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Digital Twins and Immersive Technologies in the Energy Industry

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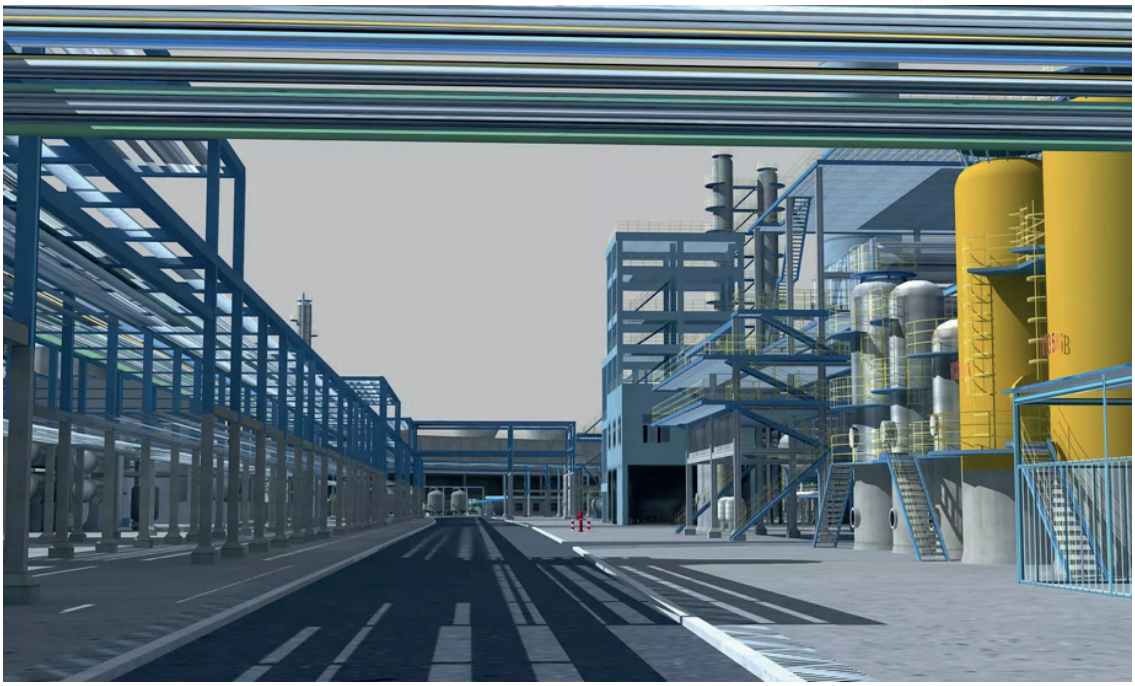


3D model of a real refinery. (Image courtesy of the Unity Asset Store from Rob Luo.)

The energy industry is faced with a tumultuous landscape of challenges that include rising costs and increased market volatility. With issues ranging from price volatility during the COVID-19 pandemic to an urgent need to reduce capital and operating expenditures, there is a pressing need for optimized efficiency at every touchpoint of the energy lifecycle—regardless of whether operations are upstream, midstream or downstream.

In this white paper, we'll examine how real-time 3D technology can enable this optimization at all stages within the energy industry.

THE ENERGY INDUSTRY

While the upstream sector involves exploration and production (E&P), midstream operations focus on transportation and storage, and the downstream segment is directed towards processing, purifying, and refining, one significant force in the energy industry is the integrated energy company, which combines upstream, midstream and downstream operations to engage in the E&P, transportation, storage, refinement and distribution of oil and gas. Since integrated companies are involved in every category of the petroleum business, they have significant control over the entire value chain. Many of the world's largest energy companies are integrated oil companies, with noteworthy examples including Shell, British Petroleum (BP), ExxonMobil and Chevron.

Despite the sophistication of available visualization tools for the management of specialized resources, these capabilities could be more streamlined across the entire petroleum enterprise. According to Unity Technologies, developer of the Unity game engine, the energy industry can benefit from leveraging a real-time 3D platform to create digital twins across all aspects of operation. By adopting emerging technology, energy companies can increase profitability by lowering operating costs and reducing break-even rates. In addressing current shortfalls, the greatest opportunities scale out to connect a larger "system of systems."

CHALLENGES FACED BY THE ENERGY INDUSTRY

Energy corporations are facing rising complications from a combination of factors including regulatory requirements, market pricing and demand. Times have changed significantly; a favorable adjustment of price is no longer as effective as it used to be. As a result, energy businesses have no choice but to radically shift their focus to driving improvements in operations and planning.

(Image courtesy of Shell.)

Most oil and gas organizations rely heavily on traditional forms of visualization, spreadsheets and a paper-driven process. While many petroleum companies are attempting to upgrade to digitized workflows and information systems, transformation can be time-consuming due to the sheer size of these organizations. This is particularly applicable in the case of integrated companies.

“If you were to drill down into different business units, a common thread in terms of challenges is data,” says Tim Wong, industry solutions lead at Unity. “We are seeing more and more companies change their approach in how they utilize, manage and govern their data. There is an emphasis on taking more ownership of the data they produce, applying standards across their organizations and building the foundational structure to enable the company to leverage and scale digital technologies. This completely changes the landscape of how companies interact with vendors and partners throughout their value chain. And by changing their approach to data, energy companies are much better positioned for innovation and to capitalize on the real-time economy.”

HOW CAN UNITY’S REAL-TIME 3D TECHNOLOGY HELP MITIGATE CHALLENGES IN THE ENERGY INDUSTRY?

Energy companies have massive amounts of data collected in disparate systems. Digital twins can provide a holistic view of connected operations, enabling organizations to make faster data-driven decision-making. Having access to accurate real-time data can help organizations visualize information in a meaningful way.

“One of the biggest goals of real-time 3D is breaking down the silos between business units in different operational groups,” explains Nick Facey, industry solutions lead at Unity. “Many business KPIs will be improved by getting to a consistent source of truth understood with a common visual language—because there will be a construction site plan that is in one data format, then there will be the schematics that operation is running and then there will be the maintenance drawings from as-builts that reflect various levels of accuracy.”

Real-time 3D also allows users to interact within an engaging, immersive digital experience that represents real-world assets and information from databases and Internet of Things (IoT) sensors, such as those located on liquid pipelines. These digital twins can serve as interactive representations within simulated scenarios in contextual environments, and be deployed across multiple platforms including mobile devices, desktops and virtual reality (VR) headsets. In the case of augmented reality (AR), organizations can overlay computer-generated content on top of the real-world environment.

Trimble XR10 with Microsoft HoloLens 2. (Image courtesy of Building Point Scandinavia.)

Intrinsic safety is built into many devices in order to protect workers operating in hazardous areas. For instance, the industrial version of the Microsoft HoloLens 2 uses a shatterproof screen and bone conduction headphones mounted on a hard hat, with a concealed battery pack to avoid static discharge in an environment potentially containing dangerous concentrations of flammable gases.

Many petroleum companies have difficulties attracting game engine software developers to their digital transformation and innovation labs. In these scenarios, Unity not only co-develops solutions, but also provides local development tools to train the next generation of oil and gas teams in building their own custom real-time 3D solutions without the need for advanced hands-on coding knowledge.

“Some companies have an innovation or digital transformation lab, in which case Unity helps to build capability and capacity inside that team to build velocity,” states Jim Bowen, a manager in Unity’s Solutions Team with over 25 years’ experience in the energy space. “All of the companion products that Unity has, in combination with the Unity Asset Store, represent a massive amount of support around our platform—it also helps differentiate what we can do. With the large volume of developers out there using our platform, and our dominance on some of the device platforms, there’s a strong community of solutions and solution builders that can deliver value quickly. You can see plug-ins, assets and new products pop up regularly, not only from Unity but also from our partners building on top of our platform.”

Unity contains valuable components for the creation of virtual environments, including animations, audio, video, cinematics, lighting, user interfaces and other visual effects to simplify oil and gas visualizations. For complex applications, Unity also provides a rich set of simulation, artificial intelligence, and machine learning tools that can integrate with various systems, resulting in simulated environments for training and validating intelligent systems. Opportunities exist for oil and gas to use these advanced tools to help with everything from value chain / supply chain optimization through to predictive maintenance.

According to a Forrester Consulting study published in March 2020, real-time 3D has proven beneficial in a wide-ranging variety of industrial use cases when applied outside of the video game sector.[1] Out of 358 survey respondents, 90 percent have found immersive technologies to be valuable in supporting interdepartmental collaboration due to the fact that once models exist in a virtual environment, they can be seamlessly integrated for use across the business.

For example, AR models can help accelerate the oil and gas asset lifecycle—from design and construction through to operation, maintenance and decommissioning—and reduce inefficiencies that stem from traditional waterfall-style handoffs between departments.

“Based on their data sets and full size, a facility can exist for planning, training and operations before the physical construction of the space is even completed,” asserts Facey. “Some of these sites have build times measured in months, and training typically has to start after the facilities are built. Creating a digital foundation during the design stage allows training to be done concurrently. This helps increase workplace safety and increase performance once the facility is commissioned.”

[1] https://resources.unity.com/white-papers/digital-experiences-in-the-physical-world

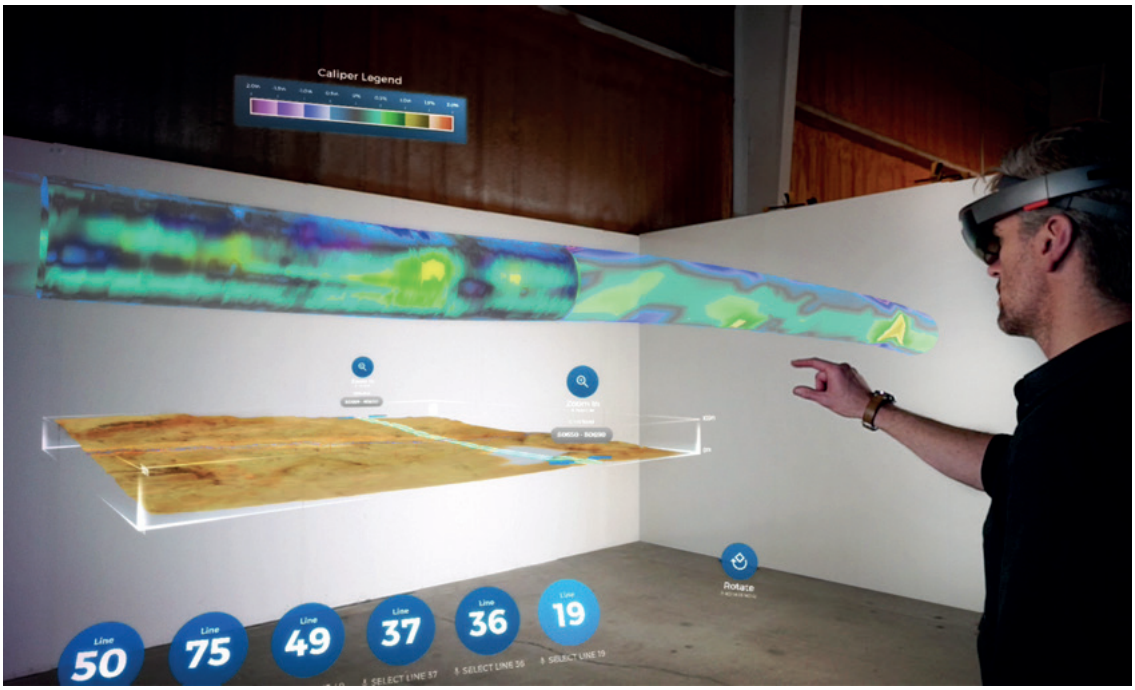
TOP USE CASES OF REAL-TIME 3D TECHNOLOGY IN THE ENERGY SECTOR

Some of the world's leading oil and gas companies are already capitalizing on the benefits of real-time 3D technology, with top use cases including maintenance and operations, staff training, and design collaboration.

MAINTENANCE AND OPERATIONS

As mentioned earlier, digital twins of physical entities (e.g., plants, pipelines, well sites, refineries, etc.) can be combined with datasets that update in real-time using live sensor data. In addition to linking ERP data with real-time 3D models, digital twins can perform as intelligent assets by connecting with processes and procedures.

"One example might be a scenario where I'm looking at the twin, at a valve that has been causing us repeated trouble," explains Bowen. "I can bring up all the maintenance records for that segment of pipe, live inside the twin. I can also spawn further analysis in the background by using machine learning to determine which valves in my facility are most likely to fail based on data patterns and their anticipated lifespan. Based on this information, I could determine that this valve might need replacing in the next few months—essentially, predictive maintenance. I could then take action and start a work order or a purchase order and start the approval process in an ERP."



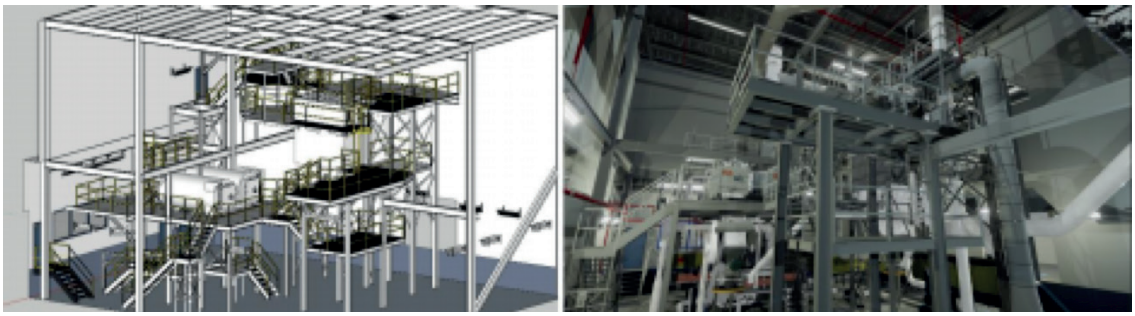
Enbridge engineers use the HoloLens to correlate different data sets in order to evaluate pipeline integrity. (Images courtesy of Enbridge.)

This functionality would allow energy leaders to make informed, real-time decisions about the design, management and performance of their oilfield assets. The result would be a drop in operating costs as well as a lower risk of negative environmental incidents caused by unexpected equipment failure and reactive maintenance.

Midstream energy company Enbridge is utilizing digital twins to visualize multiple data sets within its vast pipeline network and to diagnose pipeline fitness.

Millions of data points are first collected by In-Line Inspection (ILI) tools, strain gauge sensors, and Light Detection and Ranging (LiDAR) remote sensing systems. The information is subsequently processed within a mixed reality setting and presented as a 3D rendering of the pipeline sections, with a heat map depicting areas of concern. Enbridge's advanced analytics team uses Microsoft's HoloLens glasses to rotate, zoom and expand on the virtual image and form a collaborative assessment. The technology allows Enbridge to accurately identify potential hazards such as dents, cracks, areas of corrosion and pipeline stress points caused by incremental ground movement.

Another example of operation-based digital twins involves Ontario Power Generation's creation of a virtual environment to cut down on travel time between locations, completed in collaboration with EXO Insights[2]. As a result, multiple participants now have the ability to perform walkdowns of the company's distant Tiverton facility while collaborating through VR headsets.



Transforming 3D models and scans into a digital twin. (Images courtesy of Ontario Power Generation.)

A third example comes from Sentient, which worked with Holis to create a Unity-based digital twin of an offshore installation. It allows users to rapidly identify faults and access all critical information about equipment in a web application. Data sources, such as equipment status and maintenance history and procedures, are linked directly to individual components of the digital twin and update in real-time.[3]

[2] https://www.exoinsights.com/post/digital-twin
[3] http://sencom.com.au/case-studies/holis-offshore-installation-digital-twin/

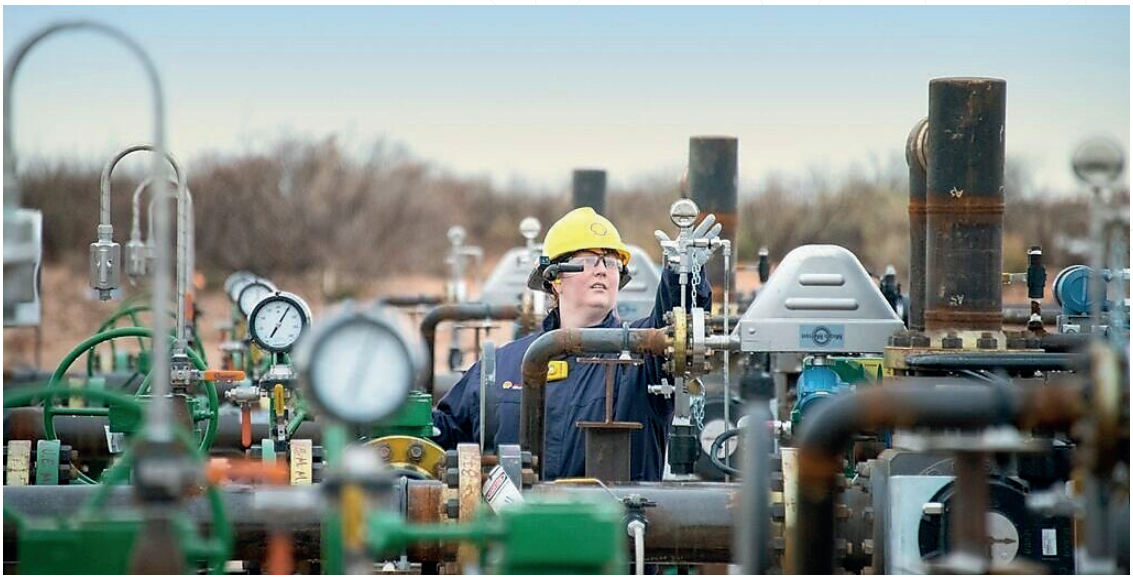
Digital twin of an offshore installation. (Image courtesy of Sentient.)

Other energy corporations are also embracing immersive technologies to support a wide-ranging spectrum of operations. For instance, Equinor and Halliburton are using a combination of seismic images and AR tools to observe layers of oil, gas and water present in hydrocarbon reserves in order to evaluate the reservoir's prospects. Chevron and ConocoPhillips are adopting virtual methods to improve drilling operations, leveraging real-time 3D technology to visualize downhole operations in real-time.

Within maintenance and operations, energy companies are increasingly employing real-time 3D technology for AR-assisted field service, leading to the quality resolution of issues. Augmented reality provides the ability to superimpose digital instructions onto equipment, and also enables video conferencing with offsite experts.

"AR technology allows for the visualization of equipment maintenance records, asset schematic, or possibly a video that to help the technician working to repair that piece of equipment," describes Bowen. "Another interesting consideration in oil and gas is the changing workforce, in particular the changing demographic inside of organizations. Companies such as Saudi Aramco are seeing a transition from an older workforce to a predominantly younger one. The older workforce often is less interested in going into the field and there's an opportunity for remote collaboration and remote assist—essentially, for subject matter experts to provide remote assist from the head office, connecting with workers in the field."

Field workers at Shell are seeing benefit from expert guidance via video calls that essentially allow the remote experts to see through their eyes and offer over-the-shoulder coaching. Experts even have the option of remotely drawing on the worker's head-mounted screen and sharing relevant documentation. By working remotely, a single expert can effectively support dozens of facilities worldwide without the need to travel.



A Shell operator utilizes AR tools to carry out operations with confidence. (Image courtesy of Shell.)

Like the Microsoft HoloLens, Shell's AR devices are mounted on safety helmets. Each device is voice-controlled, with a micro-display that presents an image to the users as though they were viewing a seven-inch screen. Information is displayed below the user's line of sight so as not to interfere with normal vision.

LEARNING AND TRAINING

Many leading energy companies are implementing high-fidelity VR training to improve occupational and process safety, increase regulatory compliance, and optimize worker performance. Along with the cost savings associated with a reduced need for travel to remote sites such as offshore rigs, organizations see numerous benefits from training staff virtually. In companies that have adopted VR training, workers demonstrate enhanced problem solving, improved knowledge retention and higher levels of engagement, which leads to accelerated proficiency in their subject matter.

VR training provides hands-on training in a safely controlled environment. (Image courtesy of Shell.)

The real-time aspect is important because static training modules can become stagnant and outdated, instead of reflecting what is current in operations. Real-time 3D technology ensures that the training environment is modeled as accurately as possible, which in turn improves worker safety.

“Oil and gas is a very dangerous industry, so frontline workers are not just training for processes and optimization—they’re also training for reduced injuries and fatalities,” says Facey.

Real-time 3D allows for the simulation of previously impossible testing scenarios, resulting in workers gaining better exposure to hazards and catastrophic incidents such as pipeline leaks or facility explosions.

“Training workers on a facility prior to its construction definitely can help to reduce recordable and serious incidents,” adds Bowen. “People can become familiar with a facility or platform before even setting foot on it. Secondly, there’s the opportunity to help establish a performance baseline for operators because it takes several months before facilities can function at optimal condition. If you have people running through a simulation environment on a digital twin, by the time the facility is operational, the staff actually have some ‘experience’ in a digital world and can start running operations in an optimal way.”

Safety training at ExxonMobil’s Immersive Technology Studio allows oil and gas operators to hone their instincts. (Image courtesy of ExxonMobil.)

In 2019, ExxonMobil launched a 3D immersive training platform (also dubbed its “digital garage”), enabling technicians to challenge themselves using cutting-edge VR simulations. By engaging multiple senses in scenarios including unplanned shutdowns and high-risk operations, operators sharpen their decision-making skills and become better equipped to work smarter and safer.

Other energy leaders using VR learning solutions include Shell and BP.

DESIGN COLLABORATION

Energy companies are recognizing real-time 3D technology as a valuable tool for different teams and business units to collaborate and align during the design and construction phase. Immersive design reviews for infrastructure and facilities can enhance the visualization of building information modeling (BIM) data, resulting in reduced design cycles, site rebuilds and construction errors.

Subcontracted Engineering, Procurement and Construction (EPC) teams can take the opportunity to carry out generative design prior to committing on a plan. This is particularly advantageous in an industry where builds occur predominantly in remote locations.

“Real-time 3D can impact design collaboration by digitizing a paper-driven process and bringing in multiple stakeholders to provide feedback in a digital space so that all the information is captured,” says Wong. “With automated processes in the design stage, when it’s time to hand over to operations, they have everything they need to keep going.”

By using digital construction site management solutions, companies such as Shell are now compiling data from a variety of systems into a single-site model that comprises an evolving project management plan—allowing previously separate systems to interact as more than the sum of their parts. Sinopec, the world’s largest petroleum conglomerate, is also using its real-time 3D VR platform to simulate refining processes within a controlled environment, in order to effectively develop and test functional modules of its petrochemical plants.

Real-time 3D technology strengthens experience-based design and visualization. (Image courtesy of the Unity Asset Store from Rob Luo.)

THE FUTURE OF REAL-TIME 3D TECHNOLOGY IN THE ENERGY SECTOR

Energy leaders are experiencing considerable benefits from modernizing visualization across the integrated oil and gas lifecycle. Real-time 3D within the petroleum industry is expected to grow significantly in the upcoming years, with analysts predicting that immersive technologies will become as ubiquitous as mobile devices by 2025.

“The industry leaders are embracing this technology to help build velocity around the real-time economy,” says Bowen. “The ones that aren’t will likely be left behind.”

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