Case Study:
Bringing Substations into the Office with Virtual Reality

Jo-Carroll Energy
Your Touchstone Energy® Cooperative

What if you could train your staff at a remote substation without anyone having to drive there? Or measure the gap distance between two terminals from your desk, without any engineering drawings? Jo-Carroll Energy (JCE) figured out how… use Virtual Reality.

Cooperative Profile

A distribution cooperative headquartered 150 miles west of Chicago in Elizabeth, Illinois, Jo-Carroll Energy (JCE) serves approximately 26,500 residential, industrial, and farm members in Jo Daviess, Carroll, Whiteside and Henry counties (see ***Figure 1***).

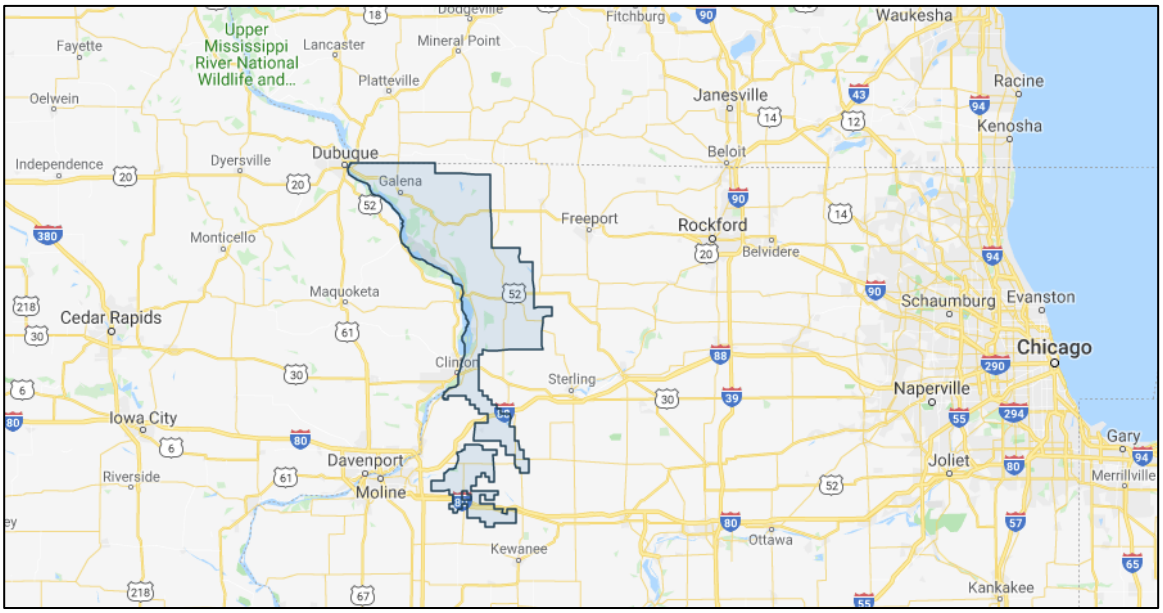

Figure 1. Jo-Carroll Service Territory. Image courtesy of Jo-Carroll Energy.

In addition to electricity, the co-op offers internet to all members, and provides natural gas in part of its service area. More than 75 employees oversee about 2,400 miles of power lines with 34 substations, 300 miles of natural gas pipe, as well as a number of programs and services.[1]

Program Background

Like most cooperatives, Jo-Carroll Energy has ongoing needs to train new hires and existing staff, and to

[1] https://www.jocarroll.com/about-jce

pass along the legacy knowledge of long-time employees. For lines-people, this typically involves visiting each substation to learn where critical equipment is located and how to operate it. When the co-op inherited 16 additional substations in 2009 through an acquisition of investor-owned utility (IOU) territory[2] that was within JCE's territory, their training and documentation needs were compounded. Not all of the engineering drawings were passed along during that transition. This meant that, in addition to training staff on the new sites, the co-op also needed to produce detailed documentation of what was there.

During this same time, DMI[3], a Dubuque, IA company that specializes in digital scanning of buildings and operational equipment for use in Virtual Reality (VR) and other applications, approached JCE with the idea of a VR training program. This would enable staff to virtually visit a substation, move around in that environment, and practice interacting with its controls – all without leaving the office.

In 2017, after a few years of informal discussions with DMI, the co-op decided to give it a try. According to Dean Skinner, Manager of Engineering Services at JCE, "We scanned a few stations just for our own knowledge. We wanted an idea of what we'd be able to get with VR technology."

The co-op was very pleased with the results. Today, JCE has scans of 18 of their 34 substations. Because the scans are highly detailed, accurate dimensions can be pulled directly from them. This eliminates the need to re-create missing engineering drawings, and enables engineering staff to view and measure substations' equipment and layout from the comfort of their desks.

Figure 2. Screenshot of 3D digital scan of a substation, with example dimensions.
Image courtesy of Jo-Carroll Energy.

[2] The IOU mentioned is Alliant Energy
[3] http://www.precisionreality.com/

To get additional value from the site scans, Skinner and his team selected one of the scanned substations to test what could be done with an immersive VR training program.

How the Program Works

The topic for JCE's first VR training session was how to interact with one of their electronic reclosers, including getting critical data out of it, and being able to open and close it.

For the footage needed to develop the VR training, JCE and DMI used Matterport and Leica digital cameras[4] to create highly-accurate, 3D digital scans of the substation's interior and exterior, including the building structure as well as controls and displays. Because this type of scan is very precise, it is sometimes described as a "digital twin" of the real-life object. With these scans, viewers can see different views of the space, similar to the Google's Street View panoramas.

Figure 3. JCE staff person doing the VR training. Observers in the room can see the footage on the laptop. Image courtesy of Jo-Carroll Energy.

Next, JCE gathered existing training materials along with input from their most experienced staff on what should be covered. DMI then created instructional graphics and videos to supplement the 3D site scans. Finally, using software to stitch all the pieces together, DMI created an immersive VR substation environment, with all the equipment in the exact same location as in real life, and the training instructions incorporated into the video.

The VR training takes place in a conference room at JCE's headquarters. Sensors are placed in the room to define the boundaries of the substation's control room. Usually, about four people participate in a training session at one time. Other staff in the training room serve as "spotters" to keep the person wearing the headset from tripping over actual cords in the room or running into real walls.

[4] For examples, see: https://matterport.com/cameras

Costs and Benefits

The total cost to develop the VR training was about $40,000. According to Skinner, the majority of that budget was spent developing the immersive training content; the 3D site scans were less than half the total cost.

The project paid for itself in just over two years, solely from reduced drive time of the more than 30 staff who have used VR. The substation selected for the immersive VR is about 50 miles from JCE's headquarters. Savings from eliminating the need to have staff drive several hours for each training session added up quickly.

Other benefits are significant, but harder to quantify. "How do you know the payback on safety and doing the training in a non-hazardous VR environment?" said Skinner. For example, he explained, "Every time you go to a substation with a whole crew, you're going to go over the safety details – what the voltages are, what kind of physical hazards are potentially there, and so on. Most substations are full of rocks. It's not a smooth surface; there are tripping hazards. There's a whole bunch of equipment that you can bump into." JCE sees that being able to do the training in the office, a non-hazardous area, is a huge advantage.

Another benefit of the VR training is increased productivity. Crews can do the training on bad weather days, when they are not able to work outside. And, by having the training available in the office, staff who do not normally go to substations can see what the experience is like. JCE also uses consultant engineers who can access the desktop VR tools from their desks. One project has already reduced engineering hours by more than the cost of the 3D scan.

Key Lessons and Insights

Overall, JCE is very happy with its first VR training experience and would like to develop similar VR experiences for other sites. This process has given the co-op insights on training program content and technical details of site scanning that it hopes to leverage for additional projects.

One lesson learned was on training program development. Skinner said the program could have benefited from early input from a training organization to help define the educational goals.

For scanning, they learned about the nuances of site lighting, filming height, and tri-pod material. The co-op found that one camera performed better than others in artificially lit interiors. Also, the first site scans were made at 5' above ground. This provided a good general view, but some substation control equipment can be 10 to 30 feet above ground. In subsequent site scans, JCE used ladders and bucket trucks to capture views from higher up. The co-op also needed a tri-pod that could go up to 12 feet high, but required an insulated model to avoid taking metal equipment into an electrical area. Thanks to land surveyors wanting lighter equipment, sturdy fiberglass tripods are now available.

Figure 4. Digital camera on tripod scanning a substation.
Image courtesy of Jo-Carroll Energy.

In addition, a very important thing to keep in mind when creating and storing detailed imagery of control equipment is physical and cybersecurity. This material should never leave the control of the co-op. To address this, Skinner explained that JCE stores all of their 3D digital substations scans on a secure cloud network.

Next Steps

JCE is now a believer in the value of VR. The co-op is planning to spend one week per year to continue scanning the remaining 16 substations. By reducing drive time to substations for staff trainings and for access to general site and structure information, the co-op has realized significant savings.

The co-op is also working to incorporate a closely related technology, augmented reality (AR), into the lines-people's set of tools. With AR, a lines-person can point a smartphone at a power line to receive real-time amperage readings, for example. JCE's vendor DMI will also support this work.

Going forward, JCE would like to find other distribution utilities to partner with, to share the cost of developing more VR training programs. Because so many of these components are used by many utilities, "There's no reason we couldn't just have a whole library of components and how to interact with them. Everybody's got different dimensions of their buildings or whatever, but the content about the specific equipment could be the same. We really ought to have a whole bunch of partners all trying to share that cost," said Skinner.

Futhermore, in the spirit of co-ops helping co-ops, JCE is hoping to develop a playbook with guidance for others on 3D site scanning and VR training program development.

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