Oil & Gas and Electric Power Practices

Digital transformation in energy: Achieving escape velocity

The need for digital value is greater and the barriers to change are lower—yet inertia persists. Three practical lessons can help energy companies break through.

by Adrian Booth, Nikhil Patel, and Micah Smith

For energy companies, achieving value from digital technologies has become the great white whale: anxiously hunted, dimly perceived, enormous, and elusive. For the past two years, energy companies of every stripe have probed digital possibilities—running pilots in analytics, process digitization, and automation. They assumed that, as engineering-savvy organizations with a history of ingenuity, they could easily find the value from digital. Reality has proved more difficult.

Energy companies have failed to achieve substantial business value from digital because their approaches do not account for the unique challenges of being an energy company, which create extraordinary inertia. Breaking that inertia will require far bolder action than energy companies have been comfortable taking to date. They must commit to transformation.

To be sure, COVID-19 has scrambled the outlook for digital in energy. Some companies, especially independent producers and suppliers in oil and gas, must focus urgently on cash and survival—digital can come later. But for energy companies with the resources to weather the storm, the disruption of COVID-19 has done two things: first, it has underlined that survival requires getting to the next level on cost and adaptability, and that requires digital; and second, by forcing companies to abandon business as usual, it has lowered the barriers to change that typically impede digital transformation.

Digital transformations have been tragically overhyped, but we believe they are both possible and necessary. Here, we describe a perspective on what it will take to achieve one in energy. We draw on lessons from early experiences in energy as well as earlier movers in high tech, finance, healthcare, and mining. These lessons were true pre-COVID and we believe they remain true now. Energy companies that harness them will have the wherewithal to invest for future leadership.

Why enabling digital in energy matters

So far, the adoption of new technologies in energy has been more hype than reality. Does it warrant so much attention?

It is truly important that energy companies realize the promise of digital innovation at scale, on a global basis. It matters to the world: over the next two to three decades, more than five billion people across the developing world will seek a path out of poverty. Unlocking the magnitude of energy resources required to improve their lives, in a way that does not choke the environment, cannot be done without the power of digital to improve efficiency and manage complexity.

And it matters to energy companies because they face unprecedented changes across the energy system: more competition, more complexity, and less predictability. Profit margins are under pressure, and the margin of error for survival is shrinking.

These changes affect every player:

— *oil and gas operators* that face price volatility, potential peak demand, and the dynamism of shale versus OPEC

— *utilities* that face distributed generation, more complex grids, and evolving customer expectations

— *refineries* that must adapt to global uncertainty over new sources of feedstock and new patterns of demand

— *renewables developers* that must survive and grow amid intensifying competition and potential commoditization

— *service companies* that must remake their delivery models to meet customers' new expectations about digital efficiencies

— *engineering, procurement, and construction companies* that struggle to deliver the types of capital projects that matter for the future

Digital innovation is one of the few means that can contend with these profound changes—by using predictive analytics to better anticipate the future, data to better inform current decisions in the here and now, and digitization and automation to take advantage of every increment of cost and speed that can be found.

In the narrow settings where energy companies have applied digital successfully, we have already seen it facilitate 2 to 10 percent improvements in production and yield and 10 to 30 percent improvements in cost. If these benefits hold true at scale, they could have a material impact on competitiveness: for example, improving cost efficiency by one to four cents per kilowatt-hour in power and $2 to $12 per barrel in upstream oil and gas production (Exhibit 1). These deltas can make the difference for a business's survival, let alone its leadership.

Challenges of digital in energy

Why have efforts to gain value from digital not succeeded? In fairness, energy companies have learned many lessons from their frustrations over the past two years. These lessons are now so widely repeated that they have almost become clichés:

— focus on the business case, not the technology

— listen to and delight the users

— people, process, and behavioral change are just as important as technology

— avoid pilot purgatory

— do not let the perfect be the enemy of the good; instead, fail fast and learn fast

— agility is good, burdensome hierarchy is bad

— transformation takes effort, whether digital or not

These lessons are true but insufficient.

Energy companies sometimes overuse being different as a crutch to explain why innovations from other industries cannot apply to them. That said, they do face different circumstances from the digital-native tech pioneers of Silicon Valley or the financial institutions that led the next wave of digital and had business models that entailed largely nonphysical, easily scaled transactions.
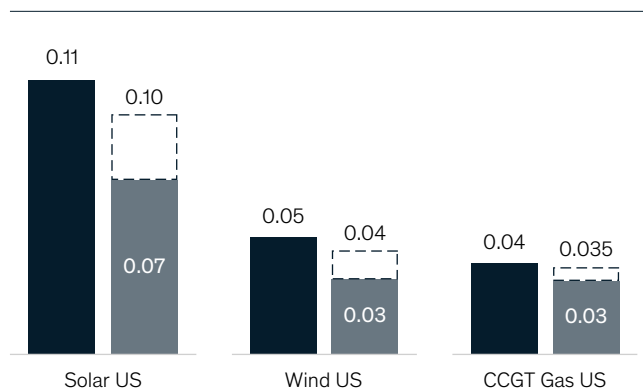
Exhibit 1

Done right and at scale, digital will materially affect competitiveness.

Narrow efforts at digital have shown ~2 to 10 percent yield improvements and ~10 to 30 percent cost improvements in capital, supply chain, and operations. **What is the cost efficiency opportunity if these impacts hold at scale?**
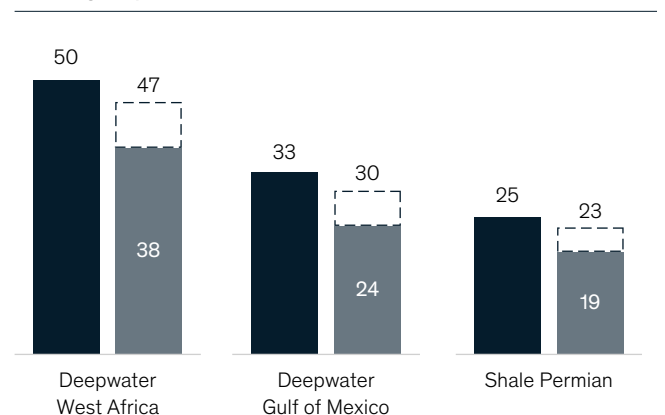
Illustrations of potential impact

■ Baseline ■ Digitally enabled

Power,[1] $/KWh

	Baseline	Digitally enabled
Solar US	0.11	0.10 / 0.07
Wind US	0.05	0.04 / 0.03
CCGT Gas US	0.04	0.035 / 0.03

Oil and gas upstream,[2] $/boe

	Baseline	Digitally enabled
Deepwater West Africa	50	47 / 38
Deepwater Gulf of Mexico	33	30 / 24
Shale Permian	25	23 / 19

[1] Assumes US average figures for all operating plants, and midrange capex from listed sources for new build.
[2] Per boe cost estimates based on assets that came online 2010-19; opex and government take based on 2019 spend and production; capex per boe for deepwater based on total investment spend from start of development to two years after start-up divided by total resources; capex per boe for Permian is based on well capex divided by estimated EUR; deepwater assets defined as having water depth of more than 1,000 feet.

Source: DOE 2018 US Wind Technologies report; Berkeley 2019 Utility Scale Solar report; Lazard levelized cost of energy v13; EIA; Rystad Ucube; McKinsey analysis

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What makes digital value difficult to achieve in the energy industry?

— *physical orientation*. The energy business is sensitive to the laws of physics—whether the geophysics of an oil and gas reservoir, quantum physics of solar power, fluid dynamics of wind, thermodynamics of fossil power, or electromagnetics of power transmission. Moreover, it is embodied in heavy capital such as power plants, offshore platforms, or LNG terminals or pipelines. This physicality makes energy operations, and therefore profit generation, fundamentally difficult. In energy, digital applications must contend with the laws of nature and be done in a way that safeguards asset health and frontline capability. And proposed technology investments must meet a high bar of proof that they are worthy of integrating into these difficult operations.

— *health and safety risk.* Energy is a powerful commodity: it supports our everyday lives, but without care, it is potentially dangerous. The industry pays enormous attention to safety, but incidents still occur—sometimes deadly, such as the Deepwater Horizon and San Bruno explosions. Given the inherent risks, energy companies must navigate a web of regulations, which span every level of government. For example, local rules about land use; state rules about water, safety, energy mix, or consumer service requirements; federal rules about interstate projects and operations; even international treaties governing the energy trade. As a result of living under regulatory

scrutiny for more than a century, energy companies are averse to risk and try to control for it through detailed and rigorous processes. This makes them slow to change.

— *engineer-driven culture.* In a physically oriented, highly regulated sector, the engineer is king. Oil and gas and power companies are dominated by current and former engineers who have risen to the executive ranks. As such, these organizations are enmeshed in an engineering mindset: a love of large, comprehensive projects, a premium on finding the perfect solution up front, detailed planning to the highest degree, and a preference for rigorous analysis and process over fast judgments and flexibility.

— *heavy dependence on third parties.* The work of energy companies depends on an extensive and fragmented supply chain. Industries such as airlines and automotive also depend on a complex supply base, but the energy industry puts supplier collaboration at the heart of operations. For example, a shale play requires a huge cascade of parties—owner companies that provide funding and regulatory engagement, third parties that drill, others that haul water and sand, others that build surface facilities, and others that integrate all these activities—just to produce a barrel of oil.

— *long careers, narrow exposure.* Many energy executives have been at the same company for at least 30 years—unusual for today—rising through the ranks by running a well-worn playbook. Such discipline makes sense given

the complexities of managing a business that is physical, high risk, highly engineered, and fragmented. These people were rewarded not on innovation but on caution and following tradition and are thus more practiced at surviving business cycles than driving sustained change.

— *global operations.* Energy companies go where the resources are. Often, this requires companies to span remarkably diverse regions: from Texas to Angola, California to India, Germany to Indonesia, the Persian Gulf to China. The legal and operating environments in these regions vary dramatically—even relatively simple things such as internet connectivity cannot be taken for granted. Some governments are content to let markets be, others use energy investments to promote national development. Labor forces vary in capability, reliability, size, and cost. Supply chains vary in maturity. And legal recourse runs the gamut from impartial courts to relying on knowing the right people.

Other industries contend with one or two of the issues above; the energy industry deals with them all. Each factor encumbers movement. Taken together, these challenges create massive inertia when it comes to digital adoption.

How to break the inertia: Digital fortune favors the bold

The only way to overcome an organization's inertia is to apply enough force. Small steps such as pilots and proofs of concept are too weak, and large technology programs run the risk of creating the wrong kind of force. The business must commit to digital transformation—fundamentally changing how the organization works, beyond technology alone—and then go after it.

COVID-19 creates a window to drive transformative change, in small part because companies and workers have been forced to accelerate their use of basic digital tools for remote work, in large part because the status quo has already been disrupted.

It is easy to say "transform," but what makes a digital transformation stick?

After much experience in the trenches, we have developed a digital transformation journey that breaks the inertia, unlocks large-scale value, and lasts (Exhibit 2).

Our digital transformation journey reflects three practical principles to tackle inertia and achieve scale:

1. don't just sponsor—own

2. don't just create tools—transform whole workflows

3. don't execute the transformation in one big bang—take bite-sized actions

These three principles animate every step of the digital transformation journey. How are they translated into practice?
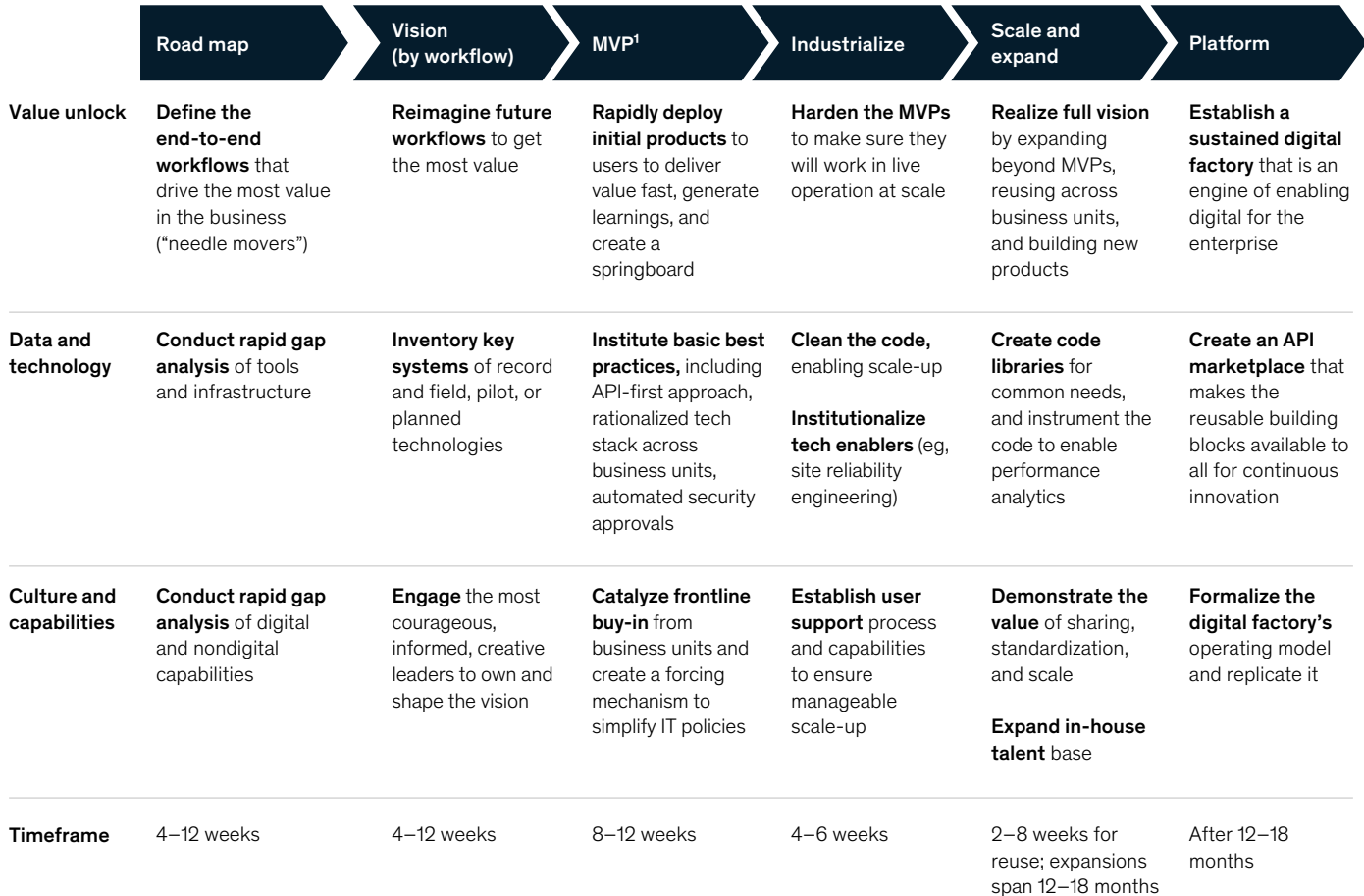
Don't just sponsor—own
Most energy companies have a matrix of business units, which run the operation, and functions (such as IT, engineering, or procurement), which provide services to the businesses. Usually, businesses, not functions, have the power. Digital transformation can only happen if businesses take responsibility for transforming themselves.

Almost invariably, they don't. The mindset of business executives has evolved over the years, but still not enough. Two years ago, business leaders relegated digital to the sidelines as a quirky IT project. Today, they recognize the value of digital but still treat it as a visionary experiment from on high. Indeed, corporate leaders hail the promise of digital technology and fund it lavishly, but they make it the purview of new digital incubators or centers of excellence rather than line operations.

Business units will not commit to digital transformation unless they have skin in the game. What does that look like?

Exhibit 2

A digital transformation journey in energy requires reimagining workflows.

Value-focused vision within weeks; value and action within first 6 months; transformation in 18–24 months

	Road map	Vision (by workflow)	MVP[1]	Industrialize	Scale and expand	Platform
Value unlock	**Define the end-to-end workflows** that drive the most value in the business ("needle movers")	**Reimagine future workflows** to get the most value	**Rapidly deploy initial products** to users to deliver value fast, generate learnings, and create a springboard	**Harden the MVPs** to make sure they will work in live operation at scale	**Realize full vision** by expanding beyond MVPs, reusing across business units, and building new products	**Establish a sustained digital factory** that is an engine of enabling digital for the enterprise
Data and technology	**Conduct rapid gap analysis** of tools and infrastructure	**Inventory key systems** of record and field, pilot, or planned technologies	**Institute basic best practices,** including API-first approach, rationalized tech stack across business units, automated security approvals	**Clean the code,** enabling scale-up **Institutionalize tech enablers** (eg, site reliability engineering)	**Create code libraries** for common needs, and instrument the code to enable performance analytics	**Create an API marketplace** that makes the reusable building blocks available to all for continuous innovation
Culture and capabilities	**Conduct rapid gap analysis** of digital and nondigital capabilities	**Engage** the most courageous, informed, creative leaders to own and shape the vision	**Catalyze frontline buy-in** from business units and create a forcing mechanism to simplify IT policies	**Establish user support** process and capabilities to ensure manageable scale-up	**Demonstrate the value** of sharing, standardization, and scale **Expand in-house talent** base	**Formalize the digital factory's** operating model and replicate it
Timeframe	4–12 weeks	4–12 weeks	8–12 weeks	4–6 weeks	2–8 weeks for reuse; expansions span 12–18 months	After 12–18 months

1. Minimum viable products.

Being a sponsor and providing funds signals interest, but it does not generate a psychological sense of accountability. If all a business does is fund a digital service that another group must deliver, it can remain at arm's length as a dispassionate judge of someone else's work.

Beyond funding, business units should first integrate digital technologies into their formal business and operational targets. This has a dual benefit. On one hand, it forces the business to take accountability for creating value from digital. On the other hand, that accountability also gives the business the power to shape digital initiatives to reflect true priorities, not the fanciful dreams of technologists.

Second, business units should commit the time and talent of their star operators. Typically, business leaders who view digital innovation as a sideshow shield their stars from digital efforts and refocus them on the traditional moneymakers: drilling wells, signing power purchase agreements, operating the

COVID-19 creates a window to drive transformative change . . . because the status quo is already disrupted.

Example: Creating business accountability for digital

At one renewables company, senior leaders recognized that digital innovation would become important for the enterprise to remain competitive amid an environment of more competitors, tax credits phasing out, and commoditization. Rather than setting up a special digital program, they pushed all the business units to define their own digital initiatives, as part of their core process of strategy, planning, and target setting. Crucially, the businesses did more than come up with digital initiatives: they had to assign a value aspiration in dollars and set their budgets accordingly. Doing so ensured that digital initiatives were practical and worthy of the same priority as growing the project backlog or keeping turbines operational. The businesses did not fly blind—they enlisted help from IT and analytics groups—but whatever initiatives they conceived, they owned with conviction. At the same time, senior executives watched for sandbagging and pushed the businesses to stay ambitious.

plant most efficiently, and so on. But if a business wants to turn digital into a moneymaker, too, it needs to put its best people on the case.

Star operators know the culture of the business, know the operation, and have good judgment about how to make changes. They are the most credible champions of a digital effort since they are widely respected by even the flintiest 30-year veterans, and they also have the capability to be creative about the future. Obviously, a business cannot afford to keep its best talent focused indefinitely on digital innovation, but by cross-pollinating between digital and core operations, they will eventually become one and the same.

Third, businesses should make the funding commitment big and bold. Digital transformation depends on deep operational change—weaving technology into operators' daily lives, streamlining processes, and radically accelerating the pace of activity. Those changes are subject to fits and starts and reversals, so it is hard to predict which changes will succeed or fail and how best to adjust. To make all this work, businesses should devote a big block of funds that covers a long time and gives digital efforts room to zigzag toward transformational change.

Don't just create tools—transform whole workflows

The prevailing approach to digital innovation in energy is to create "point solutions," which apply technology to narrow uses without fundamentally changing how people work. Energy companies succumb to point solutions partly because they have delegated digital to the IT function, which operates through a technology lens and lacks a mandate to redefine how other functions do their work. Moreover, energy executives are prisoners of precedent: when they hear "digital," they conjure images of 4-D seismic data upstream, advanced process controls downstream, or grid-operations centers in power—in short, tools to digitize the existing process rather than a wholesale reimagining of the process.

Point solutions also fall prey to the perils of inertia: they are not meaty enough to change behaviors or mindsets, they often digitize poor processes rather than improve them, they get smothered by the status quo, and they optimize targeted needs instead of the whole system.
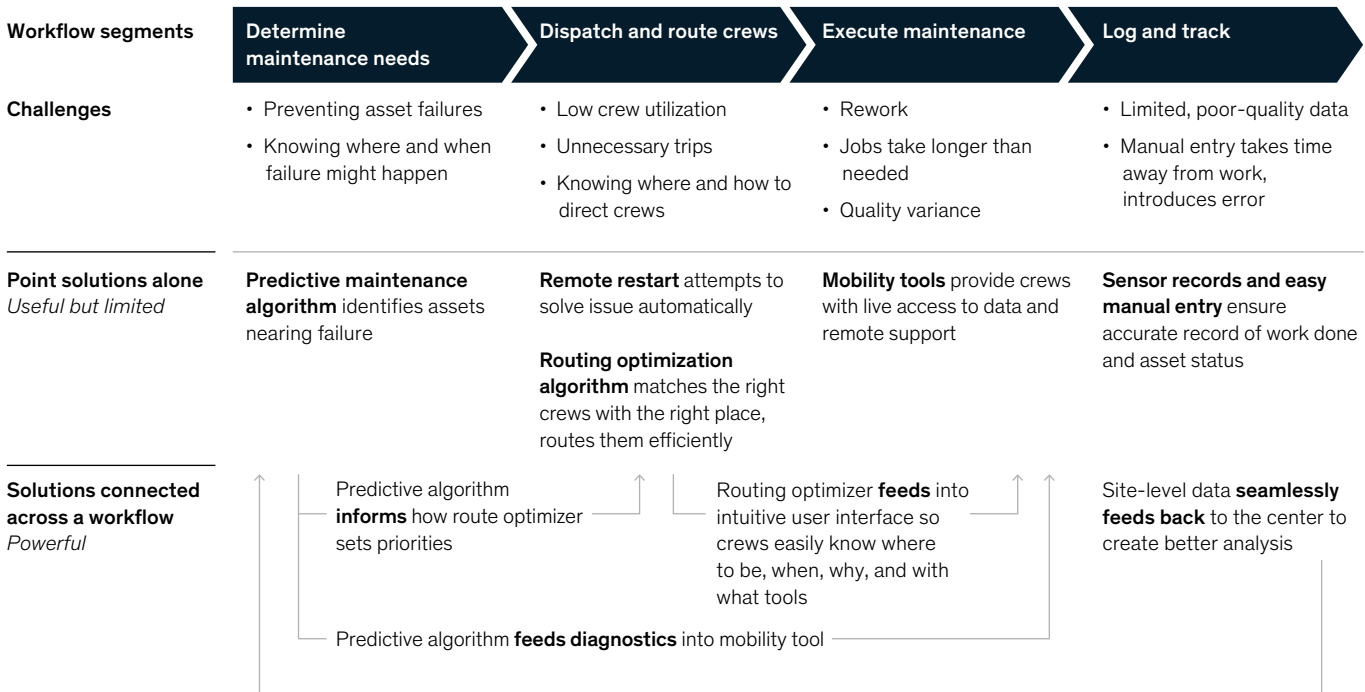
To break inertia, digital transformation requires a forceful reimagining of how people work—and the only way to do that is by rewiring entire end-to-end workflows (Exhibit 3). Workflows can be defined in a variety of ways, but they should reflect the main vectors by which a business generates value. Examples include production optimization in upstream oil and gas, real-time turnarounds in refineries or petrochemicals, and plant operations and field maintenance in power.

Focusing on end-to-end workflows is vital for success in digital transformation. First, it launches a deep rethinking of how an operation works, which generates the creativity and momentum required for true transformation and points everyone toward

Exhibit 3

End-to-end workflows have value greater than the sum of their parts.

Maintenance optimization example

Workflow segments	Determine maintenance needs	Dispatch and route crews	Execute maintenance	Log and track
Challenges	• Preventing asset failures • Knowing where and when failure might happen	• Low crew utilization • Unnecessary trips • Knowing where and how to direct crews	• Rework • Jobs take longer than needed • Quality variance	• Limited, poor-quality data • Manual entry takes time away from work, introduces error
Point solutions alone *Useful but limited*	**Predictive maintenance algorithm** identifies assets nearing failure	**Remote restart** attempts to solve issue automatically **Routing optimization algorithm** matches the right crews with the right place, routes them efficiently	**Mobility tools** provide crews with live access to data and remote support	**Sensor records and easy manual entry** ensure accurate record of work done and asset status
Solutions connected across a workflow *Powerful*	Predictive algorithm **informs** how route optimizer sets priorities	Routing optimizer **feeds** into intuitive user interface so crews easily know where to be, when, why, and with what tools		Site-level data **seamlessly feeds back** to the center to create better analysis

Predictive algorithm **feeds diagnostics** into mobility tool

a shared goal. Second, it makes all digital efforts subservient to an ambitious business vision. To transform a workflow, a business is forced to define a vision of the future state: how the activities in that workflow can be done the fastest, safest, and most cost effectively, and what needs to change from today. Digital technology only enters the picture as an enabler to help make the vision a reality.

With this approach, businesses find it easier to define digital initiatives that actually lead to transformation, not just incremental gains. Moreover, they can easily prioritize digital investments: out of the 1,000 ideas their organizations dream up, only ten really contribute to the future state vision—the other 990 get dropped. Finally, they can more easily rally the organization around the effort, because the benefits of digital become more obvious—even to skeptics.

Example: Making technology relevant to how people work

One US power company thought there might be value in drones. They started with a "technology-back" approach: they bought a small fleet of drones, which each cost around $3,000, and then looked for applications (the most obvious being inspections).

At first, they used the drones for external inspections of boilers: an operator on the ground, with line of sight to the drone, flew it around the boiler to capture video feed. This was promising, but relatively low value.

It soon became apparent that there would be more value in sending the drones inside the boilers while they were still hot, which would allow the company to run inspections without having to shut down operations.

But because this company had focused on technology first, it had not fully considered the workflow.

Operators needed a way to inspect the boilers quickly and thoroughly without any risk of damaging them. The original "user journey" entailed shutting down the boilers and having human beings go inside to perform quick inspections (to allow operations to come back online) and comprehensively (to ensure equipment integrity and absolute compliance with regulation). Any revised "user journey" utilizing drones would need to enable this same speed and comprehensiveness.

But the company had chosen its drone technology before defining what the future workflow should be. Their drones required a human operator, who had to navigate the drone within the boiler. At first, the operators were excited about the drones, but they soon became fearful about collisions within the boiler—so they simply stopped using the drones.

Leadership decided to recalibrate, directing their attention to the workflow. To get the value of internal boiler inspections, the workflow demanded a technology that could work quickly and thoroughly and provide confidence to operators. With that in mind, they went back to market and found a start-up with a drone that could fly itself, using machine vision to avoid obstacles (at one-third of the price of their original drones, no less). Moreover, they considered the full opportunity for the future workflow: What if the drone not only provided video feeds but also used machine learning to diagnose what it was seeing to identify leaks? The company is now on a path toward a much higher value ambition, with much higher adoption by the organization.

Don't execute the transformation in one big bang—take bite-sized actions

Inertia is tenacious—it will resurface over and over. Energy companies routinely try to plan every aspect of their digital efforts up front. Despite lip service to agility and modularity, they aim for engineered perfection. All of that planning and perfection leads to helplessness when momentum lags or unforeseen problems emerge during a transformation.

With digital technology, the right answer is hard to lock in right away. For one thing, technology changes at a rapid clip—current trends could become obsolete in less than a year. Furthermore, it's impossible to know what will work until it's underway—building something real, giving it to users, and testing it against reality.

Therefore, a digital transformation is best advanced in bites. Select a digital solution, cocreate it with field users, get it into those users' hands quickly, and let them start using it to generate value—and by the same token, let them get excited by it. Learn from the experience, and play those lessons into the next push. If a need to adjust arises, multiple pivot points are available. This approach offers repeated surges of action and progress to continuously break inertia.

The numerous merits of the bite-sized method have been validated many times over by energy companies that have adopted it.

One benefit is that it delivers business value and creates supporters quickly, which generates self-perpetuating momentum for the digital transformation. And as we have seen, momentum is everything.

Example: Creating momentum through surges of value and progress

A leading oil and gas company has undertaken the bite-sized approach to achieve unprecedented value, speed, and scale of transformation in end-to-end procurement and supply chain. It outlined an ambitious vision for the future of procurement and supply chain and took a starting action quickly by launching three digital products in parallel, in three business units. The company built the products and put them in users' hands within two months (including tough-to-implement elements, such as predictive analytics used by operators in the field), and scaled between businesses and asset types (which were as wide-ranging as shale, deepwater, and conventional onshore) in four to six months. The businesses were excited to reduce operating costs and speed up cycle times, and the frontline operators were thrilled that their lives were made easier. Word spread—creating pull from the rest of the enterprise.

A second benefit of the bite-sized approach is that it forces practicality. Time pressure focuses the mind on what matters.

Example: Pragmatic compromises and being quick to action can lead to better outcomes

A North American shale operator sought to transform its water logistics workflow, supported by digital technology. But making it happen would be tricky: it needed to influence a long tail of third-party water haulers of varying capability (over which it had limited control) and to create visibility across its network of hauling operations to improve cost and safety—especially important given transit through populated areas.

The answer most likely to be pitched to executives was to push all haulers to adopt standardized sensing devices selected by

the company; to create instant data feeds of where every truck is at every second; and to create sophisticated algorithms to optimize truck movements and direct them centrally. But they did not have time to gestate these grand notions—they wanted to take action. And after analyzing the workflow, they realized they did not need perfection: they could capture the bulk of the business potential through bite-sized variants. Instead of pushing standardized sensors, they made use of the devices already installed by different hauling companies on their respective trucks, and found simple methods to reconcile data from disparate systems. Instead of aiming for real-time network visibility and optimization, they realized that a "day ahead" view would do the trick.

Finally, there is simply no substitute for experience. People often struggle to understand the full value of a digital initiative on paper, no matter how well described or planned. It's only once they see the reality that they grasp the potential. In one case, a shale business unit built a demand-planning solution for drilling logistics using advanced statistical models to predict when material orders would be needed based on the depth of well, the speed of drilling, and other factors. One executive involved in the effort was supportive but believed the solution was limited to its origin (drilling logistics in shale). Over the course of two months, however, her outlook shifted. She spoke not only with users in the field, seeing how they actually used the predictive solution, but also with operators in other businesses to understand their needs. Over time, she appreciated just how big the opportunity could be—not just predictions for drilling logistics, but for all logistics; not just materials, but also services; not just this shale asset, but every asset.

A couple of concerns about the bite-sized approach are worth considering. The first is that it leads to one-off solutions that cannot scale. In our digital transformation journey, reusability and scalability both factor into decisions from day zero—about defining the future-state vision and about delivering the first minimum viable products. When done properly, we have seen MVPs scale up to new business units and masses of new users with 80 to 90 percent of the original code unchanged.

That said, the concern over scalability may be a red herring. A digital program can be re-geared to scale, even if scalability was completely ignored in the past. For example, a leading financial services company had worked to transform multiple workflows but had proceeded in silos. Each team invented its own approach to user access, business rules, data integration, and so on. As a result, a user who started in one workflow could not seamlessly move into another workflow—for instance, after a customer onboarded to a bank and received a loan, she could not automatically open a debit account. As the user base grew, this element became a real challenge. But to achieve interoperability and unlock scale, the company did not have to suffer months of agony redoing its code. Instead, it simply took a two-week "step back" to revise the workflows to act as an interconnected whole, identify the reusable components that were common across workflows, and set up the integration patterns to allow for application programming interface (API) enablement of data flow between systems. All it took was two focused weeks to reposition the effort for scalability, and it provided a huge accelerant. The company was able to go from two workflows to four to eight in parallel in about six months, and improved efficiency by more than 30 percent through automation and reuse.

A second concern with the bite-sized approach is that it may work for digital product development, but not for establishing technology foundations, developing capability, or changing culture, which require more planning and longer timeframes.

This notion has been repeatedly disproved by experience. When it comes to technology, energy companies have tried laying all their foundations up front (enter the dreaded "data lake"), but nobody races to use them. When it comes to capability, they have hired a gaggle of pedigreed data scientists and said, "Go forth, mine the data, find the money," but most of those new hires sit around waiting for a purpose. When it comes to culture, they have run interminable workshops, but never get beyond classroom theory.

By contrast, the bite-sized approach tries to advance the trifecta of business value, technology platforms, and culture and capabilities through each step of the transformation—not in theory, but through delivering on a specific business need. Any time a technology choice or a hiring push is made, it is made because it is necessary to deliver on an immediate business need. Cultural changes come from actual changes to how people work and interact with each other in the field.

For now, digital transformations in energy will largely focus on operations. That scope is hard enough and has plenty that needs to be addressed. But in successfully reimagining operations—and building digital capabilities along the way—energy companies will open the next horizon of digital opportunity: truly disruptive business models. We are only at the beginning of the journey.

Energy companies are right to take digital seriously; it is important for their future success, and it is imperative for global economic growth and environmental care. But they must summon the boldness that marked their triumphs in the past, making ingenious innovations a reality—whether creating a continent-spanning grid, extracting hydrocarbons safely from the planet's most remote areas, or using quantum mechanics to harness the energy of the sun. As in those endeavors, so with digital: fortune favors the bold.