Business & Technology Surveillance

An Introduction to Industrial Augmented and Virtual Reality

By Patrick Wilson, ModernUi/Huxmo Advisory

JUNE 2019



Business & Technology Surveillance

An Introduction to Industrial Augmented and Virtual Reality

By Patrick Wilson, ModernUi/Huxmo Advisory

JUNE 2019

SUBJECT MATTER EXPERTS ON THIS TOPIC

Adaora Ifebigh, Project Manager R&D Engagements, NRECA Business and Technology Strategies: Adaora.Ifebigh@nreca.coop

David Pinney, Program Manager Analytics, NRECA Business and Technology Strategies: David.Pinney@nreca.coop

Venkat Banunarayanan, Senior Director, Integrated Grid, NRECA Business and Technology Strategies: Venkat.Banunarayanan@nreca.coop

This article is a product of the Analytics, Resiliency and Reliability (ARR) Work Group

ARTICLE SNAPSHOT

WHAT HAS CHANGED IN THE INDUSTRY?

Augmented Reality (AR) and Virtual Reality (VR) capable technologies have reached mass adoption levels, providing enhanced information and data for a variety of work and leisure activities. The variety of existing AR apps is wide, highlighting the potential for increased task efficiency and overall potential. Google has released AR capabilities to their Google Maps app, which now displays turn-by-turn directions as a layer over a camera display. The result is that a user can open the Google Map app and see their navigation directions superimposed over a view of their surroundings. In the entertainment space, many games are now being digitally rendered as holograms in the user's physical environment. Scientific uses are coming forward now with apps like "Froggipedia," which allows for virtual dissection of a frog for biological study. The WWF (World Wildlife Fund) has created an AR app called "Free Rivers," which displays detailed topographical maps and interactive models that display locations like the Himalayas or the African savanna on a user's tabletop. In the support realm, apps like "Chalk" allow remote support technicians to draw on the user's screen remotely as a superimposed layer above the area where the user is pointing their camera. This can be used for displaying direction on technical equipment, buildings, generators, or electrical panels to identify targets from the perspective of a knowledge expert. In the solar space, "Sun Seeker" is an AR app that predicts and pinpoints the movement of the sun in the sky, showing users where sun exposure is at its greatest for any given area.

App stores for mobile devices now offer a large amount of new AR/VR application submissions, and developers can now create and submit AR applications with the same speed and confidence that they once could create and submit traditional applications. Apple, Google, and Microsoft are leading this charge by providing AR development kits, which



are freely available for independent software developers, to assist in developing custom applications for AR software platforms. While AR/VR applications are now widely available through smart devices for every day applications, a more significant development is their potential for significant benefit through adoption in the industrial space. Many companies in manufacturing industries, such as automobiles and services, are already applying AR/VR technologies that enhance performance, safety, and worker comfort, and create a competitive advantage on cost effectiveness and productivity. With the appropriate infrastructure that supports AR/VR applications, electric utilities stand on the threshold of reaping significant benefits from this technology.

WHAT IS THE IMPACT ON COOPERATIVES?

Electric cooperatives – along with other electric utilities – face a variety of challenges in meeting their goals on costeffective, safe, reliable power. These challenges include assuring line worker safety under changing grid conditions; creating, updating, and monitoring detailed grid topology and infrastructure; incorporation of newer technologies into the grid that requires re-training and re-education of the utility workforce; and increasing productivity in grid operations and utility functions, such as equipment installation, monitoring, and maintenance. AR/VR can assist cooperatives in meeting these challenges in a cost-effective and sustainable fashion.

While there are a relatively small group of emerging companies formed around using AR/VR for training purposes, the market for these types of solutions is growing quickly. An increasing number of AR/VR companies are creating products for applications in industrial risk mitigation, enhancing worker safety, increasing efficiency, and providing training. Co-ops can potentially use this technology to assist with increased safety and efficiency for a variety of areas, including helping line maintenance, substation monitoring/repair, and fault identification; training workers on new technologies; and assisting line-workers in their tasks, including grid repair and maintenance.

Further down the road, AR/VR can decrease the burden of finding skilled labor by providing instant "in-pocket" AR experiences that can be designed to serve as an expert in the field. As the labor markets tighten and more jobs go unfilled, or it is challenging to find well qualified candidates, AR/VR can allow existing workers to do more, more easily, and more safely, and provide training to new workers in a safe but comprehensive manner.

WHAT DO COOPERATIVES NEED TO KNOW OR DO ABOUT IT?

As our industry continues to evolve and the grid incorporates increasingly complex systems, it is essential that co-ops have adequate tools for training and operations. AR/VR technology may present a beneficial option to provide enhanced data and information to staff. From emergency response, to new employee training, to safety protocol, AR/VR device applications can help ensure co-op employees are adequately equipped. This article presents an introduction to AR/VR technology and some of the considerations co-ops may want to include in their investment decision-making. Subsequent articles will delve deeper into the technology and use cases.

NRECA SEEKS CO-OP AR/VR INSIGHTS

To provide more information and understanding about the pros and cons of using AR/VR, NRECA is looking for cooperatives who are currently deploying AR/VR and willing to be featured as case studies to share insights with other cooperatives.

NRECA is also looking for cooperatives who are considering AR/VR technology deployment in their regions to be involved in joint pilot projects that will demonstrate multiple use cases and assess benefits.

Cooperatives who are interested, please contact Adaora Ifebigh at Adaora.Ifebigh@nreca.coop.



What is Augmented Reality and Virtual Reality?

Augmented Reality (AR) and Virtual Reality (VR) both refer to interactive digital experiences. In recent years, the costs associated with utilizing these technologies have come down considerably, and in the case of AR, most smartphone users already have the technology required to participate resting in their pockets. Smartphones are not the only devices that are AR capable for sure, but they do allow for targeted app development without incurring the costs of excessive equipment purchasing. Tablets, Computers, Smart Glasses, sensors, cameras, range finders, and other commonly used and traditionally isolated devices also provide opportunities for deploying AR. This confluence of data on a superimposed layer empowers the user to do more, do it safely, and do it more efficiently than ever before.

VIRTUAL REALITY (VR)

Virtual Reality provides an immersive environment in which the user is isolated from the world around them, allowing them to work or play within a fabricated space. In a VR environment, users are presented with a new world that can be digitally broadcast directly to a headset (typically tethered to a computer/ device, see Figure 1) which blocks the users from seeing the real world around them. An example of the VR concept would be the Holodeck from the fictional TV series *Star Trek*, where the user can simulate entire worlds around them to experience as if they were millions of miles away and on another planet.

Some key technologies in the VR space include Oculus Rift, Sony PlayStation VR, and HTC Vive.



FIGURE 1: Example of VR

AUGMENTED REALITY (AR)

Augmented reality provides an additive environment, in which the user is presented with additional information that is visually layered over the actual world around them. In an AR environment, a user may view a display that allows them to see digitally created objects and text that seemingly co-exist in the world around them (see Figure 2). A simple example of AR would be the 1st & 10 lines that are displayed on television broadcasts of NFL games.

Some key technologies in the AR space include Google Glass, Microsoft HoloLens, and Apple iPhone AR Kit.

AR/VR technologies have existed for several decades now, though primarily utilized within the entertainment space as an enhancement to visual and auditory experiences; today, AR/VR can provide more depth and utility outside of the entertainment industry.



FIGURE 2: Example of AR Imagery.

Today, AR/VR technologies are becoming more available, and the economic entry barrier is much lower. From a software/AR development perspective, the costs involved are dynamic, based on the size and scope of the project. Harmony Studios, an expert provider The stabilized market and wide-scale R&D devoted to AR/ VR technology has technology experts bullish on the benefits of deployment. of AR solutions, estimates that the average AR content/software project developed by their studio is \$30,000 to \$40,000, with some projects coming in well below that, and as expected, some projects exceeding that. Hardware is another story, and one that is easier to define. Google's AR Smart glasses, "Google Glass," have been priced at \$999/unit. Microsoft has positioned the HoloLens2 with a price tag of \$3,500/unit. Smart glasses and wearables are only a portion of the segment though, and it is important to note that not all AR requires a user to wear technology. iOS (Apple) and Android tablets are becoming more affordable and have a strong position on AR for the longterm. Current models of AR capable iPads vary from \$329/unit to \$999/unit, depending

on model selection. When it comes to AR, the hardware entry barrier has become very manageable and budget friendly.

The timeline in Figure 3 provides examples of the debut of AR/VR products to illustrate how this technology has moved beyond merely a trend to a mature market that offers solutions for various applications.

Enterprise and industry can benefit from the stabilized nature of the market and wide-scale research and development devoted to new AR/ VR product announcements globally. Industry observers, consultants, and technology experts are generally bullish on the evolution and benefits of deploying AR/VR solutions.



FIGURE 3: A Timeline of AR/VR technology and advancements.

AR/VR technologies and solutions are currently very attractive for investors. For example, in 2018, Gartner¹ graduated "VR" from its hype cycle, implying its sustainability and marking its maturity. In Gartner's judgement, AR is also close behind VR, moving from what Gartner refers to as "Trough of Disillusionment" into the "Slope of Enlightenment." This enlightenment phase refers to the fact that AR is moving steadily toward tangible solutions and practices that can be implemented in the real world with AR solution providers approaching critical mass in offering commercially mature and sustainable solutions.

The Current Landscape of the AR/VR Vendor Market

AR/VR technologies and solutions are currently very attractive for investors. Venture capital investment into AR/VR, has been increasing dramatically, swelling from \$89 million in 2012 to nearly \$2.5 billion in 2017. (See Figure 4 for a sampling of those currently in the VR space.) In a sign of increasing demand, IDC² expects worldwide shipments for AR/VR headsets to grow to 68.9M units



FIGURE 4: Sampling of vendors currently in the VR space.

¹ The Gartner HypeCycle for Emerging Technologies is a report on the changes in the public interest to trends. Businesses can use the Gartner HypeCycle to guide technology decisions in accordance with their level of comfort with risk. Each stage of the cycle is associated with its own risks and opportunities. Leaving the HypeCycle denotes a trend of wide adoption signaling that the market and its applications have become well-understood. Gartner HypeCycle: https://www.gartner.com/en/research/methodologies/gartner-hype-cycle Industrial use seems to be benefiting from AR/VR technologies faster than the entertainment space.

As industrial demand grows, seasoned AR/ VR vendors offer easy-to-use products to end-users and industrial buyers. in 2022, with a compounding 5-year annual growth rate of 52.5 percent.

Several startups are ready to capitalize on AR/ VR technology as it reaches critical mass. Seattle, Northern California, and Northern Virginia boast dozens of venture-backed AR/VR companies that have been building for several years.

In a switch from the norm in technology, industrial use seems to be benefiting from AR/VR technologies faster than the entertainment space. Walmart recently purchased 17,000 VR Head Mounted Displays for their internal training purposes and Microsoft has a \$479 million contract to supply technology, including the HoloLens (see Figure 5), to the United States Military's Integrated Visual Augmentation System (IVARS). IVARS will help soldiers in the field with a variety of tasks from training to real-time combat scenarios. While it is too early to identify all the areas in which HoloLens will impact military technologies, facial recognition, GPS, Drone command and control, range finding, communications, medical triage, and remote enemy combatant identification could likely be some common areas of application.

While the per unit cost of the Microsoft HoloLens product for the defense contract has not been disclosed, costs are coming down from the \$4,999 Vuzix Star 1200, released in 2010. Microsoft is currently pricing individual HoloLens 2 devices, along with accompanying software at \$3,500 per unit. Rental programs are available as well, with per user costs priced at \$125/month per user.

Other companies are also considering using this technology, with Verizon announcing that they are transforming their safety training with the use of VR. While the details have not been publicly announced, it could conceivably include safety efforts like those practiced by electric cooperatives for line work and training.

As industrial demand grows, the vendor market grows with it, and today, seasoned AR/VR vendors offer easy-to-use prod-



FIGURE 5: Microsoft HoloLens. Image by Ramadhanakbr—Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index. php?curid=52546267

ucts to end-users and industrial buyers. Figure 6 highlights just a few of the notable companies who are currently providing services in the retail, industrial, and real estate AR/VR space. This list is not comprehesive, and given the rapid development of the AR/ VR market, it is assumed the companies within this space will evolve.

For cooperatives making investment decisions, there could be significant benefits in considering AR/VR technologies for adoption as alternative options, to meet business needs in a more cost-effective, safe, and efficient manner.



FIGURE 6: A sampling of notable AR/VR service/hardware/software providers today.

² IDC is a global provider of market intelligence and advisory offering regional, and local expertise on technology and industry opportunities and trends in over 110 countries. https://www.idc.com/getdoc.jsp?containerId=prUS43639318

Basic Components of an Augmented Reality Platform

All implementations of an Augmented Reality platform require the following components:

- 1. The Display such as Smart Glasses Google Glasses, Microsoft Hololens, Tablet, Smart Phone etc. While Smart Glasses seem like the best choice for AR, the intended use will dictate the best approach. For example, it may not be practical for workers performing dangerous or intricate work to be encumbered by a physical headset. In these scenarios, tablets or secondary displays might make the most sense, as the operator has more flexibility in deciding when to focus on the extra information that AR provides. A combination of wearable technology and fixed displays could provide an optimal environment.
- 2. The Tracking System built in camera into the Smart Glasses/Tablet/Phone, accelerators, GPS, compass, gyroscope, etc., depending on the applications. Most tracking comes in a combination of a camera that is mounted into either the headset or tablet, and the Accelerometer used to measure acceleration, movement, or vibration. In some cases, external cameras might make more sense when a 360-degree view of an object is required. Wearable technologies in the AR space include many of the sensors that we have become accustomed to in our smartphones. Some of the sensors available could include the GPS, Accelerometers, Compass, Thermometer, Infrared Camera, Humidity Sensors, Voltage Meters, and Sound Level Meters, among others.

3. AR Software and Mobile Computing Power - Database to recall information, software to process data, and mobile computing power to interface with database, display data, and facilitate real-time communications. As with most computing projects, the hardware and software must work together to achieve the desired result. Depending on the desired system, a combination of local computing on the device and cloud-level computing may be required to achieve success. Bridge systems that utilize Bluetooth or WiFi can communicate to back-end cloud servers to gather, store, and recall data when needed. This allows the AR operator to have access to Terabytes of data without the need to store it locally.

How Industrial Operations are Planning to Leverage AR/VR Technologies Now and in the Future

AR/VR FOR TRAINING & TECHNICAL ASSISTANCE

Training & Technical Assistance are the two most prominent uses of AR/VR today. Walmart, Verizon, and Volkswagen are all launching AR or VR products to assist in training or as a site-reference tool.

Volkswagen

In Volkswagen's case, AR/VR is being used to make service manuals available in real-time to mechanics. These manuals can overlay information onto visuals of the actual car the mechanic is repairing (see Figures 7 & 8). This capability helps ensure accurate reference



FIGURE 7: Use of SAR in the interior design process: setup with two projectors and a real model.



FIGURE 8: Use of SAR in the interior design process: projection of various design variants onto the model.

information on repair and equipment are available to the mechanic as needed. The advantages of using AR/VR to improve the precision and accuracy of those Volkswagen repairs and services are expected to reduce errors significantly.

In addition to AR/VR training environments, Volkswagen is using Spatial Augmented Reality (SAR) to assist in design choices, which are decreasing the costs of research and development (R&D). SAR utilizes a series of projectors and models that allow designers and engineers to visualize assembly behavior or installed outcomes prior to engaging in the expense of full prototype development.

Verizon

A growing base of AR/ VR software companies can speed deployment through licensing of existing products.

Verizon plans on using AR/VR applications to simulate realistic scenarios of some of the more challenging field environments: working in a bucket truck, going into a utility hole in busy traffic, or climbing ladders on utility poles. Verizon believes that practicing these scenarios in a simulated environment will reduce errors and increase safety. Co-ops may find benefit from AR/VR applications for similar job functions. Figure 9 shows an example of an AR training application.



FIGURE 9: An Example of an AR training application: ScopeAR (WorkLink) helps companies create AR training videos to walk workers through task.

Walmart

Walmart is in the process of rolling out four physical VR headsets manufactured by Oculus to each Walmart store, to enhance associate training. According to Walmart, VR training boosts confidence and retention, while improving test scores 10 to 15 percent. Walmart has also identified the benefit of providing all their associates with the same training opportunities that managers and department managers currently have.

The deployment costs and timelines of AR/ VR technologies will be as varied as the use cases that drive them. iPhone based AR Kit deployments will move a different pace than Google based products for example. Because the technology (particularly for AR) is so readily available, custom development can be an option even for smaller enterprises.

There is a growing base of AR/VR software companies which can speed deployment through the licensing of existing products. It is important to note that in some cases AR/VR equipment, such as HoloLens, can be leased. Depending on the deployment and use-case requirements, there could be additional costs required, such as software development, data storage, hosting, analytics, etc. However, SaaS products may be available within the AR/VR space already that can solve some common challenges, and with so many startups in the AR/VR space, it may not be long before there are as many options available for AR/VR as there are for more traditional software and hardware needs.

A Look at Productivity Enhancements with AR/VR

Utility workers today are asked many times to diagnose challenging faults in systems or infrastructure. This may require them to access, aggregate, and act on vast amounts of information, in real-time, and sometimes while weather conditions are becoming dangerous around them. Adding to this challenge, lower unemployment and the drive for workers to move to more urban environments can leave co-ops with fewer staff and a stronger need to provide electronic guidance in the field.

As our industry advances, our systems become more complex, and as a result, the

tools required to train staff and maintain systems must also become more sophisticated. With added complexity, typically repair and maintenance slow, unless more specialized tools are available. Maintenance and repair tools must evolve at the same rate as industry advancements, or any gained efficiencies of system modernization will ultimately be lost during the maintenance cycles.

Today, workers are finding themselves in need of next-generation instruments and devices that afford them a new way to interface with their work and enhanced information required to do their job successfully. AR and VR can provide a new and real-time link to large amounts of data and knowledge needed to solve problems on the modern grid. In Figure 10, we see Hyundai providing visual AR instructions showing the user where the coolant reservoir is located. Figure 11 shows us an overview of user serviceable areas of the engine compartment such as battery, washer fluid, and coolant, etc.



FIGURES 10 and 11: Examples of enhanced information available through AR/VR. Photos: Hyundai

AR and VR can provide a new and real-time link to large amounts of data and knowledge needed to solve problems on the modern grid.

A Practical Overview of the Safety Benefits of AR/VR Technologies

For decades, simulators and simulations have been the basis for AR/VR technologies. In the airline industry, where flight simulators are frequently required for students and recurring education, simulators are such a prominent fixture that they are often not even mentioned in AR/VR literature. In the airline industry, it is easy to see how a VR simulation boosts safety. On the grid, the safety benefits may be just as impactful and critical.

Consider the following potential uses of AR/VR technology in the utility industry:

EXAMPLE 1: TRAINING OPPORTUNITIES

Many cooperatives are facing retirements of seasoned employees, presenting a challenge in ensuring comprehensive training for new employees to fill the gaps. In addition, the evolution of our industry regarding renewable power resources as well as shifts to more consumer-centric operations is requiring ongoing training for existing staff. As mentioned previously, AR/VR technology is being used by a variety of companies to provide effective tools for training. These tools support the availability of enhanced information and data, and better sharing of insights to assist employees in acquiring the necessary knowledge to successfully adapt to changes in the co-op industry. Such adequate training is key to supporting safety in the workplace.

EXAMPLE 2: STORM RESTORATION USING UTILITY REPAIR VEHICLES WITH MOUNTED INFRARED/THERMAL CAMERA, GPS RECEIVER, AND DASHBOARD-MOUNTED DISPLAY

During a storm, or in the aftermath of a storm, vehicles equipped with AR/VR technology could identify overheating transformers or lines passively (see Figure 12 for an example). Location and temperature status could be visually displayed to the driver, confirmed, and wirelessly transmitted back to a dispatch location where field-identified problems are added to reported issues and work prioritized. Using a combination of remote sensing and AR, a passive AR system like this could result in potentially strained resources being more appropriately dispatched with fewer reactive situations.



FIGURE 12: During a storm, or in the aftermath of a storm, vehicles equipped with AR/VR technology could identify overheating transformers or lines passively. Photo: DAQRI – Ubuntu AR

EXAMPLE 3: FIELD TECHNICIAN HANDLING OF UNFAMILIAR EQUIPMENT

With the complexity of the modern grid and its continual evolution, there are likely times when staff may arrive upon equipment configurations with which they are not fully familiar. One such probable scenario is with wide variety of distributed energy resources deployments. Using AR software and the technician's smartphone, that equipment could be identified, and handling instructions transmitted directly to the technician and overlaid through video onto the field-smartphone-device. This approach would provide critical insight and guidance to the technician to better ensure safe, knowledgeable handling of the equipment.

Opportunities for AR/VR on the Grid: Some AR/VR Benefits for Co-ops

AR/VR GRID OPPORTUNITY #1

Equipment Placement and Site-Planning

Deploying resources as small as transformers, power poles, or even new substations require planning. AR/VR can provide digital survey capabilities that deliver real-time data directly to a central office where instructions can be visualized on a field-technician's hand-held smartphone or tablet. Transmit dimensionally accurate blueprint overlays directly to build-teams on the ground, and make modifications in real-time, remotely.



FIGURE 13. AR displaying placement directions.

AR/VR GRID OPPORTUNITY #2

Equipment and Part Identification and Troubleshooting

Field equipment can change and evolve rapidly, company acquisitions and mergers can introduce equipment to your staff that is not familiar. Using an AR/VR database, field technicians would have the power to point their tablet or smartphone at a piece of



FIGURE 14. AR display of compoents in exploded view.

equipment or part and have it identified. From that identification, a proper course of action can be delivered with any required instructions (see Figure 14 for an example).

AR/VR GRID OPPORTUNITY #3

Fault Identification and Analysis

Combining AR/VR with IR/ Thermal technologies like FLIR, visual overlays could be provided to a technician's smartphone or tablet to assist in identifying equipment that may be operating outside the established thermal range. AR/VR use, when combined with thermal



FIGURE 15. Virtual part assembly and visualization.

technology, may identify shorts or failures before they happen and either notify appropriate staff or provide real-time instruction and guidance to the technician in the field who has discovered the problem.

AR/VR GRID OPPORTUNITY #4

Training and Field Observation

New or less experienced staff need training. Smaller operations may only have a single qualified person to train that staff, which can lead to incomplete training or slower onboarding. The use of AR/VR can provide that trainer with "eyes on the ground" and the ability to mentor and train less experienced staff remotely and immediately. AR/VR could allow a single trainer to manage

many trainees successfully and concurrently from a central location.

AR/VR GRID OPPORTUNITY #5 Virtual Expert in

the Field

In rare or extreme circumstances, seasoned staff may be unavailable to solve a problem on-site. AR/VR



FIGURE 16. AR live chat with visual AR layer direction.

can provide an environment where the expert can give a field-technician an AR "game plan" in real-time to less experienced hands in the field. By using AR markup as an overlay to a video feed which is held by the technician, the AR/VR system can identify problems, so the remote expert can evaluate those problems and provide a course of action which is directly viewable to the field-technician.

Conclusions

While the terms Augmented Reality and Virtual Reality have been in use for 30 years, emerging technology is rapidly changing how we view Augmented and Virtual Environments. The most dramatic change in the last ten years is the availability of AR capable technologies. Today, most tablets and smartphones of reasonable quality that are sold are AR capable – which provides a popular, familiar, and easy gateway to deploy AR technologies. The availability of AR-capable devices creates a game-changing scenario that brings the potential to harness AR technology into the hands of industries and franchises with even modest budgets. With the potential for direct savings through enhancing safety and improving performance through training, it is likely that these technologies would pay for themselves quickly.

Augmented and Virtual Reality is a topic which needs more in-depth analysis and investigation of use cases, because of the potentially significant impact offered by these technologies. In this article, we discussed basics of AR/VR technologies. NRECA plans to continue to research and monitor these technologies and provide additional information to members as beneficial, including use cases and case studies.

IS YOUR CO-OP USING AR/VR TECHNOLOGY... OR INTERESTED IN PARTICIPATING IN A PILOT PROJECT?

NRECA is interested in investigating the potential for AR/VR technologies through pilot projects and partnerships with co-ops and vendors. We would very much like to hear from you on these technologies.

If you are using of AR/VR at your co-op or are interested in pilot projects using these technologies for case studies, please contact Adaora Ifebigh, NRECA Project Manager R&D Engagements, at **Adaora.Ifebigh@nreca.coop**.

REFERENCES

How VR is Transforming the Way We Train Associates

Apple ARKit

Google ARCore Overview

Microsoft Mixed Reality is ready for business

In 2018, Over 1 Billion Augmented Reality Enabled Devices Will Be in Existence -Future Proof Your Business Now

19 for '19: Augmented Reality Trends & How They May Play Out This Year

Volkswagen Virtual Technologies

Verizon using Augmented Reality and Virtual Reality apps to train employees

The 10+ Best Real-World Examples of Augmented Reality

How Virtual Reality Facilitates Social Connection

Augmented Reality in Military: AR Can Enhance Warfare and Training

Gartner Hype Cycle

5 Trends Emerge in the Gartner Hype Cycle for Emerging Technologies, 2018

HoloLens 2 pricing and options

How Much Does Augmented Reality App Development Cost in 2018?

How Much Does Augmented Reality Cost?

Vuzix STAR 1200 augmented reality headset hands-on

Note: All images included unless otherwise noted were either created by the author or licensed from **pexels.com**

ABOUT THE AUTHOR

Patrick Wilson, President, ModernUi/Huxmo Advisory. Patrick is an expert in enterprise software, hardware, and engineering. He has worked with and led dozens of industry giants including MIT, HP, Dreamworks, Blackboard, and Discovery Communications toward successful releases of both R&D and Flagship products. Patrick is an inventor on several U.S. Patents related to technology and is an industry speaker and author on the topics of User Experience, Research & Development, Product Design and Launch, Artificial Intelligence, and Augmented Reality UX. Patrick is currently utilizing his experiences with Blockchain technologies to find ways to improve the grid. He lives in Southern New Hampshire, with his wife and two children. Patrick is frequently found in Boston, a short drive, and Washington DC/Northern VA, where he is in high demand to provide guidance to startups and established enterprises alike.

QUESTIONS OR COMMENTS

- Adaora Ifebigh, R&D Engagement Project Manager, NRECA Business and Technology Strategies: Adaora.Ifebigh@nreca.coop
- David Pinney, Program Manager Analytics, NRECA Business and Technology Strategies: David.Pinney@nreca.coop
- Venkat Banunarayanan, Senior Director, Integrated Grid, NRECA Business and Technology Strategies: Venkat.Banunarayanan@nreca.coop
- To find more resources on business and technology issues for cooperatives, visit our website.

ANALYTICS, RESILIENCY AND RELIABILITY (ARR) WORK GROUP

The Analytics, Resiliency and Reliability (ARR) Work Group, part of NRECA's Business and Technology Strategies department, is focused on current and future data and research required to provide prompt technical and economic support to the NRECA membership. Specifically focused toward the electric co-op community, ARR products and services include: development and maintenance of a portfolio of energy analytics products and services; collection and analysis of data; and provision of additional products and services in the areas of the data collection, IT architecture, sensors, and energy markets. For more information, please visit **www.cooperative. com**, and for the current work by the Business and Technology Strategies department of NRECA, please see our **Portfolio**.

LEGAL NOTICE

This work contains findings that are general in nature. Readers are reminded to perform due diligence in applying these findings to their specific needs, as it is not possible for NRECA to have sufficient understanding of any specific situation to ensure applicability of the findings in all cases. The information in this work is not a recommendation, model, or standard for all electric cooperatives. Electric cooperatives are: (1) independent entities; (2) governed by independent boards of directors; and (3) affected by different member, financial, legal, political, policy, operational, and other considerations. For these reasons, electric cooperatives make independent decisions and investments based upon their individual needs, desires, and constraints. Neither the authors nor NRECA assume liability for how readers may use, interpret, or apply the information, analysis, templates, and guidance herein or with respect to the use of, or damages resulting from the use of, any information that the use of these contents does not infringe on privately held rights. This work product constitutes the intellectual property of NRECA and its suppliers, and as such, it must be used in accordance with the NRECA copyright policy. Copyright © 2019 by the National Rural Electric Cooperative Association.