CAMUS
Zero Carbon Grid Orchestration

CASE STUDY

Blazing a Trail with Holy Cross Energy

Holy Cross Energy (HCE), an electric cooperative in Western Colorado, has an ambitious goal to transition from a coal-heavy power mix to 100% carbon-free electricity by 2030.

To enable HCE to progress towards its vision and goals, Camus Energy deployed a secure, cloud-based grid orchestration software platform.

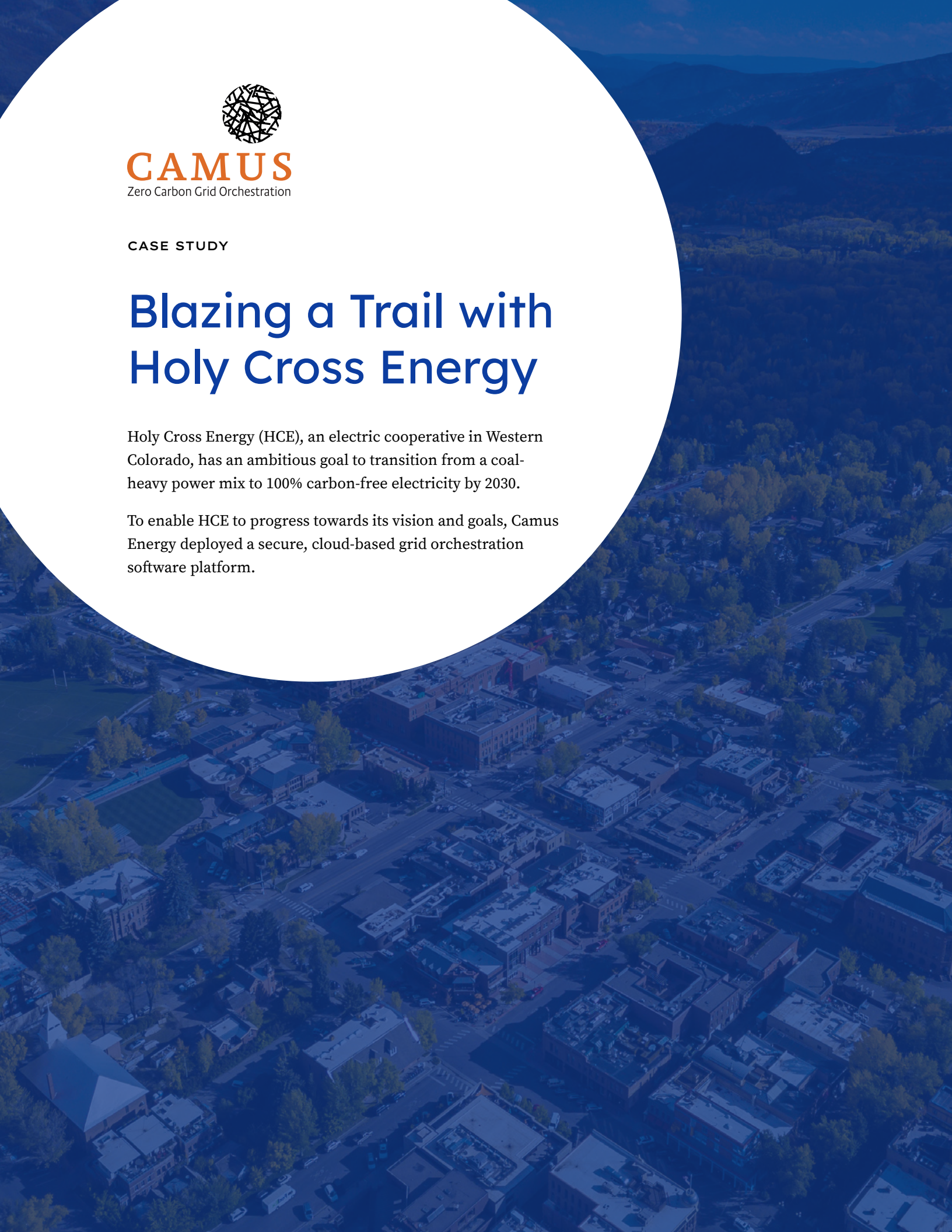


TABLE OF CONTENTS

EXECUTIVE SUMMARY

Blazing a Trail for the Utility of the Future

Challenge

Holy Cross Energy (HCE), an electric cooperative in Western Colorado, has an ambitious goal to transition from a coal-heavy power mix to 100% carbon-free electricity by 2030. About 80% of its carbon-free generation will come from utility-scale solar, wind, and battery storage, with the remaining 20% coming from local distributed energy resources (DERs), such as rooftop solar and batteries at homes and businesses. As HCE makes this shift, it seeks to keep its service affordable while enhancing the resilience of its grid and members.

To get there, HCE is fundamentally re-envisioning grid operations. Its vision is to become a **distribution system operator** that can manage the local grid and orchestrate complex interactions among diverse energy resources—similar to how independent system operators manage transmission systems today. The cooperative wants to treat all of its energy resources agnostically so that its members can participate in its portfolio in the same way as bulk resources.

As more HCE members deployed DERs, the cooperative recognized that managing proliferating DER types, vendors, data, and programs was getting complicated. It needed to simplify the operational complexity while maintaining the flexibility to offer new programs and support more resources.

About Holy Cross

Holy Cross Electric Association, Inc. (HCE) was established in 1939 as a member-owned Electric Distribution Cooperative in Colorado. It serves more than 43,000 members with 58,000 meters in the Aspen and Vail areas, as well as the farms, ranches, and friendly rural communities that provide resources for tourist and outdoor recreation industries.

Solution and Approach

To enable HCE to progress towards its vision and goals, Camus Energy deployed a **secure, cloud-based grid orchestration software platform**.

The platform combines monitoring, analysis, and control of HCE's grid on an interface overlaid with Google Maps. Its features include:

- Quick access to comprehensive information on energy resources and grid assets for day-to-day operational decisions as well as deeper-dive analyses
- Aggregation and control of large numbers of DERs for diverse applications such as coincident peak reduction
- Peak and net load forecasting tools to inform timing of demand response and DER control events
- A tool that estimates loading across different time intervals for each of HCE's 14,000 distribution transformers

Deploying the platform involved collecting, transferring, and integrating HCE's datasets, such as Supervisory Control and Data Acquisition (SCADA), advanced metering infrastructure (AMI), geographic information system (GIS), powerline sensor data, weather data, and data from DERs and renewable energy plants.

Holy Cross Energy reached 48% renewable power supply as of December 2021.

Results and Benefits

- Granular, **real-time grid visibility** and a more accurate connectivity model
- **Direct control** of 500 kilowatts of member-sited batteries and access to 2 megawatts of demand response, **scaling to 35 megawatts** by the end of 2023
- **Significant reductions in HCE's bill** from its wholesale power supplier, saving more than $90,000 between November 2021 and March 2022 and expected to scale with the >10x growth in flexibility resources
- Identification of HCE's **highest-loaded transformers** to inform strategies for safe, efficient operations

A Foundation for the Future

Camus has provided the cooperative with a **strong foundation for its transformation** into a 100% carbon-free distribution system operator:

- The platform can quickly integrate new energy resources as they are deployed, enabling HCE to optimize their use and avoid adverse grid impacts.
- As Colorado transitions to a wholesale electricity market, HCE can use the platform to optimally dispatch its energy resources.
- HCE can establish a local energy market, using the platform to orchestrate the market and maximize value for all of its members.

The platform's deployed capabilities were selected based on the near-term needs of the cooperative. The HCE team plans to deploy additional capabilities to address more opportunities and challenges.

CHAPTER 1

The Strategy

Western Colorado is renowned for the towering peaks of the Sawatch Mountains that attract outdoor lovers from around the world. The region also has the equally impressive, though lesser known, distinction of leading the clean energy transition.

Holy Cross Energy (HCE), an electric cooperative based in Glenwood Springs, has an ambitious goal to provide 100% carbon-free electricity by 2030. That target puts HCE in the company of just a handful of utilities in the United States. Today, 48% of HCE's power supply comes from renewable energy.

To reach 100% carbon-free energy in less than eight years, HCE is fundamentally re-envisioning grid operations. In 2020, the cooperative began a long-term partnership with Camus Energy to support its vision through a grid orchestration software platform.

This case study documents the collaboration—the activities, new capabilities, benefits, and insights. This work is breaking new ground in grid management.

HCE's Goals

The HCE-Camus collaboration began with conversations about how Camus' grid orchestration platform could support the cooperative's goal to provide safe, reliable, affordable, and sustainable energy and services for its members.

Decarbonize.

First and foremost was HCE's ambition to transition from a coal-heavy power mix to 100% zero-carbon generation. To meet the goal, HCE considered different mixes of large-scale renewable generation and distributed energy resources (DERs), such as rooftop solar and member-sited batteries.

Its 100x30 plan calls for ~80% of its clean energy supply to come from utility-scale solar, wind, and battery storage, with the remaining ~20% from local DERs. The Camus platform offered an integrated solution for HCE to manage both sets of resources to support its grid and its members.

Improve Resilience.

In 2018, a wildfire burned halfway through a critical transmission pole that powers a significant part of the cooperative's service area. This close call prompted HCE to expand its grid resilience efforts and mitigate wildfire risks.

The cooperative has optimized vegetation management via satellite imagery, enhanced grid inspections with infrared cameras, and added sectionalizers to help minimize the impact of preventive shutoffs.

With Camus, HCE saw an opportunity to take resilience to the next level through real-time grid visibility and enhanced management of local energy resources.

Lower Costs.

Core to HCE's mission is providing affordable power that helps improve the quality of life for its members and their communities.

In early discussions, HCE and Camus identified a promising avenue to make a meaningful cut in costs: peak management.

HCE's power supply contract with PSCo includes a dollar-per-kilowatt (kW) coincident peak charge, the fee associated with the hour each month in which PSCo's overall system is at peak load. In 2021, HCE paid about 26% of its total annual power supply costs in coincident peak costs. For most years, these charges account for about 20% of HCE's power costs.

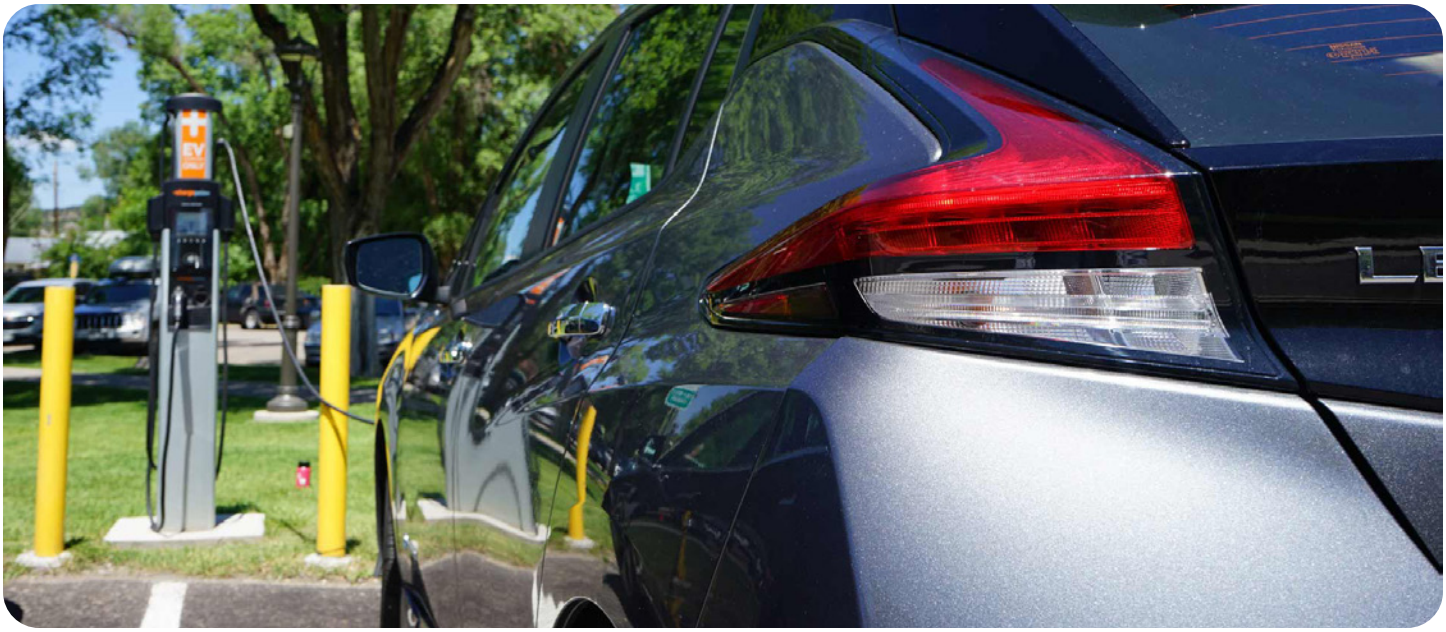
Recognizing the potential to save hundreds of thousands of dollars per month from peak shaving, HCE turned to Camus to better understand when and where to call demand response events. The co-op regularly uses Camus' coincident peak forecasting module alongside the platform's direct control of distributed energy resources (such as member-sited batteries) to call events and reduce coincident peak demand.

Innovate.

HCE is led by CEO Bryan Hannegan, a former Associate Lab Director at the National Renewable Energy Laboratory. Hannegan is keen to demonstrate cutting-edge solutions on HCE's grid and carve a path that fellow utilities can follow.

A core component of HCE's vision is to leverage demand flexibility and distributed generation alongside utility-scale resources. The cooperative plans to do so by creating rates, programs, and a local marketplace where it compensates members for contributions to the grid. This would transform HCE into what's often referred to as a distribution system operator (DSO).

HCE hopes to demonstrate a successful DSO model and help other power providers make the same transition. It views the Camus platform as a key enabler of HCE's DSO capabilities by helping the co-op monitor and manage local resources.



Above: Holy Cross Energy partners with EV infrastructure company ChargePoint to provide equipment and manage the charging network.

The Evolving Role of DERs on HCE's Grid

HCE has made progress toward its vision of sourcing an increasing amount of its carbon-free power supply from local DERs. Relative to other cooperatives around the country, HCE is ahead of the curve with DER adoption. It has recently implemented a range of member programs to support continued adoption and tap DERs for grid services like peak shaving.

While HCE's members are adopting DERs faster than members of many other co-ops, the trends that HCE is seeing will quickly become top-of-mind for utilities across the country over the next few years.

Electric vehicles

Since 2018, HCE has managed programs that incentivize and deploy EV charging infrastructure at homes, communities, workplaces, local transit agencies, and the co-op's vehicle fleets. It partners with EV infrastructure company ChargePoint to provide equipment and manage the charging network.

HCE provides members with free home chargers in exchange for auto-enrolling in the co-op's "distribution flexibility" tariff. The tariff enables HCE to adjust the rate of charge of the chargers to meet the needs of the member and the network, known as "managed charging." HCE is also covering grid upgrade costs to develop a public fast-charging network.

Since 2018, HCE has deployed about one home charger every three days. According to a progress report in 2021, there were 270 home and workplace chargers, 278 level 2 community chargers, and 38 community DC fast chargers in HCE's service territory. This puts 2 of the 3 counties HCE serves in the Top 10 US counties for EV charging.

Renewable energy

Since 2009, HCE has offered installation rebates and net metering to members who install renewable electricity generation at their homes or businesses. Eligible systems include solar, hydropower, biomass, geothermal, and wind. As of 2021, members have deployed 19 megawatts (MW) of distributed generation. In total, HCE leverages 30 MW of distribution-connected solar, 12 MW of biomass, and 369 kilowatts (kW) of small hydro from both member installations and power purchase agreements (PPAs). Going forward, the co-op aims to support deployment of at least 2 MW of rooftop solar per year.

Residential batteries

In 2021, HCE launched the Power+ program through which the cooperative installs Tesla Powerwall residential battery systems for its members, covering the upfront costs in exchange for a small monthly bill charge and the ability for HCE to call upon the batteries.

HCE can do so up to 10 times per month to reduce peak demand costs. Participants are eligible for bill credits through HCE's "distribution flexibility" tariff.

Currently, more than 500 kW of Powerwalls participate in the program. HCE expects that number to increase to 2,000 kW by the end of 2022. The program's goal is 5 MW / ~15 MWh of residential storage.

Microgrid

In 2018, HCE worked with the National Renewable Energy Laboratory (NREL) to deploy a microgrid that connects the Basalt Vista affordable housing community with solar power arrays and batteries. The project continues to examine the value of behind-the-meter DERs to members and the grid.

Flexible loads

HCE offers rebates to homes and businesses for installing smart thermostats, heat pumps, heat pump water heaters, and other loads. In 2021, HCE members deployed 624 member-owned flexibility devices.

Demand response

Since 2019, HCE has called upon member resources to support the grid via demand response events. Today, HCE regularly calls events to lower its coincident peak and ensure reliability. Members who are enrolled in HCE's Peak Time Payback program and reduce their energy use during these events receive credits on their bill. Currently, HCE has access to about 2 MW of demand response resources through this program. HCE's system peak demand is 270 MW. HCE is also piloting their Green Up program to incentivize increases in usage during renewable oversupply events.

Simplifying Grid Management with Orchestration

As more HCE members deployed DERs and enrolled in HCE programs, the cooperative recognized that managing proliferating DER types, vendors, and programs was getting complicated. They needed to simplify operations while maintaining the flexibility to offer new programs and support new resources.

"Several years ago, I walked into our dispatch room and noticed that we had gone from three monitors to six monitors," said Chris Bilby, a Research Engineer at HCE. Bilby's role includes day-to-day grid operations and managing how HCE's members interact with the grid.

"I thought, 'This is going in the wrong direction. We need to filter this down to one interface that provides only the information you need to see and that can recommend decisions based on information that's in the background.'"

That's why HCE partnered with Camus Energy in 2020: to simplify complexity. Camus' grid orchestration platform integrates the utility's data into a single interface that can monitor and control devices across the network.

> "We joined forces with Camus knowing that we have a lot of DERs coming down the pipeline. Camus' platform is an orchestrator. It allows you to dispatch DERs and provides awareness of grid conditions to inform those dispatches."
>
> Chris Bilby, Research Engineer

In 2018, HCE worked with the National Renewable Energy Laboratory (NREL) to deploy a microgrid that connects the affordable housing community with solar power arrays and batteries.

CHAPTER 2

The Setup

Data Collection and Integration

One of the most intimidating aspects of managing a multitude of member DERs is handling all the associated data. In this digital age, utilities already have more data than they're able to leverage. Layer on telemetry from thousands to millions of devices on the grid, and it gets complicated quickly.

To achieve its vision of orchestrating local devices as a meaningful part of grid operations, HCE needed Camus' help in figuring out how to deal with the data, collecting and integrating it into a unified data foundation.

HCE's data collection systems included:

- Supervisory Control and Data Acquisition (SCADA)
- Advanced Metering Infrastructure (AMI)
- Geographic Information System (GIS)

The cooperative also collected datasets from powerline sensors, DERs, and renewable energy systems.

Above: Astrid Atkinson (Camus Energy) and Chris Bilby (HCE) stand next to two Tesla Powerwalls at the Basalt Vista Affordable Housing Community.

Collecting the Data

Camus worked with HCE's IT team to understand the cooperative's network architecture and agree on an approach for the data transfer and collection. HCE set up data transfer infrastructure within its secured internal network.

Camus ordinarily installs and configures its data collection server during a site visit. But because of the COVID-19 pandemic, HCE completed these tasks with Camus staff guiding HCE remotely. Using its standard server configurations, HCE deployed Camus's data collection server in a "demilitarized zone"—in other words, a network separate from HCE's internal network.

Camus provided the data collection scripts to the HCE team, who moved them onto the server, where they worked as expected. The data transfer infrastructure pushed the data over a secure VPN outside HCE's network boundary where Camus's server collected them in the cloud. This approach allowed Camus access to necessary data while protecting HCE's internal network from cyberattacks.

Camus' systems never crossed the HCE network boundary. Throughout the transfer process, Camus always completed tasks on HCE's server in a group setting with HCE and via remote control initiated by HCE using Webex. Every task happened with HCE's consent, involvement, and direct supervision.

Integrating the Data

After the data transfer, the next big step was to integrate HCE's datasets into the Camus platform. This was a critical part of the Camus-HCE collaboration. Camus' objective was to deploy its platform as a unified, coherent view of the grid, including all the information needed for HCE's day-to-day operational decisions.

The interface had to be simple and easy to navigate, while providing quick, actionable insights about the grid and DERs. At the same time, it had to enable easy access to additional data to inform deeper-dive analyses.

Camus started by integrating its standard datasets: SCADA, AMI, and GIS, followed by optional datasets chosen based on HCE's resource mix:

ChargePoint EV chargers

ChargePoint provided credentials and an application programming interface, or API, for its charging network. This allows the Camus platform to communicate with, collect data from, and control ChargePoint's chargers. Data integrated into the platform includes but is not limited to: station location, historical and current use, port configuration, port state, voltage, and current. The integration enables platform users to send commands via the API to different groups of chargers (such as chargers at homes and businesses, public chargers, and chargers at HCE headquarters) as needed to shave peaks.

Tesla Powerwalls

Similar to ChargePoint, Tesla provided Camus with credentials and an API to enable data access and aggregated control of Powerwalls installed at member homes. Data integrated into the platform includes but is not limited to: site location, battery instantaneous power, site instantaneous power, site solar power, state of charge, and maximum energy available. The platform user can specify when and for how long the Powerwalls charge, discharge, and hold energy. Users can also view and download battery power data for peak management events.

Community and utility-scale solar, biomass, and hydropower plants

The Camus platform also incorporates available telemetry from community and utility-scale solar PV, biomass and hydroelectric plants within HCE's territory. Specifically, Camus pulls in revenue meter, SCADA and AMI data from such assets including, but not limited to, real and reactive power, current, voltage, power factor, state of charge (SOC) and energy production. Camus Energy achieves this via APIs, automatic generation control (AGC) signals, industrial protocols or even flat text files provided by third-party distributed energy asset or instrumentation suppliers.

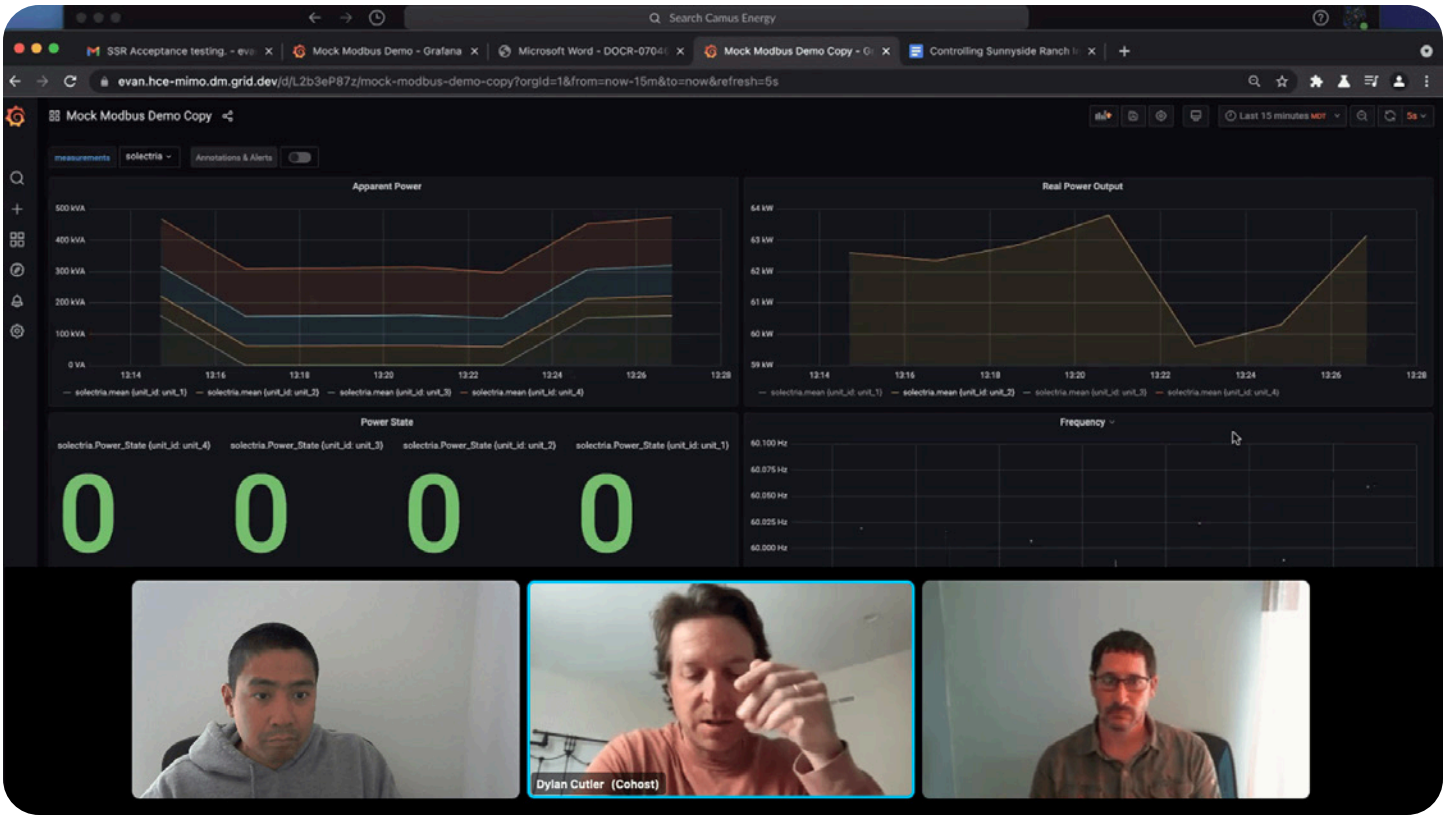
Weather data

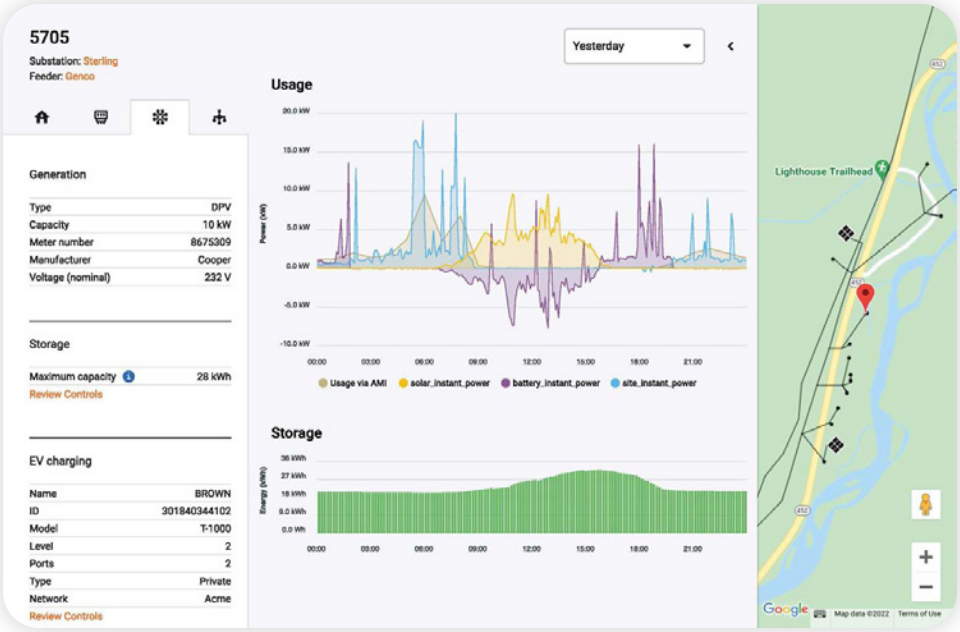
Camus integrated data on current weather conditions and weather forecasts from several sources, including OpenWeather API, National Weather Service API, and the Weather Company/IBM.

Other datasets planned for integration or in progress at HCE include:

- Utility-scale energy storage
- Renewable project site weather stations
- Smart home aggregators
- Smart thermostats
- Residential heat pumps and heat pump hot water heaters
- Electric school buses with smart charging and discharging

Below: Astrid Atkinson (Camus Energy) and Chris Bilby (HCE) stand next to two Tesla Powerwalls at the Basalt Vista Affordable Housing Community.





Above: Camus' monitoring interface showcases data from multiple sources, including AMI, GIS, SCADA, and DER telemetry with geospatial information overlaid on Google Maps

Onboarding the HCE Team

To best utilize the platform, HCE wanted to be sure that all of its team members – regardless of technical expertise - could access and analyze the data. By offering a simple user experience with robust analysis tools, it was easy for Camus to onboard a wide range of HCE staff members with varying goals, responsibilities, and skill sets.

Camus first provided select HCE power supply and engineering staff with unique login credentials to enable them to navigate the new platform in their web browsers. Then, Camus conducted a series of canary and acceptance tests on various aspects of the platform, ranging from the verification of specific data points to detailed tests of key interfaces and controls observed by HCE's "super users."

When these initial tests and verifications were complete, HCE extended platform access to additional users from member support, engineering, operations, and program administration.

Camus staff and HCE's super users provided training to the new users on key aspects of the platform. Fortunately with the platform's simple interface, anyone at HCE —whether it be a member support representative or an executive—can use the platform to gain a bird's eye view of HCE's grid and analyze data for more informed decisions. It's as easy as using Google Maps or Google Search.

At the same time, the platform also provides access to powerful capabilities. It encapsulates millions of data points, so that resource schedulers, like David Manning, can conduct complex analyses like voltage heatmaps and orchestrate distributed assets in real-time.

CHAPTER 3

The Platform in Action

Above: Camus' cloud-based grid orchestration platform is deployed at distribution utilities and load serving entities across the U.S.

Seeing Immediate Value

After the platform's launch in early 2021, HCE's engineering and power supply teams quickly began to use it for their distinct needs. There was an immediate recognition of its benefits and its potential to take grid management to the next level. These early benefits included:

One interface for grid-wide orchestration.

In contrast with HCE's prior grid management activities, the platform combined monitoring, analysis, and control of the grid and its energy resources in a single interface. By reducing the need for control room staff to move back and forth between different monitors, HCE was able to streamline its day-to-day operations.

> "The platform provides a single dashboard that can manage and aggregate a multitude of DERs for many different applications. This simplifies what would otherwise be a very complicated task."
>
> Chris Bilby, HCE Research Engineer

"A key value of the platform is that it integrates all the controls in one place," said Sam Whelan, HCE's power supply manager. "If we see something happening on the grid or in our energy portfolio, we can make the necessary adjustments to our various programs and large-scale resources at the same time."

Better visibility.

Nothing is more frustrating for grid operators than being unable to see what's happening on their system. Despite progress in other industries, most grid operators today are forced to rely on data that lags hours or even days behind. At HCE, siloed and delayed data was a barrier to flexible grid operations.

The Camus platform immediately provided more granular, real-time visibility by combining grid and device data with near-term forecasts.

"Over the last several years, we've been collecting more and more granular data," said Bilby. "Our demand data from smart meters has gone from one-hour intervals to 15 minutes. Now that we've deployed Tesla Powerwalls and wireless energy monitors for our members, we're getting five minute data and even 30-second data. The Camus platform puts this data in front of the right people and helps them understand what they can do with the data. It allows them to make decisions."

With a clearer picture of grid conditions, operators at HCE are able to identify problems more quickly.

> "Recently, we noticed a big jump in the load on a substation. Because our grid data is so accessible, we were able to quickly determine that there was an outage at one of our largest generators."
>
> David Manning, Resource Scheduling Analyst

Manning points to other benefits of grid visibility that he expects to see in the near future.

"With new utility-scale solar resources coming online, there's a growing risk of reverse power flows on certain substations," he said. "The visibility every day into what's happening on our system is useful for me in thinking about problems that we have coming down the pike."

Enhanced data quality.

When integrating data in the platform, Camus helps utilities identify and correct discrepancies, errors, and other data shortcomings. The improved data quality serves as a stronger foundation for monitoring, analysis, and forecasting.

During the process of collecting and integrating HCE's data, Camus and HCE found and fixed issues such as out-of-date firmware on meters at substations and solar arrays, inaccurate calculated points in the SCADA system, and insecure, clear-text file transfers.

> "One of the areas where we saw value right away was in Camus flagging data that looked out of bounds or off — problems that are difficult to catch with the human eye."
>
> Sam Whelan, HCE Power Supply Manager

An up-to-date grid connectivity model.

Prior to working with Camus, HCE was only able to update the grid model in their meter data management system (MDMS) quarterly, due to constraints with its existing vendor. That meant that HCE was using a model that was as much as three or four months old.

"If we wanted to implement new services or evaluate new grid assets, the vendor wasn't able to provide the timely feedback loop that we needed for those activities," said Bilby. "Since Camus integrated our grid data, we have been able to update our grid model weekly."

Peace of mind.

With coordinated control, real-time visibility, and improved data quality, HCE is better able to serve the diverse needs of its membership. The Camus platform has helped HCE's leaders tackle today's challenges while preparing for the future. That flexibility has, in turn, delivered more peace of mind for team members across HCE.

Above: An early use case of the Camus platform included estimating transformer loading.

Initial Use Cases

The platform's visibility serves as a foundation for Camus to help HCE operate its rapidly changing grid. HCE and Camus plan to continue to add tools to the platform as part of their ongoing partnership. As a starting point, HCE asked Camus to deploy two high-priority capabilities:

- Net demand and coincident peak forecasting to support HCE's power supply management and scheduling
- A tool to estimate loading on each of HCE's 14,000 distribution transformers

As the co-op continues to decarbonize its grid and become a distribution system operator, HCE plans to leverage the Camus platform for additional use cases.

Peak Forecasting for Power Supply Management

For utilities across the United States, power supply portfolios are continuing to shift. HCE is no different, moving from heavy reliance on coal toward a goal of 100% renewable supply by 2030.

The HCE power supply team views all energy resources on the same playing field.

"Our goal is to be agnostic as to where our energy comes from and to view all of our resources holistically," said HCE Power Supply Manager Sam Whelan.

> "We want to be able to design programs that allow members to participate in our portfolio in the same way as a bulk system resource."
>
> Sam Whelan, Power Supply Manager

Implementing an agnostic approach can be complex and cumbersome.

"We already have numerous grid datasets and internal data streams," said Whelan. "When you start controlling EV chargers, batteries, and other resources, you need to pull up more screens and applications because every manufacturer has a different control interface. That's why we've asked Camus to pull all our data and controls into one simple, user-friendly platform that lets us treat our resources agnostically."

Aggregating Member Resources

Member-owned resources must be aggregated to be effectively coordinated for power supply management. While some utilities rely on third-party aggregators to coordinate member- or customer-owned resources, Whelan said that HCE wants to aggregate resources itself.

"Based on our cooperative principle of serving our members, we want to keep that direct relationship with members," he said. "HCE is focused on member satisfaction and making sure everyone feels a part of the co-op. We want that to continue."

Coincident Peak Forecasting

In 2021, HCE hired David Manning as a Resource Scheduling Analyst to schedule power procurements and balance near-term supply and demand. In addition to managing the co-op's supply resources, Manning must forecast expected demand, fully considering the impacts of distributed resources like rooftop solar arrays and electric vehicles.

To tackle this complicated forecasting challenge, HCE turned to Camus.

For HCE, a core driver of its power supply costs is the co-op's coincident peak with the Public Service Company of Colorado (PSCo). PSCo's 12 annual coincident peak charges amount to roughly 20% of HCE's annual power costs. By forecasting PSCo's system peak, Manning can find ways to meaningfully reduce power supply costs through peak shaving. As more dispatchable DERs connect to the system, the value of accurate forecasting and peak shaving will increase.

At the outset of the Camus collaboration, HCE relied on an internal peak forecasting tool that needed gut-checks from other data sources.

> "When we were forecasting the peak, we would have our internal forecast pulled up, an external forecast data source pulled up, and a couple different weather sources pulled up—all on multiple different windows or screens."
>
> Sam Whelan, Power Supply Manager

To simplify the forecasting process, Camus launched a coincident peak forecasting module that automates the process that HCE's forecasters had used for years.

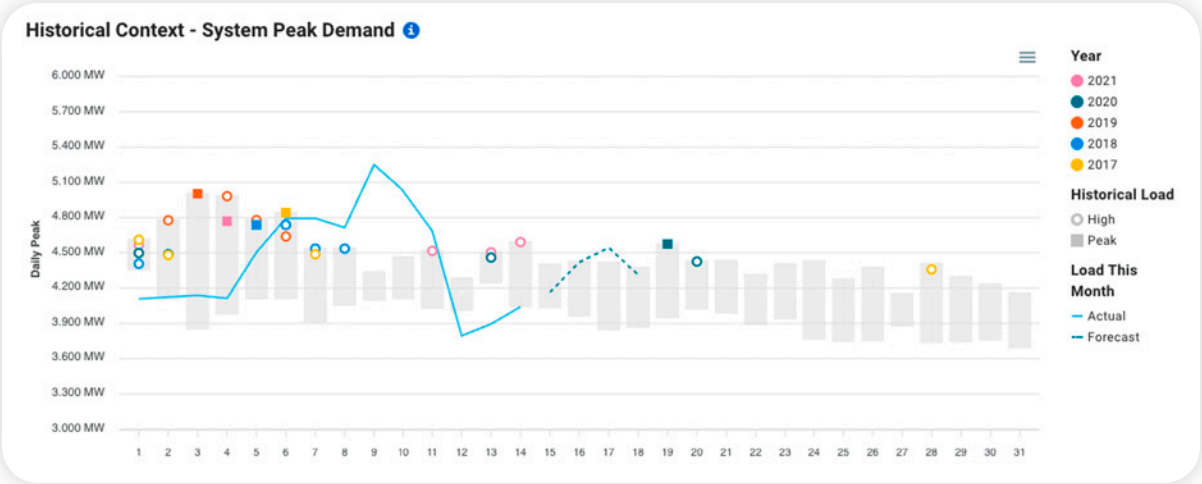
A machine learning model combines historical PSCo peak demand values and weather forecasts in a regression model that generates a point forecast for the PSCo system's peak demand, including the hour in which it occurs. The point forecast is then combined with the month-to-date peak value and historical load ranges in a statistical classification algorithm, which classifies the forecasted peak as very likely, likely, or unlikely to be the coincident peak for the month.

The results inform when Manning uses the platform to call demand response and battery discharge events to reduce the peak. From November 2021 through March 2022, these events saved HCE a total of about $90,000 in power supply costs.

"The Camus platform is much more user-friendly and neatly packaged than any of our internal Excel-based tools, and it's much easier to get up to speed on it," said Manning.

> "I was able to use it to call a battery event in my first two weeks on the job. Being able to click a button to say when I want to dispatch them has allowed me to create immediate value in my position."
>
> David Manning, Resource Scheduler

Below: Example coincident peak forecast with historical peak demand information.



Determining When To Call Events

In addition to pinpointing the specific peak hour, Manning points to another advantage of the Camus forecasting tool over HCE's status quo: It provides better insight into whether or not events should be called early in a month.

Forecasting peak demand at the start of a month is inherently trickier due to the large number of days remaining in the month. As the number of remaining days decreases, the uncertainty decreases. This occurs because each month has only one coincident peak, so predicting a peak early in the month requires more assumptions about what potential peaks will look like the rest of the month.

Before adopting Camus's approach that considers time of month, the HCE team relied on simple heuristics to incorporate time-of-month considerations.

"If you're at the beginning of the month, the demand forecast for the peak hour on a certain day might be a relatively low number of megawatts, but the Camus tool might still say it's likely or very likely to be the coincident peak," said Manning.

> "In October 2021, before the Camus tool was up and running, I missed the coincident peak because the weather was mild at the beginning of the month. I thought chances were high that we were going to see a higher peak later in the month. With Camus, I wouldn't have missed that peak."
>
> David Manning, Resource Scheduler

This approach to forecasting helps Manning call the optimal number of demand response events to substantially reduce the coincident peak without over-burdening local resources. It also frees up behind-the-meter resources to add more value, e.g. by participating in wholesale markets.

"There is a finite number of events we can call," said Manning. "If we call an event and the peak doesn't occur on that day, there can be a relatively significant cost associated with that. The Camus tool is helping us save money by avoiding unnecessary events.

Automating Peak Management

Currently, Manning is validating the tool alongside HCE's internal forecasts. He expects his reliance on Camus to continue to grow over time, especially as he's able to look at the contribution of specific factors, like weather, to peak forecasts.

"When we can look under the belly of the forecasts, I will rely completely on the Camus tool," said Manning. "Our vision is that these decisions will be automatic, or at least that the platform will make a strong recommendation and I can say yes or no to that. Given how accurate the tool has gotten so quickly, I imagine doing that in the next year."

Net Load Forecasting

An understanding of peak demand is crucial to reducing costs, but the challenge of managing power supply doesn't stop there. Utilities like HCE must also forecast overall net loads on their system to ensure they're matching supply with demand 24/7/365. And as rate structures and incentives become increasingly complex, accurately forecasting net load becomes more difficult.

Camus's net load forecast provides HCE with a more accurate picture of hourly demand over the next few days—accounting for distributed generation like rooftop and community solar systems.

The tool automates the net load forecasting methods already in use by HCE's power supply team.

Better forecasts help HCE procure wholesale power, call upon demand-side resources to shift load, and anticipate emergency demand response events. For example, if the net load forecast shows a gap between projected demand and procured supply, HCE can purchase more power or adjust demand-side resources.

The tool is currently in the beta phase. The team is fine-tuning its accuracy and integrating it with the platform's controls.

Above: An early use case of the Camus platform included estimating transformer loading.

"The vision is to create a circular loop where the forecast informs a decision about when to charge the batteries, for example, and the results of that decision flow back to the forecast so that we know what we need to procure each hour," said Whelan

> "The insights from the forecast will be essential to our control decisions when we start seeing oversupply from renewables."
>
> Sam Whelan, Power Supply Manager

"Once we're comfortable with the level of accuracy of the net load forecast, we plan to use the tool to identify trading opportunities in energy markets so that we can procure power a lot more strategically and in ways that reduce costs for our members," said Manning. "I see a lot of potential in feeding data streams into the tool, such as how DERs are currently being managed and how much power we've already scheduled to purchase."

Transformer Loading

The proliferation of renewable energy and DERs on HCE's grid has not only affected its power supply mix. It is changing how its control room staff operate and manage their critical grid assets. The first major opportunity to support the HCE engineering and operations teams was to address data gaps related to transformer loading.

With more than 14,000 transformers, HCE is committed to reducing transformer failures and outages due to overloading, identifying transformers in need of replacement, improving utilization of transformers, and understanding the extent to which new loads can be accommodated on different parts of the grid.

Estimating Loading

In December 2021, Camus rolled out a tool that uses available data to estimate current and historical loading on each transformer. It uses GIS data to match each meter with the transformer that serves it. Then it uses AMI data to aggregate the power consumed at all the meters served by a particular transformer.

By comparing a transformer's actual loading with its nameplate rating (from GIS data), HCE can identify which transformers are over-, under-, or efficiently loaded. Today, HCE uses a report that highlights the 25 highest-loaded transformers as a percentage of rating over the prior day, week, and 30 days.

The tool provides data on local grid conditions to help HCE's team put the transformer loading information into context. Data on voltage (maximum, minimum, median) and power consumption at each downline meter enables HCE to better understand how different members contribute to each transformer's loading over time.

Protecting From Failures

While the feature is still quite new, HCE is already gaining valuable insights from its use. For example, HCE has identified its highest loaded transformers—some at 200-300% of their nameplate ratings—and is evaluating the causes of the high loading. The team expects the lessons from these analyses to inform new strategies to support safe, efficient operations.

> "The transformer loading tool gives us a real-time picture of aggregated voltage at each transformer. Two of our transformers recently prematurely failed, and if we had had this tool up and running, we probably could have saved them and avoided five hours of outages."
>
> Chris Bilby, Research Engineer

Bilby added that HCE plans to use the aggregated voltage readings to better understand grid conditions and inform decisions about discharging large numbers of batteries or charging EVs. A next step is to enhance the tool to include planning capabilities.

"Let's say that we've identified an overloaded transformer that serves four homes, and one of the homes wants to get an EV. What do we need to do to enable that?" said Bilby. "We want to add a feature to the platform that simulates how the transformer's load would be impacted by a new EV."

Preparing for HCE's DSO Vision

HCE is preparing for a significant shift in its grid operations as it works toward its goal of 100% carbon-free electricity by 2030. It aims to become a distribution system operator for a grid in which both utility-scale resources and local DERs play meaningful roles in grid operations.

The Camus platform is directly supporting HCE's preparations. It helps HCE quickly and easily integrate new energy resources, providing visibility into a changing landscape and more flexibility in managing local grid conditions.

The platform also helps HCE take a strategic approach to the deployment of DERs and utility-scale renewables. The platform arms HCE with data to inform decisions on the optimal location and configuration of these resources. And it provides a transparent way to communicate these insights to members and project developers.

"We're working with Camus to create voltage maps of our system," said Chris Bilby, HCE Research Engineer. "These may show us that there is more room for renewables in some areas. But they may lead us in other areas to require members to couple their rooftop solar with batteries so that they're not generating during the daytime."

Emerging Wholesale Energy Markets

In 2021, the Colorado legislature passed a bill requiring the state's transmission utilities to join organized wholesale electricity markets by 2030. The transition to wholesale markets is likely to occur over the next several years, making available day-ahead and real-time markets for procuring energy. HCE wants to be prepared to optimally dispatch its diverse local assets in these markets.

> "We're focused on peak reduction for just a few hours each month. For the rest of the time, I see incredible potential to look at energy markets across the West, take a financial position, and meet that with our fleet of resources."
>
> David Manning, Resource Scheduler

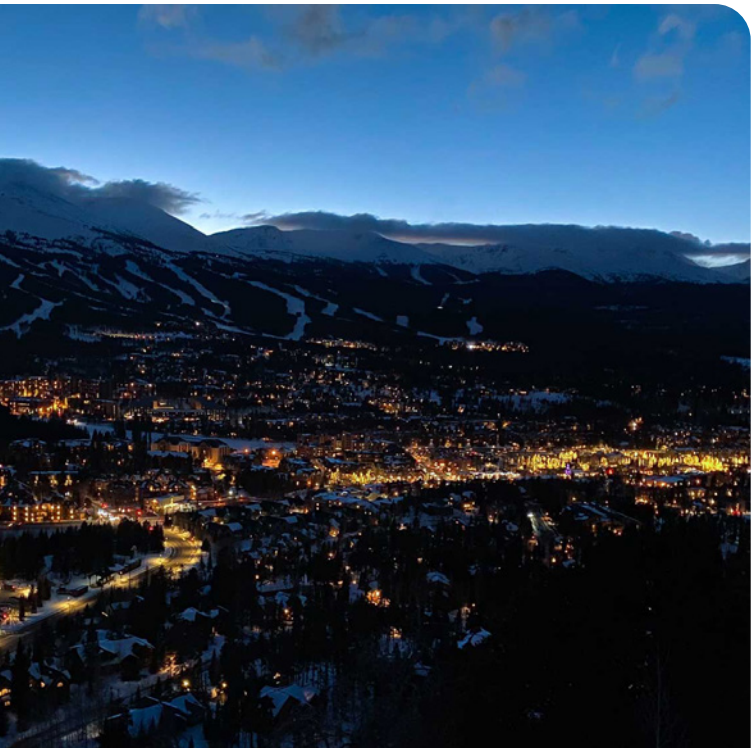
Investigating Local Energy Markets

In addition to participating in a wholesale market, HCE plans to establish a local energy market in its service territory.

Rather than implementing distinct control policies for different types of local resources, a local market can communicate real-time values of energy and capacity that enable all local resources to participate on a level playing field. Those real-time values could be informed by factors such as HCE's grid operational costs, day-ahead wholesale prices, coincident peak charges, and constraints on local feeders.

Managing Local Markets

HCE envisions using Camus to manage this local market. With the platform, HCE's grid operators can orchestrate all energy resources in a way that optimizes their use and maximizes value for HCE and its members. The idea is to expand the field of resources that can provide services needed by the distribution grid.



As a first step to enable the local market, Camus and HCE are conducting modeling analyses on dynamic rate and incentive structures. By leveraging customer data already integrated into the platform, the team is evaluating how different rates would impact energy bills and encourage market participation among groups of members: low-income, those who own solar + batteries, and those located in particular parts of the grid.

HCE is also investigating the value of various member-provided grid services and how member-owned devices may respond to market signals. A key step in understanding these dynamics more completely will be a pilot program that enables members to sign up for real-time rates and receive signals from HCE about changing their energy use or production.

> "Our vision with Camus is to figure out how to send our members the right price signals based on the market—and how to automate the responses of our members' devices to get them the lowest cost."
>
> Sam Whelan, Power Supply Manager

The extent to which market activities are automated will depend on members' preferences. Camus and HCE will set up programs and processes in the platform that allow members to participate at the level they want.

"We will need to make it easy for our members and give them simple opt-in/out-out decisions that they can make with their smartphones," said Bilby. "As the orchestrator, we will use the platform's controls to implement these decisions."

> "What gets me super-excited is the prospect of leveraging grid visibility to run a market in our system and manage congestion and voltage."
>
> David Manning, Resource Scheduler

Said Manning, "The platform will be steering the ship and automatically making course corrections during day-to-day operations. That will give me more time to think strategically and focus on long-term procurement decisions."

Conclusion

A Glimpse of What's Possible

HCE is at the leading edge of the clean energy transition, with an ambitious goal to provide affordable, reliable, and 100% carbon-free electricity by 2030.

To reach the finish line, the cooperative is fundamentally re-envisioning how it operates its grid. HCE is striving to take on the role of a distribution system operator, enabling its members to participate alongside conventional resources.

Camus Energy's secure, cloud-based grid orchestration system is a critical enabler of this transformation. The platform combines monitoring, analysis, and control of grid-connected resources to provide HCE with the data and orchestration it needs for a community-focused future.

HCE has made remarkable progress. Its power supply is ~48% carbon-free (up from ~30% in 2015). It has demonstrated the orchestration capabilities that it will need as a distribution system operator. And it is continuing to push forward with new programs that incentivize members to support the needs of the grid.

For other community-focused utilities, HCE's success to date offers an **exciting glimpse of what's possible** with a sustained commitment to a bold vision.

To learn more about Holy Cross Energy's partnership with Camus or to evaluate how your utility can make progress towards similar goals, contact us at **info@camus.energy**.

Start your transformation today.

CAMUS
Zero Carbon Grid Orchestration

Camus Energy is building an open source software platform to enable the future Distribution Service Operator (DSO). Providing grid operators and load serving entities with advanced situational awareness, insight, and control, Camus' platform empowers industry leaders to safely and strategically manage a rapidly changing grid environment.

Camus' founders and partners are leveraging experiences from other industries – including the founders' pioneering work building Google's global traffic management platform – to address new opportunities on distribution grids.

info@camus.energy | www.camus.energy
1333 Minna, San Francisco, CA 94103