



WHITE PAPER

# How the **Digital Evolution Accelerates** the Transition to Energy 4.0

# Introduction

With continued global pressures compounded by the decreasing cost and widening applicability of smart technologies, the energy industry is finally taking the next vital steps in digitization.

While digital twins, machine learning (ML), artificial intelligence (AI) and other leading-edge technologies are gaining momentum in widespread use, well-orchestrated, organization-wide digitization is less common but essential for true transformation.

This is analogous to the difference between a single smart/artificial intelligence (AI)-enabled vehicle and an entire smart city ecosystem, where the vehicles and traffic signals all work together to achieve efficiency and safety.

Industry 4.0 provides a well-established framework for systemic integration of technologies into traditional manufacturing processes. The underlying technologies and implementation methodology of Industry 4.0 map readily to oil and gas facilities, including the use of technologies such as the Internet of Things (IoT), robotics, augmented reality (AR) and virtual reality (VR) to drive efficiency and safety.

## Why Now?

The energy industry, and particularly the oil and gas sector, is at a pivotal period. The energy transition accelerates at a great pace at a time of novel geopolitical and supply chain stresses. The high volatility of the past few years is driving the need for more stable and predictable energy sources.

We've seen ever-increasing investment in renewable energy technology, which will make a price-competitive market for oil, for the first time in the modern age. This means that oil and gas operations must be cost-optimized, and that there's a great need for technology to support environmental performance and intelligent assets.



# Benefits & Underpinning Technologies for Asset Optimization

The core benefits of optimizing assets are maximizing energy production by minimizing unplanned downtime, cost efficiency per barrel, environmental impact, personnel safety and asset management.

As asset orchestration increases, so does asset efficiency, since issues are identified and mitigated earlier, and the time between action and reaction is minimized.

Currently, infrequent data points and the need for manual monitoring and intervention mean that systems can only be aligned at given intervals and that systemic optimization is unlikely. Changing this time-to-action from weeks to seconds in a field that produces tens or hundreds of thousands of barrels of oil each day can have a [significant financial impact](#).

A state-of-the-art technological asset is predictive instead of reactive. This means timing maintenance and equipment replacement ahead of failure at the most opportune time for the operator and the cost. Unexpected downtime due to equipment failure can be costly and often results in more days offline as parts and labor are not mobilized — reducing these instances is a benefit to the asset operator. Safety is a top priority in all oil and gas operations, and improving safety saves both lives and money. Bringing the latest technology in wearables and VR/AR to energy facilities means the right people in the right places with the right knowledge at the right time; aligning these factors will reduce incidents on site. The following technologies are critical to achieving asset optimization, and orchestrating them is paramount to transformation success.

**Edge computing** brings data analysis and storage closer to the source on which IoT depends; when data is collected, it can be processed near the point of collection, at or near the sensor, as opposed to a centralized cloud location. This technology reduces latency, improves response times, enhances real-time data processing and is [critical in many use cases, such as autonomous vehicles](#), where the minimal time between information intake and reaction is necessary for safety. It can also enable wearable technology, which can interact with the system to prevent personnel from entering an unsafe area or taking risky actions.

In oil and gas, there are many applications at the asset where reduced reaction time will drive value. Safety applications at drilling and production sites, such as the immediate detection of anomalies, leaks or hazardous conditions, enables prompt emergency responses and mitigation of potential risks. Edge computing also increases reliability in remote monitoring and asset control, as there is no dependence on constant, uninterrupted communication with a central server. An additional benefit to data processing at the source is an increase in data security. Ultimately, optimized production will be driven by faster reaction times to changes in production conditions. This time-to-action can be reduced with edge computing.

**Digital twin** technology is essential for safety, production optimization and efficiency in operating assets. This technology creates digital replications of physical assets. It can simulate the conditions and attributes of a physical entity based on data from sensors and IoT devices.

Predictive maintenance and lifecycle management are key benefits of digital twin technology on equipment in oil and gas. Particularly in remote or offshore applications when maintenance and downtime are costly, the ability to plan for these scenarios virtually can result in major savings for operators.

Oil and gas companies need an end-to-end partner to deliver and embed digital twin into day-to-day energy production operations. For one upstream operator, we partnered on a single-asset deployment of the foundational digital twin features to integrate and visualize 3D models and drawings, generating \$8M in annual business value. Companies are seeing this business value multiplied tenfold by deploying predictive features, integrating across multiple processes and deploying to multiple assets.



**Robotics** include machines and mechanical systems designed to perform tasks autonomously or semi-autonomously, typically with some degree of programmability and physical interaction with the environment.

Robotics already have many applications here, including the use of remotely operated vehicles (ROVs) for subsea inspection, installation and maintenance as well as onshore drilling applications. In the future, there will be increased applications of robotics to increase autonomy at assets, particularly in offshore applications. Automated processes, including drilling, will decrease cost, build human capability and increase safety by reducing routine tasks with better information. Personnel will have more time to develop insights and for decision making.

**AI** encompasses a range of technologies that assist in processing vast amounts of data, recognizing patterns, making predictions, understanding and generating human language, interpreting visual information and interacting with the environment.

The key functions of AI in oil and gas assets are: (1) to optimize maintenance and (2) to reduce downtime via automated decision-making and action. This would allow for more rapid time-to-action and increased safety due to removal of human operators. The future of oil and gas production will see AI processing diverse data sources to optimize production automatically at a field level, including predicting and scheduling downtime and balancing costs due to equipment life and cost of replacement.

Technologies like our proprietary [AI-enabled platform GRAIN](#) can collect data from different sensors and process the data through edge machine learning and smart predictive analytics. This technology is highly applicable to the oil and gas industry for use cases such as pipeline anomaly detection and automated inspection, drone surveillance of pipeline construction, oilfield safety via wearables and full-scale VR for effective off-site training.



# A New Disruption: Generative AI

Lastly, the burgeoning interest within the energy industry in generative AI has established an environment in which companies rush to understand, create and incorporate generative AI solutions. However, the mere presence of AI solutions does not equate to an effective AI strategy or one that is well orchestrated with a company's broader digitalization efforts. Distinguishing one's firm position here demands substantial financial returns from AI investments and embedding cutting-edge solutions within a digital enterprise strategy.

It's important to note that just [10% of companies](#) see significant financial returns from AI projects. The scramble to adopt generative AI has led to a proliferation of proof-of-concepts (POCs) within the past twelve months. Regrettably, most of these initiatives are on the cusp of obsolescence and won't transition to the pilot stage.

Companies need to begin with a compelling business case that leverages their investments in digital twin, edge computing and data science. Our experience suggests that the probability of success is amplified when clients merge various unique factors that influence their business operations through automation. For instance, roles that are highly specialized and demand a premium for their execution present an enticing opportunity. By providing an employee experience that augments these workers' capabilities and productivity, ROI is almost guaranteed. For the most specialized, most-expensive team members, incremental improvements in productivity are more easily correlated to revenue or profitability increases. Similarly, automation of an existing process is another sure way to achieve ROI. Nevertheless, generative AI is only apt for the job if it interacts with one or both product experiences within your organization.

Even after dedicating time to determine which use cases will drive value for the business, many customers falter with governance and formulating an overarching technology strategy. This involves building a business-centric AI delivery organization and ensuring a well-maintained portfolio of data assets.

While we are equipped to build and scale generative AI, we urge clients to invest in curating high value, differentiated data assets. Relying solely on public data assets and models merely puts you at par with competitors. Start with your most promising use case that strengthens foundational capabilities paves the way for success. Swiftly follow with the next-best use case, and you'll start to build a robust data science competency within your organization. This iterative process aligns effort with value, transforming your organization into a data-driven entity.

Scaling from individual activities for a single POC to enterprise-wide programs and processes, you transition from ideation sparks with stakeholders to an innovation pipeline. Strategy and discovery sessions morph into your data governance program, and legal review evolves into a [responsible AI](#) and regulatory work stream.

Product-level activities for a single project become a data product mindset, and your enterprise security becomes your AI and ML operations. This metamorphosis from singular activities to scalable programs is integral in the evolution of your organization towards being a regular operator in the generative AI landscape.



# Mitigating Risks in Digitizing Assets

Digitizing assets can help energy companies mitigate risks from both inside and outside the industry.

Effective data management serves as a foundation for effective digitization. This also enables more seamless energy diversification by having the data to compare one-to-one in investment and resource allocation decisions.

The effective use of data and digital also makes it easier to collaborate with partners such as governments, NGOs and other oil and gas companies. The rise of joint ventures to develop and produce assets is driving good data practices such that these companies can share and use data intentionally and securely. The increasing adoption of data platforms like OSDU is an indication that exploration and production companies are finding value in giving groups across their organization – such as exploration, drilling and production teams – access to the same trusted data; this reduces silos and increases good decision making.

It is key for companies to recognize their current digital maturity and define a proper roadmap with alignment across business- and technology stakeholders. By defining existing capability and ownership in the data and digital space needed to drive forward the roadmap, synergy can be recognized and alignment can prevent roadblocks. Alignment around a roadmap that drives toward a common North Star objective at the outset enables identification of tangential or conflicting initiatives in the organization that need to be considered and mitigated. For example, if there is a long-term data strategy, then implementing any technology needs to take that strategy and timeline into account to ensure optimization. Additionally, if two groups within an organization are considering the same technologies they can find synergy in shared resources and achieve better outcomes by sharing lessons learned.



# How will Transformation Manifest in the Energy Industry?

Transformation and continuous evolution must occur for energy companies to realize full business value from the disruptors, accelerators and innovations mentioned. Successful companies continue to reimagine operating models, processes and systems along with advancements in data integration and advanced analytics. Our clients appreciate the power of culture and people; and they promote that people are essential to ensure change is adopted, reducing redundancy risk and lost investment cost.

In our experience, the following key levers establish a strong foundation necessary to power transformation:

- **Culture and leadership:** Leading companies promote and nurture experimentation, a learn-fast philosophy, a digital-first approach and a learning mindset to enable continuous improvement. Their leaders are visible and exemplify the desired mindset and behaviors and are at the forefront to adopt new ways of working. Initiatives have greater chances of success when there is true sponsorship and role modeling of leaders. Accelerators and playbooks can be crucial to cultivating the desired culture and bolster successful transformation.
- **Organization, roles, performance management, recognition and rewards** are all essential to help people adapt and adopt. These are additional areas in which energy companies need more focus to embed transformational change. Clarity of roles, setting priorities, work processes and motivational approaches (how people are recognized, evaluated and rewarded) need to be established and clear to align people around the priorities of the transformation.
- **Enablement:** Employees need to have the foundational digital tools to do their jobs, data literacy and the capacity to learn and grow their competencies. Given that lack of end-user adoption is the number-one reason for failed technology-led transformations, it is necessary to double down on enabling employees to ensure they understand and have the capacity and capability to adopt changes. EPAM ensures that our capability-building approach is tailored to the client company and targeted audience, to embed new ways of working and use real-time data and information to make decisions and drive performance.
- **Empowerment and activation of the front-line are required.** Front-line operators, technicians and crafts professionals are closest to the work and are also the change agents with power to sway and support their peers. Furthermore, shift work is prevalent for front-line staff in 24x7 energy operations. Especially during the evenings, nights and weekends, the front-line crews rely heavily on each other, and this is when digital transformations can be most impactful.

Embedding transformational change is complex, but this is the only way to realize business value from digital investments. Addressing the key areas mentioned above ensures successful change adoption based on our experience in working with energy clients.



One of the top cited reasons that transformation initiatives fail is change [resistance among employees.](#)”



# How to Move Forward

As technological maturity increases in the energy industry, companies can benefit from pinpointing where they stand on the spectrum and defining their North Star. Integrating technology and data at a systemic level — based on the building blocks of best practices in data and existing piecemeal technologies — can provide the greatest benefit to oil and gas companies looking to make better and faster decisions. This can decrease speed to first oil, increase production and decrease cost per barrel produced.





# About EPAM

Since 1993, EPAM Systems, Inc. (NYSE: EPAM) has used its software engineering expertise to become a leading global provider of digital engineering, cloud and AI-enabled transformation services, as well as a leading business and experience consulting partner for global enterprises and ambitious startups. We address our clients' transformation challenges by fusing EPAM Continuum's integrated strategy, experience and technology consulting with our 30+ years of engineering execution to speed our clients' time to market and drive greater value from their innovations and digital investments.

We deliver globally, but engage locally with our expert teams of consultants, architects, designers and engineers, making the future real for our clients, our partners and our people around the world.

We believe the right solutions are the ones that improve people's lives and fuel competitive advantage for our clients across diverse industries. Our thinking comes to life in the experiences, products and platforms we design and bring to market.

Added to the S&P 500 and the Forbes Global 2000 in 2021 and recognized by Glassdoor as a Best Workplace in 2023 and 2024, our multidisciplinary teams serve customers across six continents. We are proud to be among the top 15 companies in Information Technology Services in the Fortune 1000 and to be recognized as a leader in the IDC MarketScapes for Worldwide Experience Build Services, Worldwide Experience Design Services and Worldwide Software Engineering Services as well as a leader in the 2023 Gartner® Magic Quadrant™ for Custom Software Development Services, Worldwide.\*

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