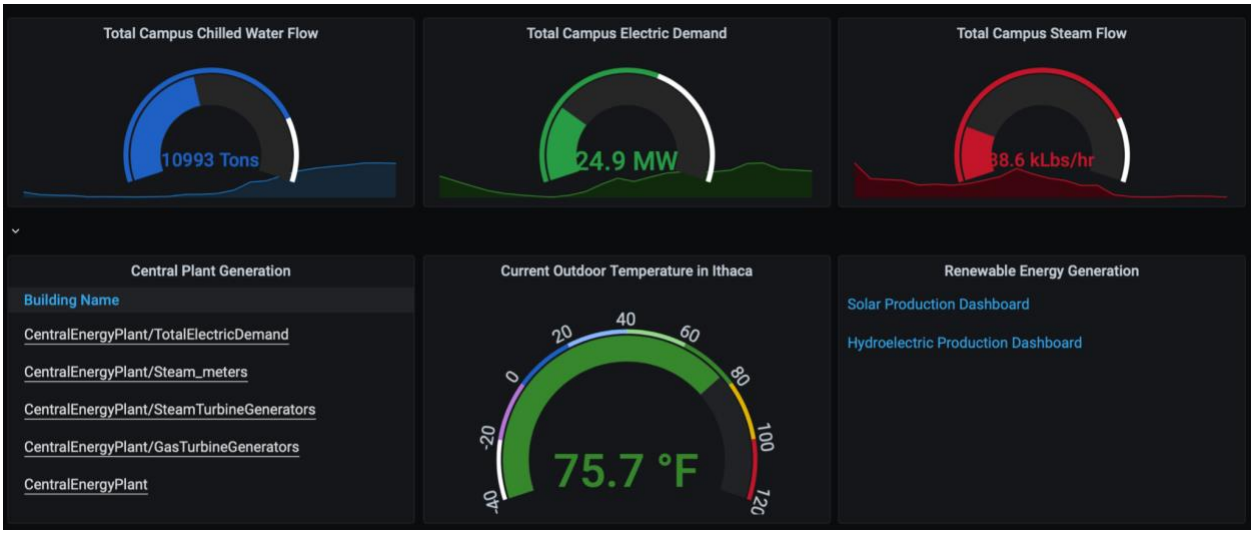
Fig. 5. Comparison of the (A) original and (B) modified versions of the CEP Generation dashboard panel on the landing page of the portal. The original version (A) has a list of hyperlinked dashboard names that are more difficult to immediately understand compared to the list of hyperlinked dashboard names of the modified version (B).

2) Making Landing Page Meters More Intuitive

Two main issues with the original landing page meters involved (a) the three overview meters for the total campus chilled water flow, the total campus electric demand, and the total campus steam flow and (b) the temperature gauge (see Figure. 6A). Modifications were made to these two aspects to make the landing page more intuitive. These can be seen at a glance in Fig. 6B.

The goal of the three overview meters is to provide visitors to the portal with a quick glance at the current state of energy consumption on Cornell's campus. In the original version of the dashboard, this objective was hindered by the outer circle around the inner gauge of the three overview meters. This outer circle was a source of confusion as we only learned later that it was the theoretical maximum of energy consumption that Cornell could handle, based on calculations from the CEP. Without any explanation, it potentially prompts questions for the user (see Fig. 7A), while also trivializing the energy consumption since the maximum capacity is much greater than the current consumption. To mitigate this confusion and make the visualizations easier to understand, the outer circle was removed from the visualization, leaving the focus on the main point of interest: the sparkline portraying energy consumption over the last 24 hours for each of the three metrics (see Fig. 7B). Additionally, notice that the color of the Total Electricity Demand meter was changed from green to yellow to maintain consistency between the landing page meters and time plots contained in the Building Utility Monitoring-specific dashboards which display the same three metrics.

(A)



(B)

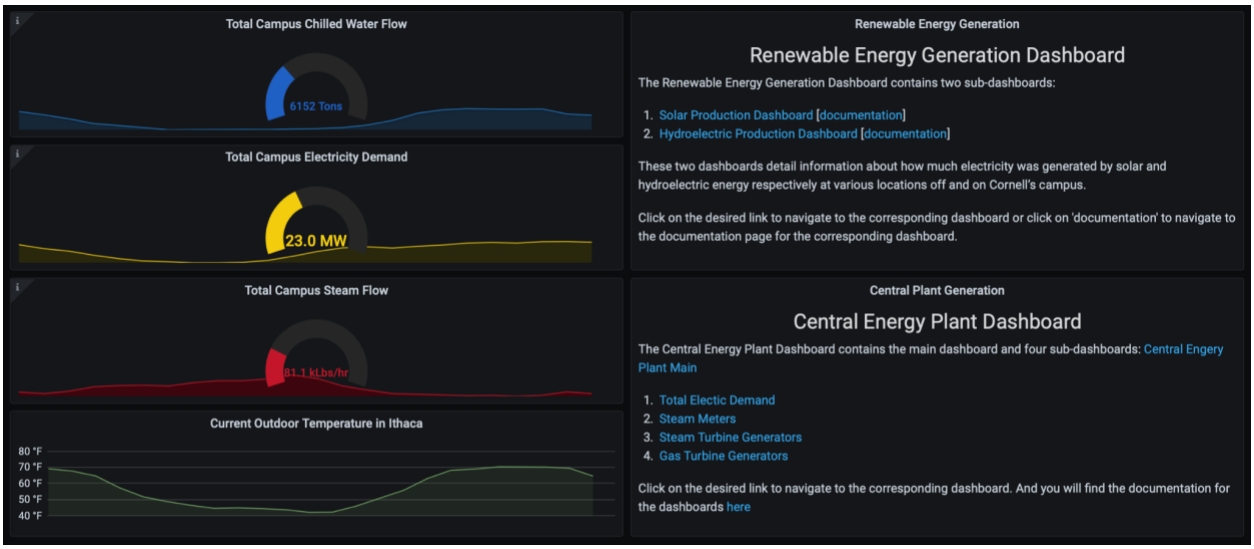


Figure. 6. Comparison of the (A) original and (B) modified versions of the landing page of the portal. The original version has an outer circle on each overview meter while the modified version does not. The original version uses a large panel to place a gauge for temperature while the modified version uses a more unobtrusive panel to display temperature as a time plot to represent data over the last 24 hours.

(A) (B)

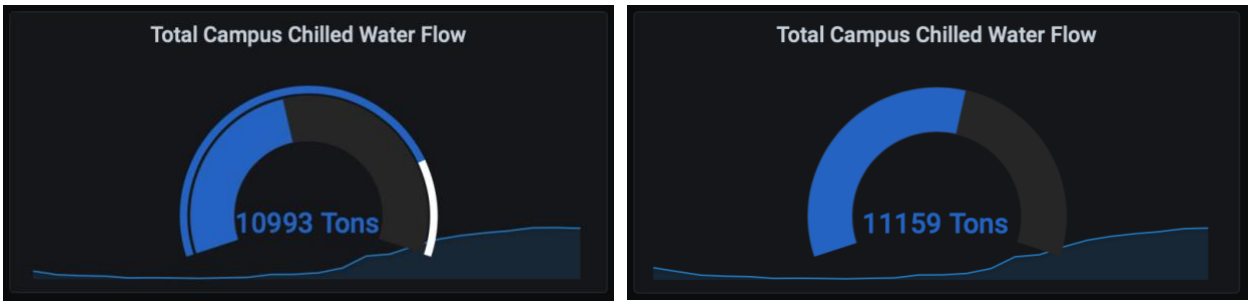


Figure. 7. Comparison of the (A) original and (B) modified versions of Total Campus Chilled Water Flow overview meter on the landing page of the portal. The original version has an unexplained outer circle that was removed in the modified version to mitigate confusion.

Knowing the current temperature and the temperature trendline over the last 24 hours can convey the correlation between temperature and energy consumption levels if the time axes are identical (24 hours). However, in the original version of the dashboard, only the current temperature was displayed on a gauge (see Fig. 8A). In this visualization, the temperature was not represented in the most intuitive way, and there was no indication of the temperature data over time. The temperature panel also took up a sizable amount of space and was portrayed with many colors on the landing page which partly drew attention away from the actual energy consumption data provided in the three overview meters (see Fig. 6A). As such, the temperature panel was changed to be a time plot so that the user can visualize the temperature trend over time and observe the relationship between energy consumption and temperature over time (see Fig. 8B). The panel was also placed and resized in a manner that would not detract from the other meters.

(A) (B)

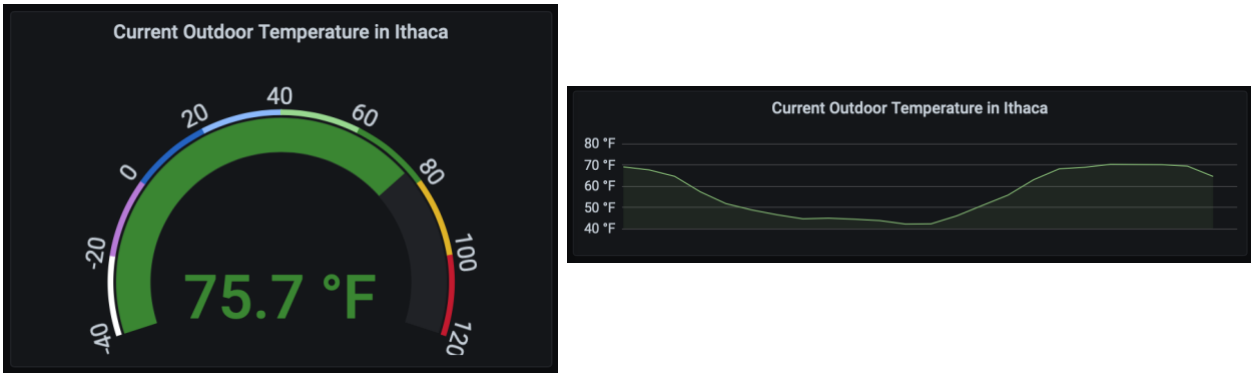


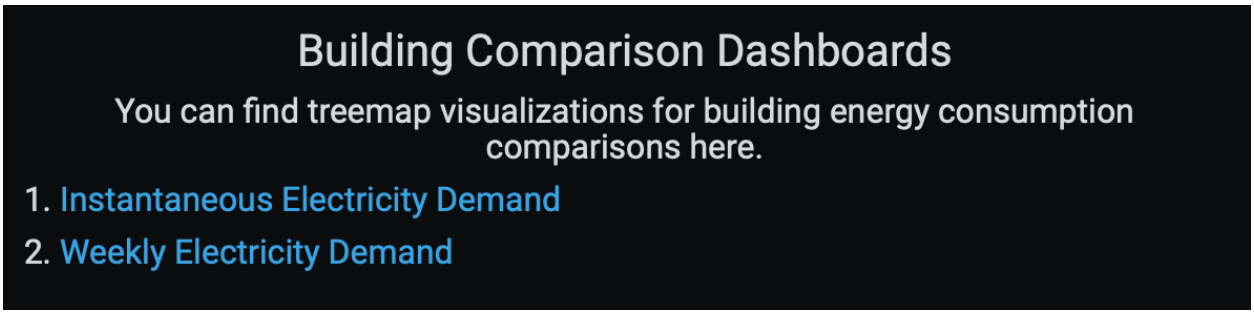
Fig. 8. Comparison of the (A) original and (B) modified versions of the temperature panel on the landing page of the portal. The original version uses a large panel to place a gauge for temperature while the modified version uses a more unobtrusive panel to display temperature as a time plot to represent data over the last 24 hours.

Adding The Building Comparison Dashboard

One requested feature was the functionality to compare energy consumption metrics between different buildings on Cornell's campus. To accommodate this, the Building Comparison Dashboard panel was added to the landing page (see Fig. 9A). It includes two visualizations, both of which are

treemaps. The two treemaps show instantaneous and weekly electricity demand, which depicts the buildings on campus that are currently consuming the most energy (see Fig. 9B) and have consumed the most energy over the last week respectively. Buildings that are currently using more energy are represented by larger rectangles. Buildings that are currently using less energy are represented by smaller rectangles. Color is also used to indicate energy consumption, with red representing the greatest energy consumption and green representing the least energy consumption. The rectangles can be moused over to see which building each rectangle represents. This visualization allows the user to compare how buildings stack up at a glance. A future goal would be to include information about the number of residents or building capacity to compare buildings with respect to a set of more standardized metrics.

(A)



(B)

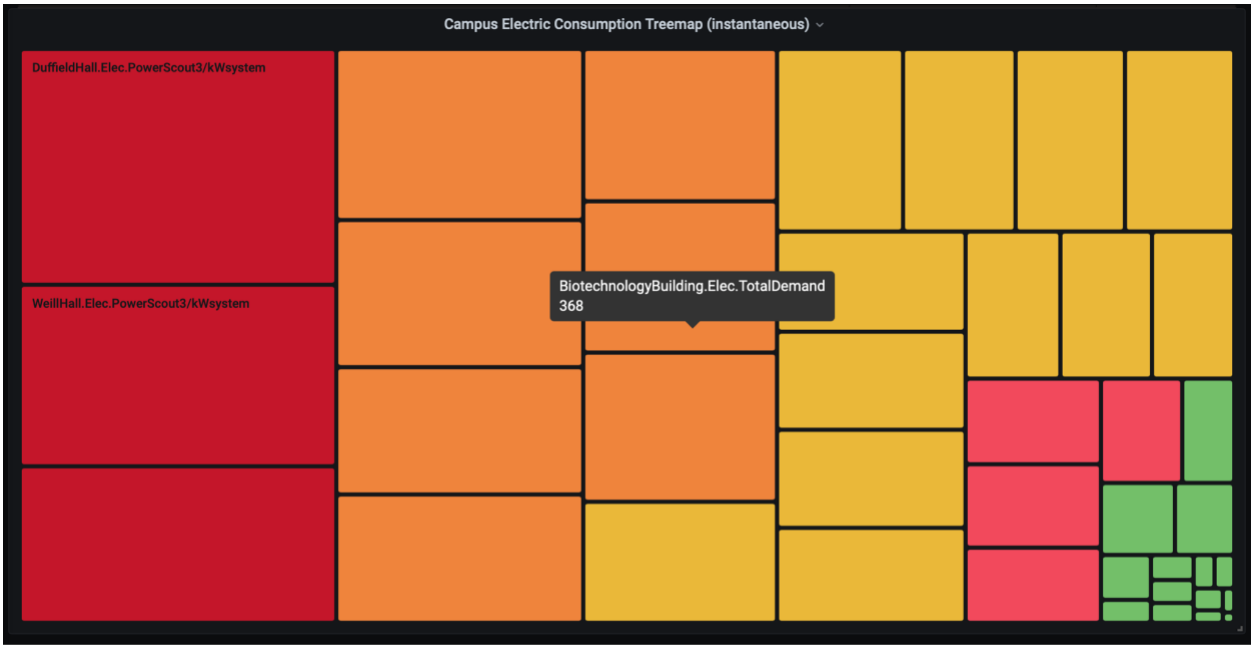


Fig. 9. Screenshots of (A) the Building Comparison Dashboard panel on the landing page and (B) the instantaneous electricity demand visualization that can be accessed by clicking on 'Instantaneous Electricity Demand' hyperlink.

B. Documentation

The second major area of improvement that was implemented involved developing user documentation that would help the portal visitors navigate through the dashboards and give a better

understanding of the energy data. This was done by adding landing page meters and unit explanations, revising the general help page for the portal, and incorporating dashboard-specific help panels and pages.

1) Landing Page Meters and Units Explanations

To ensure that users, such as Cornell students or the general public, who may not have advanced knowledge of energy consumption data are still able to understand the visualizations, we wrote explanations of the landing page meters and the units that appear throughout various dashboards on the portal landing page. The brief explanations of the meters themselves can be accessed by mousing over the information icon in the upper left corner of each respective panel (see Fig. 10). They provide new dashboard users or users with little to no knowledge of energy data with information to understand what the landing page meters are depicting.

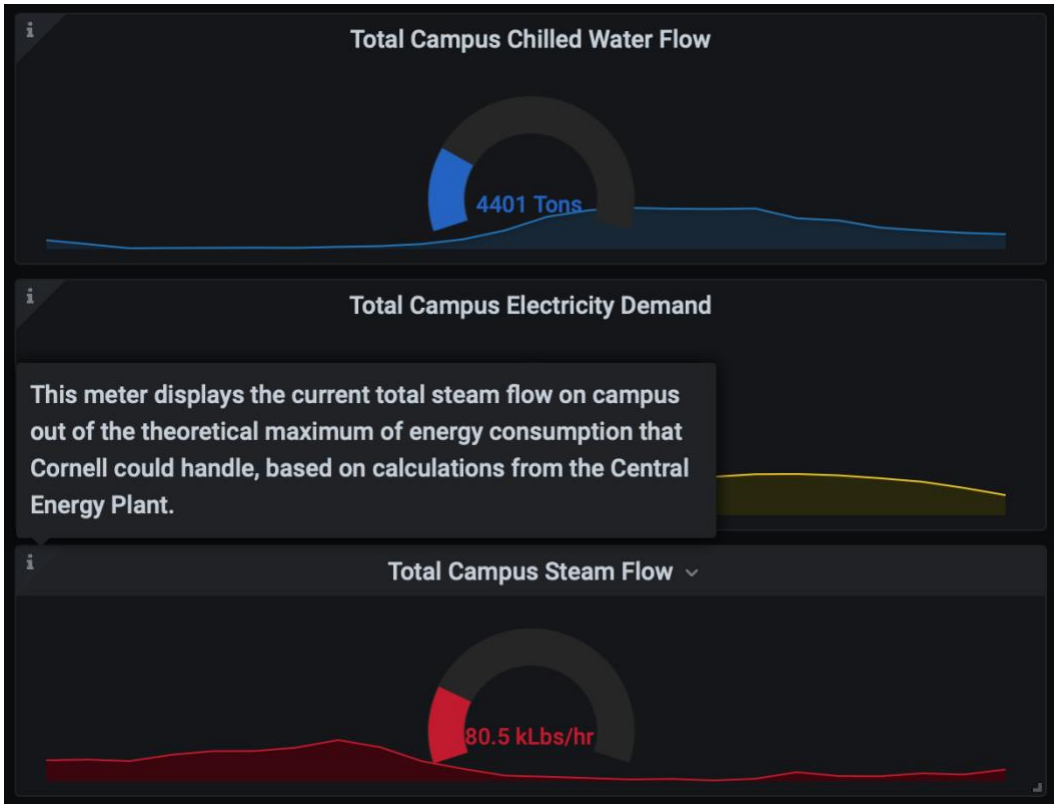
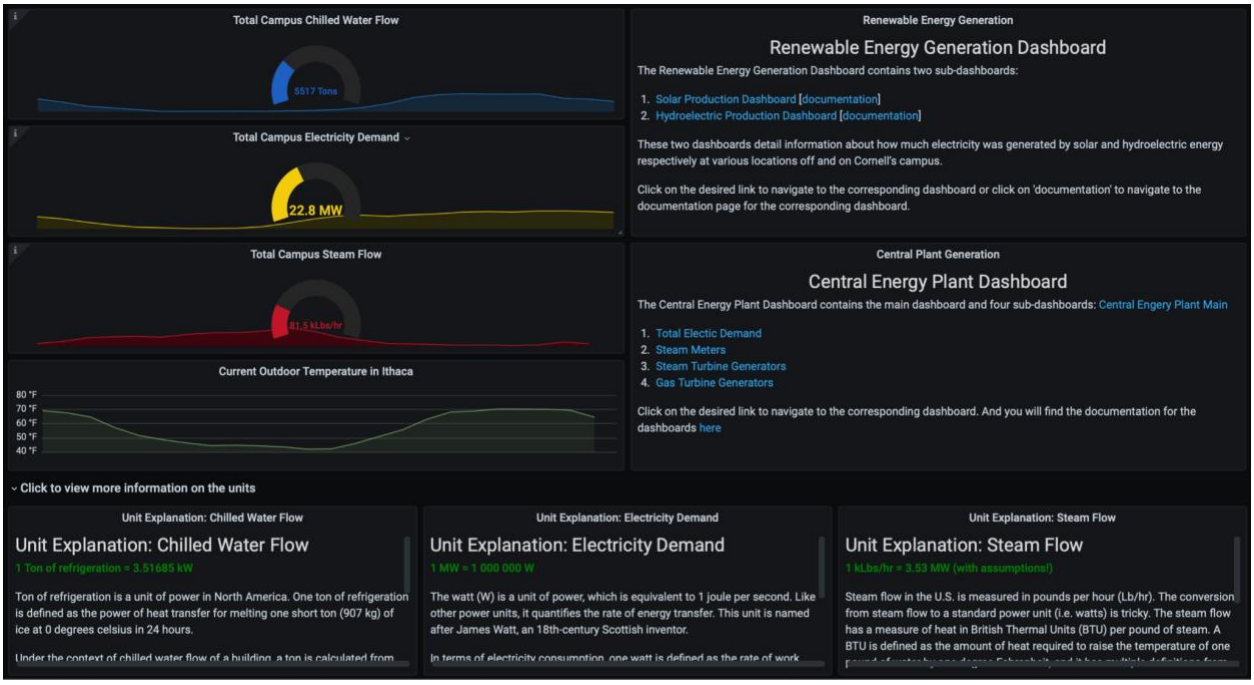


Fig. 10. View of all three overview meters on the landing page of the portal with the description of the Total Campus Steam Flow meter accessed by mousing over the information icon in the upper left corner of the respective panel.

The unit explanations are easily accessible when a user first navigates to the portal underneath the 'Click to view more information about units' bar (see Fig. 11A). This section can be collapsed by clicking on the bar an additional time. Having this information be collapsible at the command of the user allows us to cater to the different user groups. While users with little to no knowledge of energy consumption data may find this information helpful, other advanced users who have intimate knowledge of the subject matter may not need these explanations and can just as easily view the visualizations without being distracted by the explanations (see Fig. 11B).

A



B

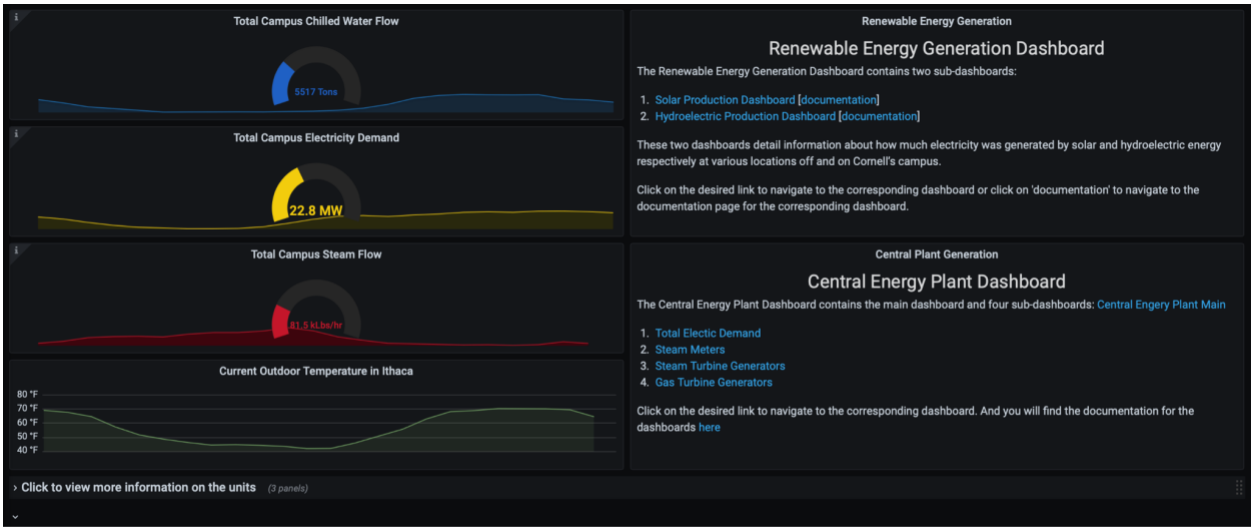


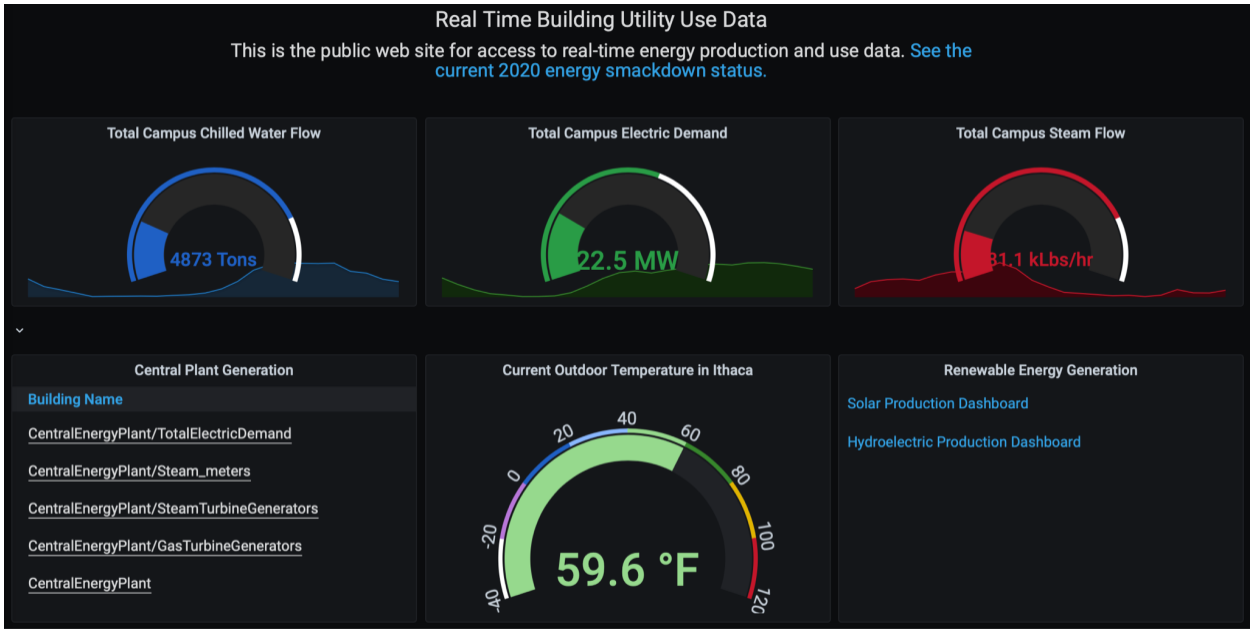
Fig. 11. View of overview meters on the landing page of the portal (A) with the unit explanations section opened (what is first seen when a user first navigates to the portal) and (B) with the unit explanations section unopened.

2) General Help Page

Another important feature that needed improvement from the original portal was the general help page. The purpose of the general help page is to provide portal users with basic information about how the energy data is collected and how to navigate and use the various features of the portal. Despite the potential value that it could provide to users, particularly new users, the general help page was not easily noticeable or accessible from the landing page (see Fig. 12A) and was

burdensome to read through due to its disorganization (see Fig. 13A) in the original version of portal [1]. In order to address the accessibility of the general portal help page, a prominent panel that provides a brief description of the portal and a direct link to the general help page (termed 'Navigation Guide') was added to the top of the landing page (see Fig. 12B). A visitor to the portal can find the general help page by clicking on 'Navigation Guide.' This change tackles the problem users had with difficulties finding the general help page.

A



B

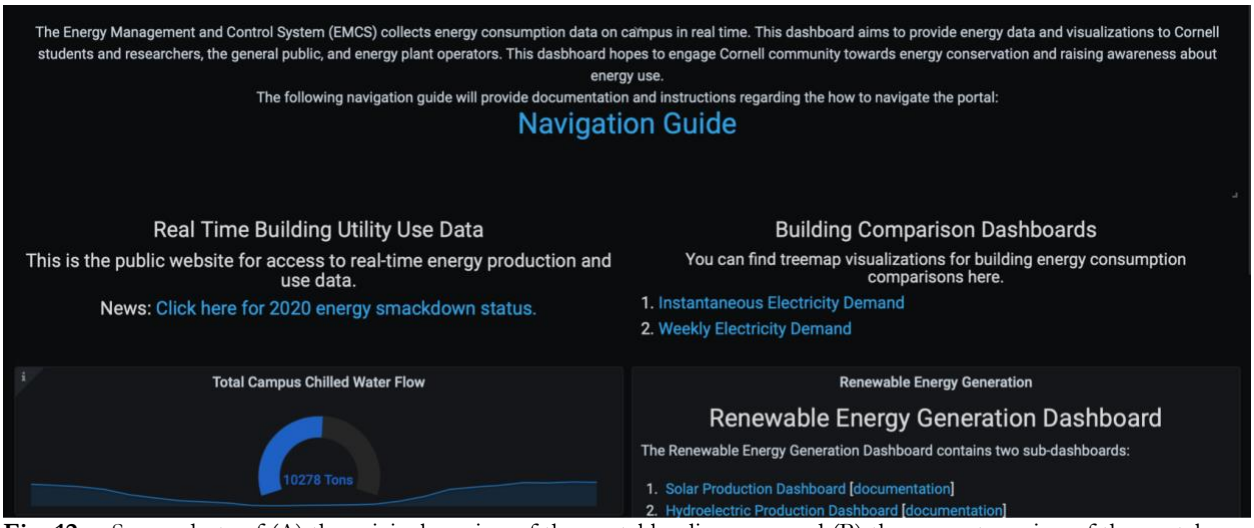
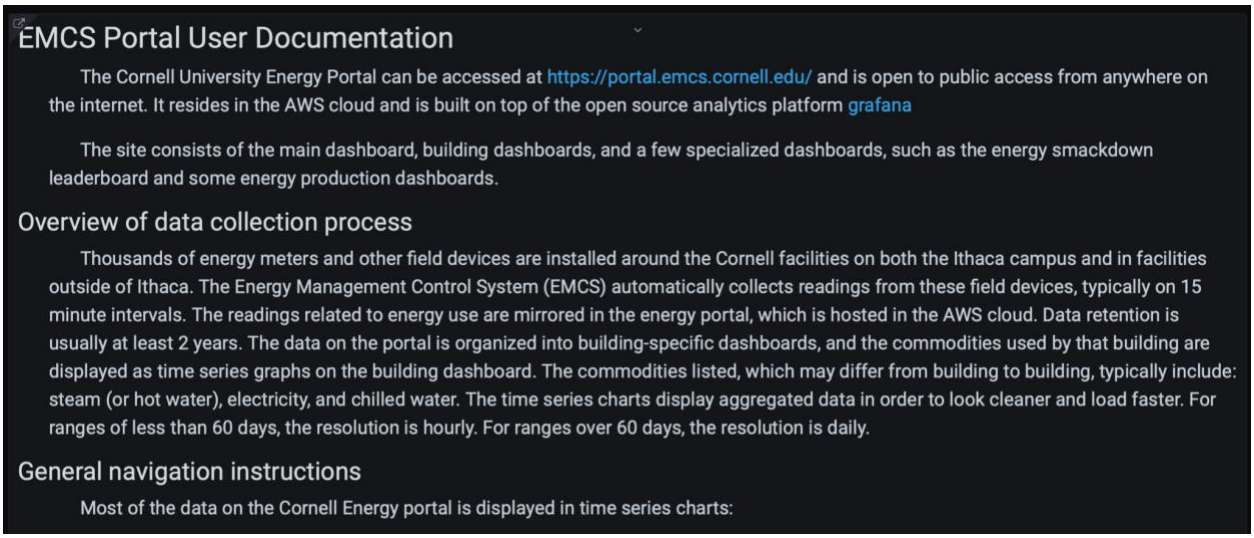


Fig. 12. Screenshots of (A) the original version of the portal landing page and (B) the current version of the portal landing page. (A) In the original version of the portal landing page, the general help page is difficult to navigate to. (B) In the current version of the portal landing page, the general help page is easily accessible and can be navigated to by clicking on 'Navigation Guide.'

To address its previous disorganization, the general help page was broken down into sections that are labeled by topic and collapsible by the user based on what they would like to learn more information about (see Fig. 13B). In addition to editing the look of the general help page, the team also revised the content of the help page by updating relevant sections based on the changes implemented in the rest of the dashboard by the team and by adding sections detailing general instructions about how to navigate to specific dashboards and where documentation for those dashboards can be found that were previously absent.

(A)



(B)

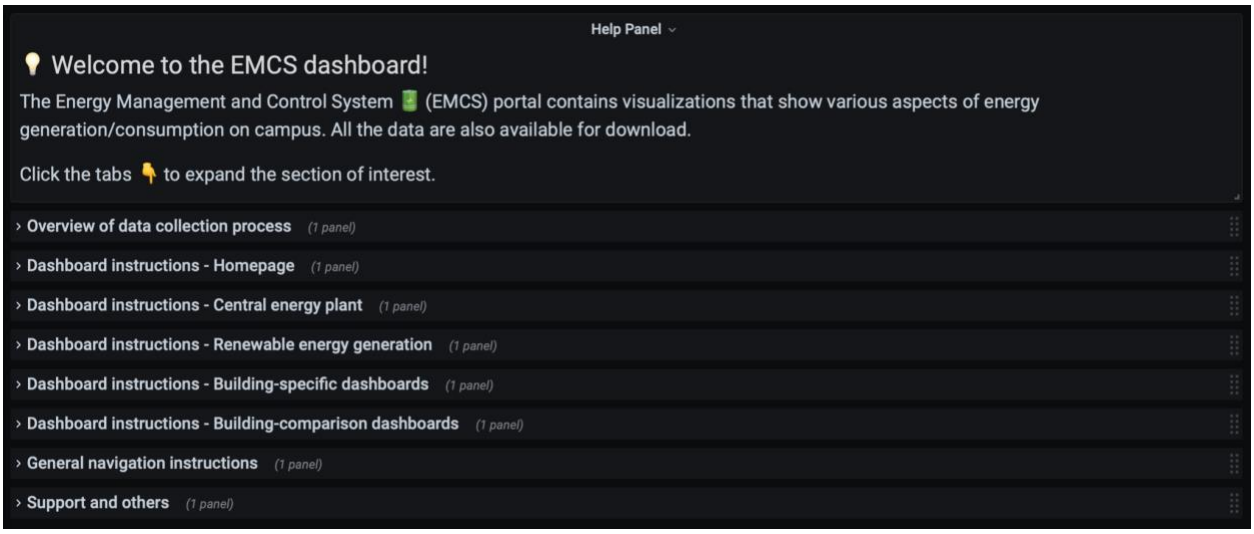


Fig. 13. Comparison of a portion of (A) the original general help page and (B) the modified general help page. (A) The original general help page lacks information about certain aspects of the portal and is hard to read and navigate. (B) The modified general help page contains sections on previously missing information and is separated by section to increase readability and ease of navigation.

3) Dashboard-Specific Help Panels

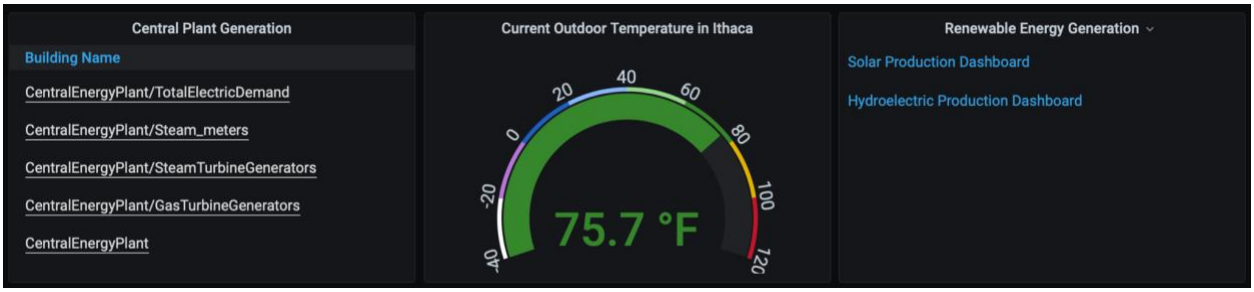
The portal contains different groups of dashboards including the Central Energy Plant Generation dashboards, the Renewable Energy Generation dashboards, and the Building Utility Monitoring dashboards. These dashboard groups contain different forms of energy data that provide information about various aspects of energy production and consumption on and off-campus. Users who are not familiar with the energy data or the portal can face difficulties understanding the purposes of these dashboard groups and how to navigate and understand them. The previous version of the portal lacked documentation for these dashboard groups. The current version of the portal includes dashboard-specific help pages and panels to provide the user with information about what the dashboards are and how to use their features.

One change that was implemented to address this overall problem was adding more descriptive names and instructions to the Central Energy Plant Generation and Renewable Energy Generation dashboard panels present on the portal landing page. Previously, these panels only included links to their sub-dashboards with no documentation or descriptions of what the dashboards were (see Fig. 14A). The improved versions walk the portal user through what they are seeing in the panels and provide links to the dashboards as well as their respective documentation pages (see Fig. 14B). In the improved version of the portal, the dashboard-specific documentation for the Central Energy Plant Generation and Renewable Energy Generation dashboards can be accessed by clicking on the indicated areas as shown in Fig. 14B.

The CEP Generation dashboard-specific documentation can be seen in Fig. 15. It includes information about the dashboard's four sub-dashboards. The Renewable Energy Generation dashboard-specific documentation can be seen in Fig. 16. This dashboard consists of two sub-dashboards, Solar Production and Hydroelectric Production, whose documentation pages can be seen in Fig. 16 and Fig. 17, respectively.

From these documentation pages, the user can navigate to their respective dashboards by mousing over the external link icon in the upper left corner of the panel and clicking on the title of the dashboard (see Fig. 18). This functionality allows the portal user to be able to easily access the dashboard from the documentation without having to first navigate back to the homepage.

(A)



(B)

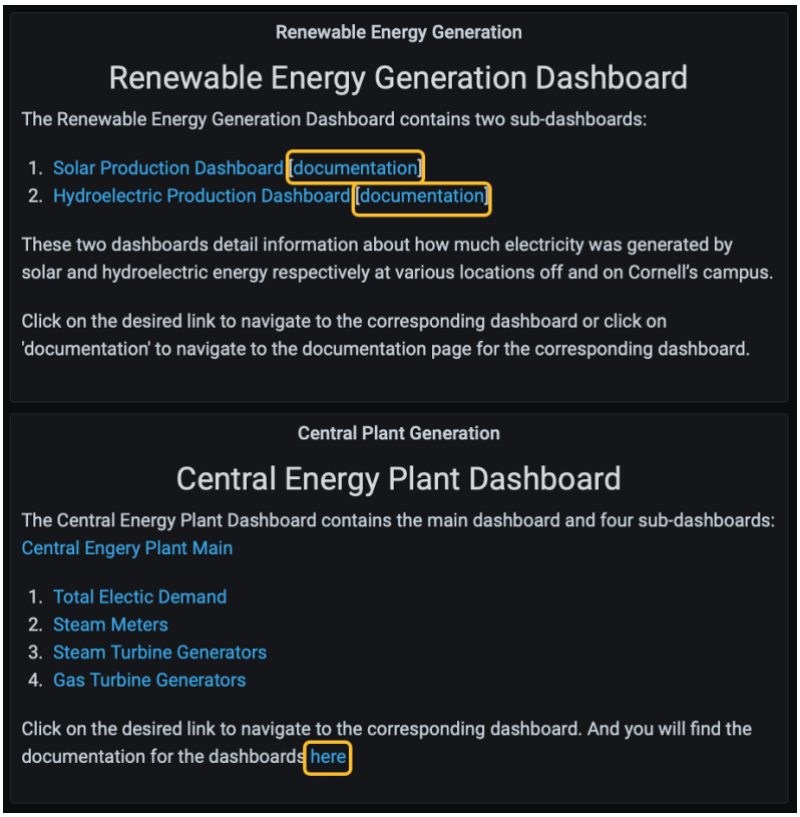


Fig. 14. Landing page panels for the CEP Generation and Renewable Energy Generation dashboards on (A) the original portal and (B) the modified portal. The original version does not guide the user through what sub-dashboards are available nor include links to documentation pages, while the modified version does. The orange boxes indicate where the user would click to access the documentation.

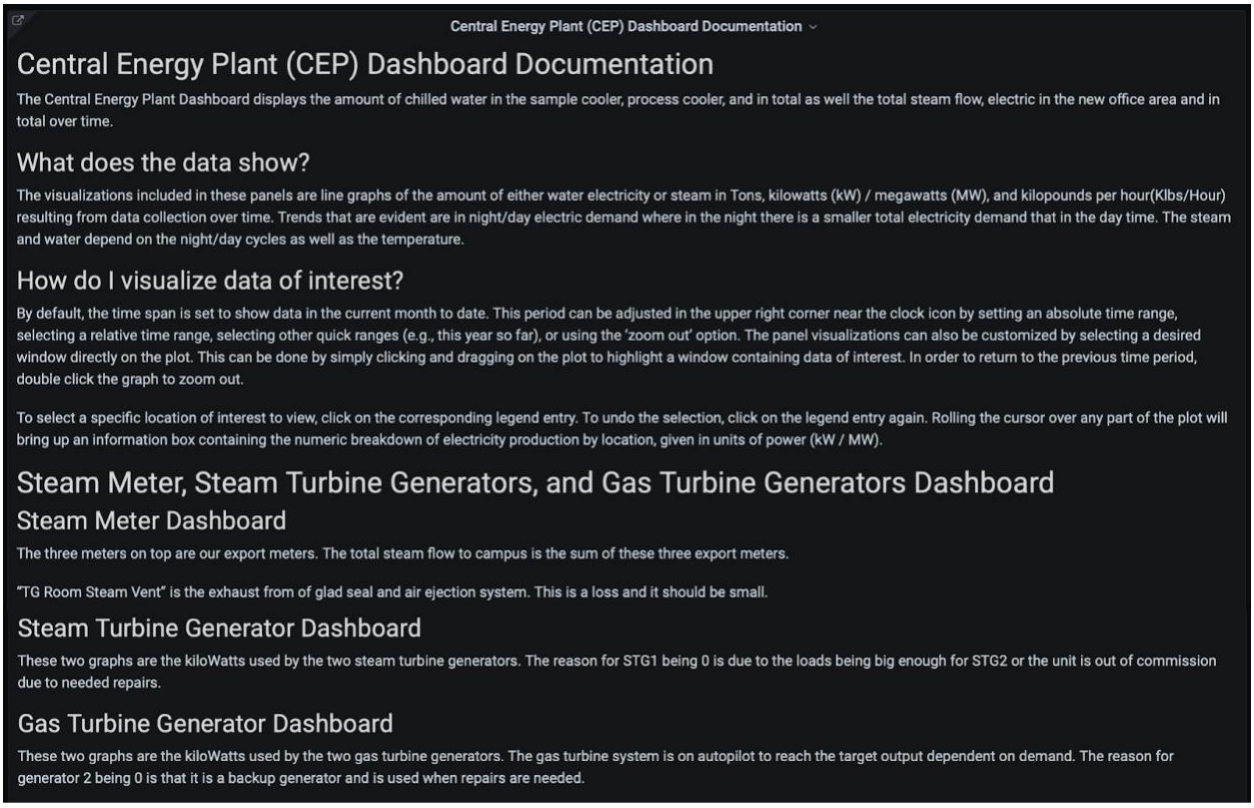


Fig. 15. View of the Central Energy Plant Generation dashboard-specific documentation page. This was added to provide users with more context and information about the Central Energy Plant Generation Dashboard.

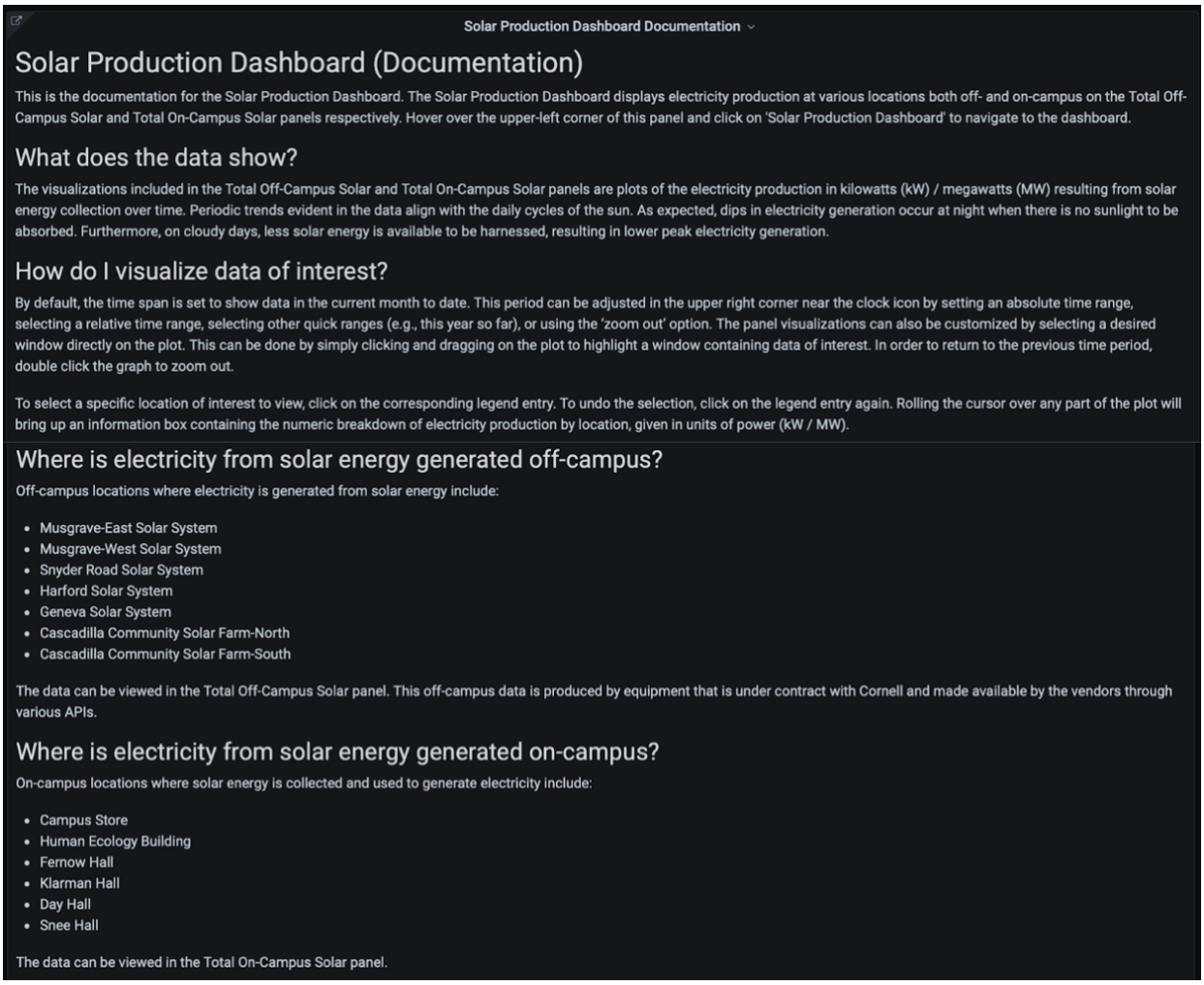


Fig. 16. View of the Solar Production dashboard-specific documentation page of the Renewable Energy Generation dashboard group. This was added to provide users with more context and information about the Solar Production Dashboard.

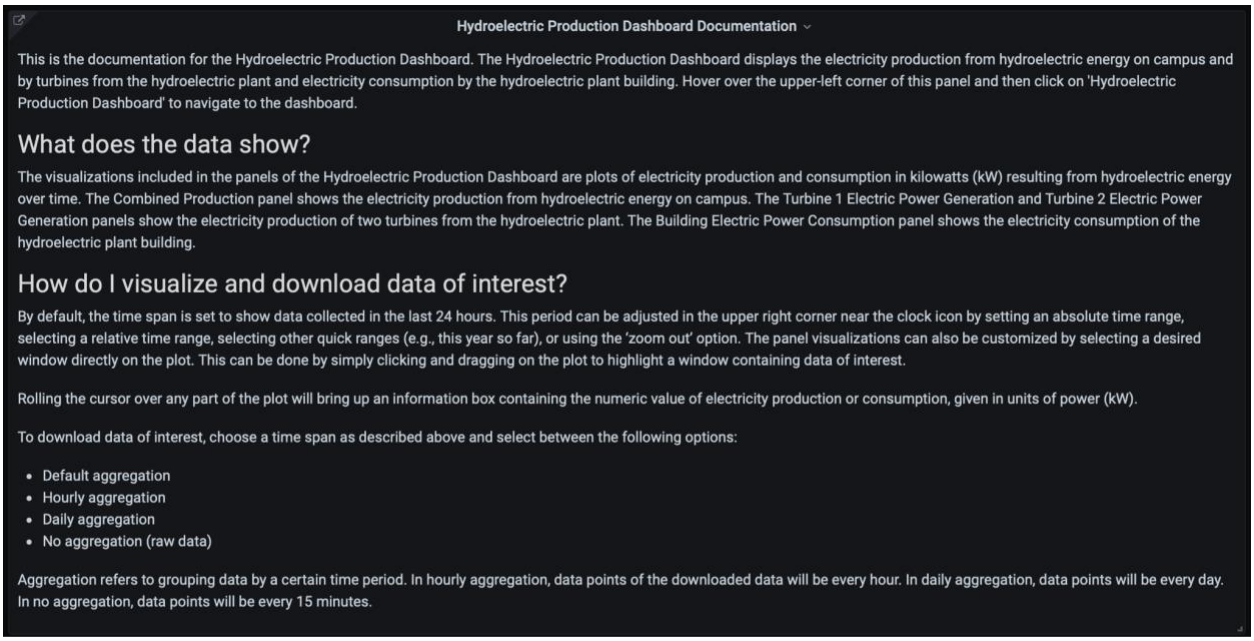


Fig. 17. View of the Hydroelectric Production dashboard-specific documentation page of the Renewable Energy Generation dashboard group. This was added to provide users with more context and information about the Hydroelectric Production Dashboard.

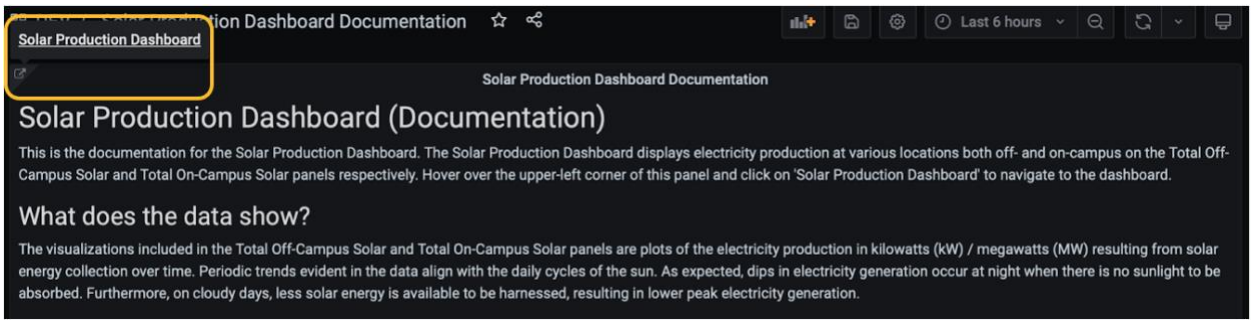


Fig. 18. View of where to click to navigate from the Solar Production Dashboard documentation page to the Solar Production Dashboard. This is analogous to where to click to navigate from the Hydroelectric Production Dashboard and the Central Energy Plant Generation Dashboard documentation pages to the Hydroelectric Production Dashboard and the Central Energy Plant Generation Dashboard respectively.

III. Conclusion

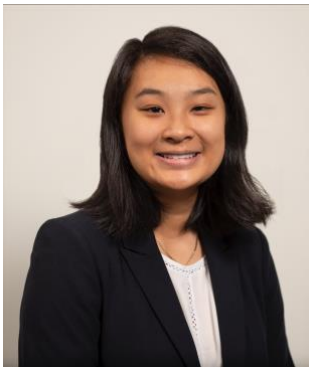
The original EMCS dashboard contains valuable information for various user groups, including the Cornell community, scientists, and researchers. However, certain aspects of the visualization limit the accessibility of some data on the website, despite having the potential to promote sustainability goals and impact the community. Throughout this semester, our team has not only improved visualizations and added additional graphics, but also fixed legends of graphs and created guidelines for newcomers to navigate the website. Once the changes are deployed to the main website, we believe it would greatly benefit all user groups and potentially attract more traffic within and outside the Cornell community.

Team Member Biography

Owen Deng is an undergraduate senior in Electrical and Computer Engineering. Owen enjoys making data visualizations, especially for sustainability-related topics. Owen saw the potential of data from the original EMCS dashboard to be useful for the Cornell community. He thus chose this project. His goal is to raise sustainability awareness on the Cornell campus.

John Lee is an undergraduate junior in Electrical and Computer Engineering. John hopes optimizing the visualization of EMCS gathers more attention to sustainability on Cornell's campus, and raises awareness of electricity consumption.

Ishneet Sachar is an undergraduate senior computer science major. Ishneet is excited about the use of data to improve sustainability and bring attention to sustainability on Cornell's campus! She has enjoyed working on improving the EMCS dashboard and making it accessible for others as a first step of getting students interested in how energy is used on campus.



Jennifer Tieu is an undergraduate senior studying Biomedical Engineering and Computer Science. She is passionate about sustainability and believes that drawing attention to the personal energy usage of individuals is one critical way to reduce energy consumption. As such, she is grateful to have played a part in improving visualizations and documentation for the EMCS portal with the goal of raising awareness of energy consumption on campus by making energy data more accessible to the Cornell community. She hopes that these improvements to the portal will make it easier for the Cornell community to engage in energy conservation.

References

[1] S. Zemanick , Lucid Interview Questions EMCS, 2020. [Dataset]. Available: https://docs.google.com/spreadsheets/d/1q1RlzEfvMK2olpVmgKx4XYk2AkmL8srP/edit#gid=1686122667. [Accessed: May 23, 2020].

[2] G. Sedrakyan, E. Mannens, and K. Verbert, "Guiding the choice of learning dashboard visualizations: Linking dashboard design and data visualization concepts," *Journal of Computer Languages*, vol. 50, pp. 19–38, Feb. 2019, doi: 10.1016/j.jvlc.2018.11.002.

[3] F. Nakazawa et al., "Smart power strip network and visualization server to motivate energy conservation in office," *2011 9th IEEE International Conference on Industrial Informatics*, Lisbon, Portugal, 2011, pp. 352-357, doi: 10.1109/INDIN.2011.6034901.

[4] L. K. Murugesan, R. Hoda, and Z. Salcic, "Design criteria for visualization of energy consumption: A systematic literature review," *Sustainable Cities and Society*, vol. 18, pp. 1–12, Nov. 2015, doi: 10.1016/j.scs.2015.04.009.

[5] MIT, "MIT Shares Energy Data with New Website: Energy Dashboard Will Provide Access to Campus Building Data." *Buildings*, no. 6, 2017, p. 12. *EBSCOhost*, search.ebscohost.com/login.aspx?direct=true&db=edsgbe&AN=edsgcl.498485228&site=eds-live&scope=site.

[6] Harvard University, "Harvard's 2019 Sustainability Report," Mar. 05, 2015. https://report.green.harvard.edu/ (accessed Mar. 28, 2021).

[7] University of California, Berkeley, "UC Berkeley Energy Dashboard." https://engagementdashboard.com/ucb/ucb (accessed Mar. 28, 2021).

[8] N/A, *Grafana*. [Online]. Available: https://play.grafana.org/d/000000012/grafana-play-home?orgId=1. [Accessed: 20-May-2021].

[9] C. F. Blanco, R. G. Sarasa, and C. O. Sanclemente, "Effects of visual and textual information in online product presentations: looking for the best combination in website design," *European Journal of Information Systems*, vol. 19, no. 6, pp. 668–686, 2010.

[10] researchinuserexperience, "Visual Appeal vs. Usability: Which One Influences User Perceptions of a Website More?," *RUX*, 15-Oct-2009. [Online]. Available: https://researchinuserexperience.wordpress.com/2009/10/15/visual-appeal-vs-usability-which-one-influences-user-perceptions-of-a-website-more/. [Accessed: 20-May-2021].