



TECTONIC SHIFTS IN THE ENERGY INDUSTRY

Changes in Demand, Growing Data drive New Technologies,
Capabilities, and Priorities

FROST & SULLIVAN VISUAL WHITEPAPER

CONTENTS

- 3** Energy industry undergoing the most dynamic evolution in its 150-year history
- 4** Digital transformation is fundamental to adjusting to change and creating success
- 5** Fueling and powering the world takes deft data strategies
- 6** The energy industry's digital future will reach across value chains and ecosystems
- 7** Despite major market disruption, utilities can thrive with the right partners
- 8** Growing sustainability goals drive wind power modernization
- 9** Sustainability measures promote a circular economy of renewables, smart cities, and the private sector
- 10** The issue is not cloud, it is ensuring the right cloud

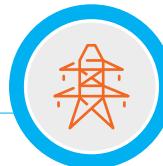


Energy industry undergoing the most dynamic evolution in its 150-year history



Oil & Gas Repositioning

- Rebranding themselves as Energy Companies
- Aiming to fuel and power the world, regardless of technology
- Expanding renewable power and energy storage assets
- Expanding environmental mandates and aging infrastructure
- Encroach on the utility space, subject to growing regulations and to new data usage and security demands



Power Grid Transformation

- Traditional utility hub-and-spoke models give way to matrix and new X-as-a-service business models
- Distributed Energy Resources (DERs) adoption increases and strains operations, leading to higher power volatility
- Also, aging grid fail to keep up with new technologies, worsening natural events and cybersecurity risks
- New types of market players need and contribute to energy data



Across Energy Data is ubiquitous, critical, challenging

- Operation optimization and cost reductions are distant but achievable goals
- Renewable power is less predictable than fossil or nuclear and needs advanced analytics to thrive
- Energy industry ill-prepared to fully leverage new technologies such as artificial intelligence, machine learning, Internet of Things (IoT) devices, virtual/augmented reality, digital twins, drones, and predictive analytics
- Recent, prominent ransomware incidents highlight growing cybersecurity risks

Cross-industry trends include: a large retiring workforce resulting in skillset gaps, IT/OT divide, cyberthreats, mounting environmental regulations, and inability to modernize technology and culture quickly.

Once independent industries now sharing same challenges as everything becomes more connected.

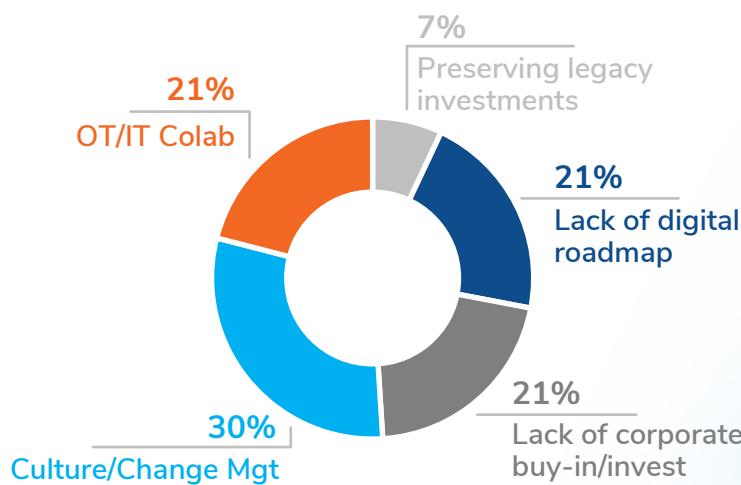
Source: Frost & Sullivan

Digital transformation is fundamental to adjusting to change and creating success

Frost & Sullivan research shows that businesses recognize the value of digital transformation but struggle to incorporate data-driven strategies fully. The energy industry is flooded with growing volumes of information and pressure to utilize this data to lower costs and create new business models.

COMPANY CULTURE CHALLENGES DIGITAL TRANSFORMATION:

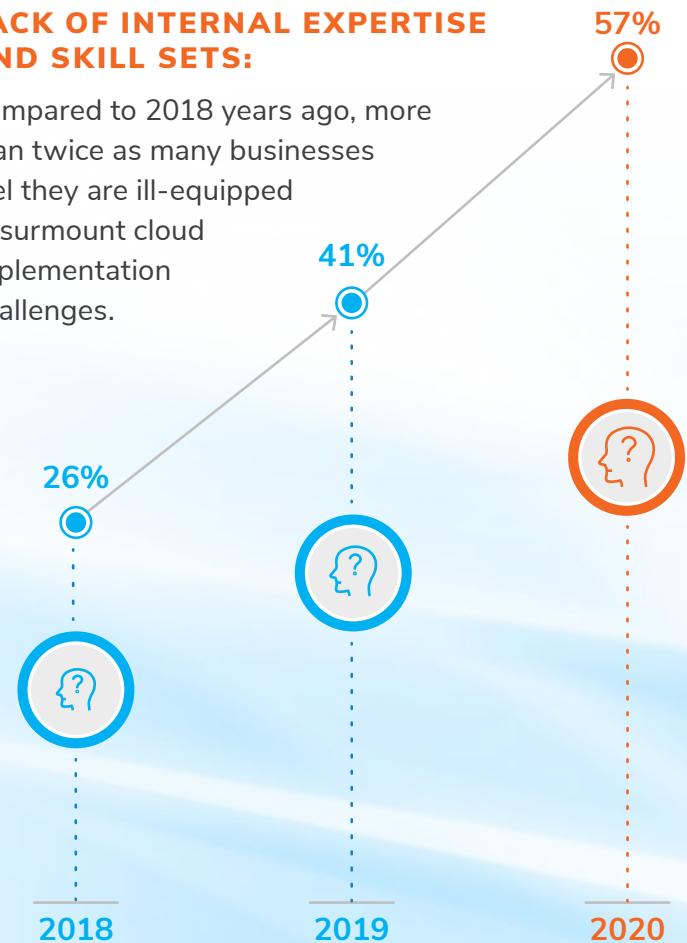
Change management, IT/OT collaboration, and a lack of corporate buy-in make up almost three-fourths of transformation restraints.



Open platforms can enable secure and intelligent sharing of processes and data insights, accelerating digital transformation, improving operations, and creating outcomes and organizational visibility that promotes a digitally forward culture. Businesses that embrace this will move forward, faster.

LACK OF INTERNAL EXPERTISE AND SKILL SETS:

Compared to 2018 years ago, more than twice as many businesses feel they are ill-equipped to surmount cloud implementation challenges.



Source: Top restraints for digital transformation, Global, 2020

Fueling and powering the world takes deft data strategies

Growing environmental pressures, rapid price fluctuations, and the rise of new solutions such as electric vehicles and renewable power means energy companies are rapidly diversifying their asset portfolios. Oil & gas (O&G) companies are embracing the concept of providing energy to fuel the world, not just natural gas and petroleum. Utilities are operating in increasingly complex environments.

ENERGY INDUSTRY DATA COMES FROM A VARIETY OF SOURCES, INCLUDING:



Pipelines: condition monitoring as well as drones, autonomous land vehicles and satellite imagery

Across oil field: pumps and valves, drilling and boreholes

Off shore rigs: production data, health and safety, AUVs

Refining operations

Grid operations

Power generation, both centralized and distributed

Condition-based monitoring

Logistics and suppliers

Corrosion mitigation

Seismic information for exploration and revisiting retired reservoirs

Business systems such as CRM, ERP, EQMS, and others

External data, such as pricing and trading, weather conditions, and logistics

NEW INSIGHTS THAT WILL NEED TO BE INTEGRATED INTO BUSINESS INTELLIGENCE SYSTEMS INCLUDE:

- **Operations information**, which is critical for hard-to-access wind turbine gearboxes, both on- and offshore
- **Grid flexibility**, which stems from intelligent integration of edge data, compute analytics, and a growing number and type of connected devices
- **Wind and solar power** that is generated more intermittently than fossil or nuclear power, and energy storage that will help generation match usage patterns
- **Cloud-centric automation**, which helps generate audits and reports on operations, costs, and security measures for management, auditors, and regulators

DATA TRENDS:



An offshore oil rig can generate as much as
2TB of data per day.

Up to **90%** of the global pipeline infrastructure **lacks** real-time monitoring.

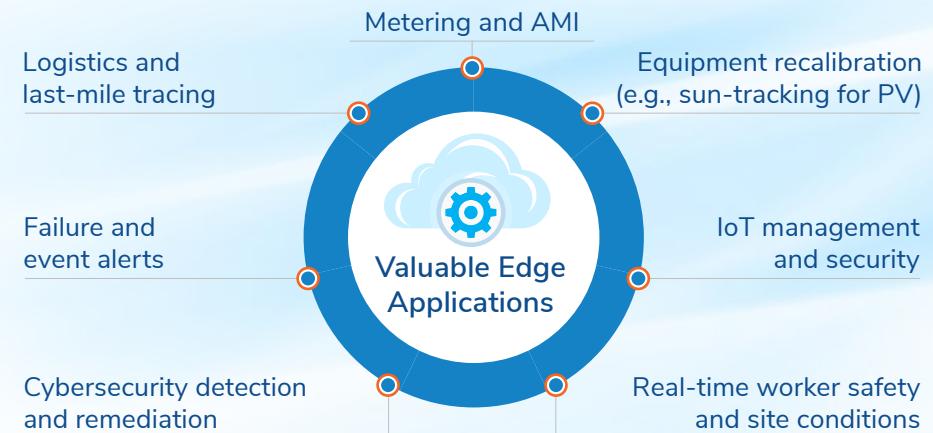


Source: Frost & Sullivan

The energy industry's digital future will reach across value chains and ecosystems

Data-driven insights from the grid or an oil rig, combined with supplier and customers information and robust analytics, increasingly impact operations and planning. As edge analytics become more robust and capable, real-time tasks can be enhanced while reducing data transfer costs and security risks.

However, the cloud remains critical for processing growing data volumes quickly and securely. To help create the right applications and workflows, scale operations, and remain compliant across global regulatory bodies, energy companies will need strong partners with energy industry knowledge that are well versed in the edge and cloud.



THE CREATION OF A DIGITAL ENERGY WORLD

Smart Equipment and Edge Capabilities

These are increasingly pervasive across grid and O&G operations, amounting to billions of IoT-enabled sensors and devices across the ecosystem.

Integrated System

Integrated systems include AMI systems and smart transformers for grid applications; connected pipelines and oil fields in O&G; and systems that bridge edge to cloud, cooperate across networks, increase efficiency, and reduce failures.

Intelligent Operations

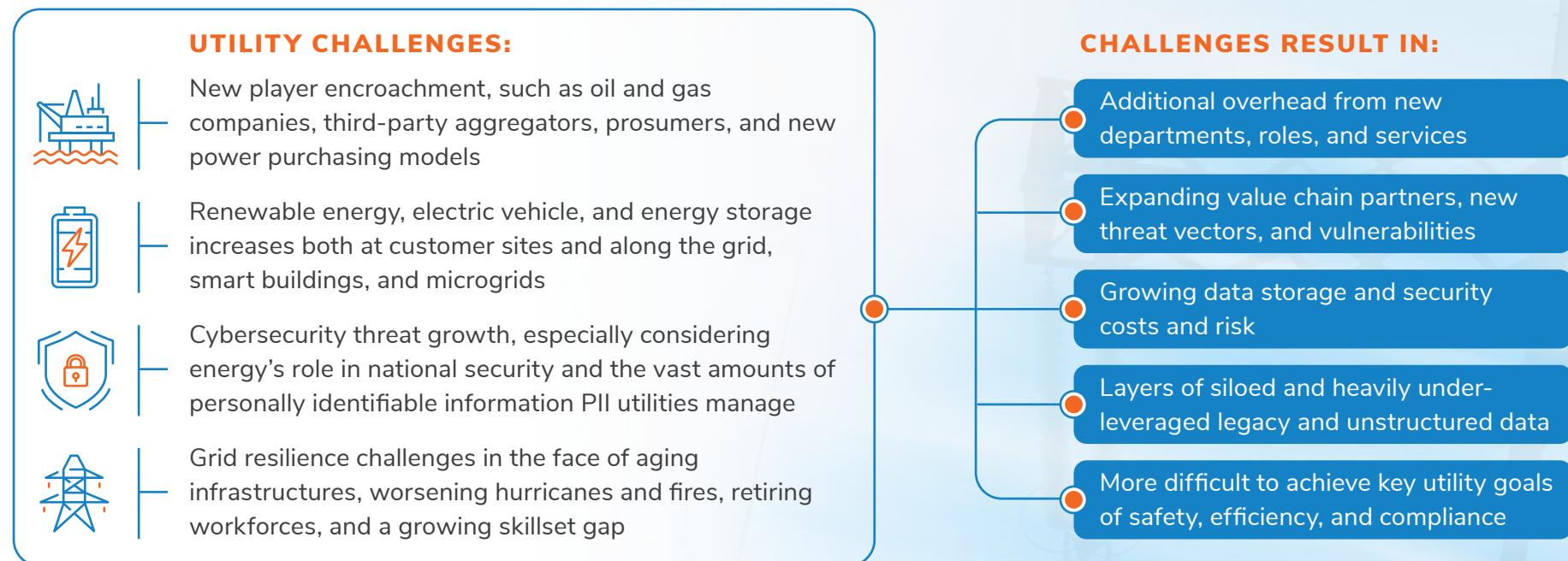
Incorporating business systems and external data such as weather, logistics, and supplier and customer data drives digital twins and enables predictive capabilities. Outcomes include optimized operations and improved business visibility.

Connected Ecosystem

A connected ecosystem provides enhanced insights across value chain partners. The future of this could see oil prices directly impacting drilling operations, blockchain-enabled power trading within microgrids, and the merging of energy and mobility ecosystems.

Despite major market disruption, utilities can thrive with the right partners

Power grids are among the largest interconnected systems in the world and span hundreds of millions of kilometers. The power companies that operate these systems are massive, complex, and decades-old organizations that are often the result of multiple mergers and acquisitions. Their information systems are rife with isolated data lakes, paper-based records, unstructured data, and siloed systems and apps. The lack of organizational coordination and visibility reduces operational efficiency, leads to higher power prices, slows outage response times, creates safety challenges and cybersecurity vulnerabilities, and makes it difficult to meet regulatory compliance.



A connected utility ecosystem brings device and equipment OEMs, connected building solution providers, third-party power aggregators, and customers together on a consistent, robust, and secure platform. Each segment of the link is critical but potentially vulnerable. An **open but secure** solution enables every part of the ecosystem to collect, synthesize, and integrate data while reducing risk more effectively than islands of connectivity and data.

OVER 300 MILLION SENSORS ARE DEPLOYED ACROSS POWER GRIDS, generating over 900 TB of data. Less than 5% of this information is fed into analytics.

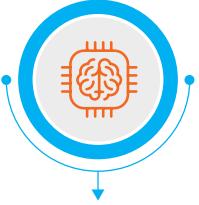
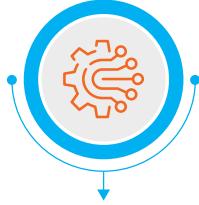
Source: Frost & Sullivan

Growing sustainability goals drive wind power modernization

The wind industry's opportunity to advance through technology seems boundless. For sustained growth and to excel at operations, it will need to embrace new solutions, data sources, and business models.

Data is pouring in through connected equipment, systems and processes, suppliers, logistics partners, and customers. Key technologies include IoT across equipment and fields; remote condition monitoring, especially in gearboxes and off-shore turbines only accessible by ship or helicopter; Drones and UAVs; LIDAR; and VR/AR.

Information and analytics feed into new, compelling solutions with rapid ROIs:

- Enables artificial intelligence- and machine learning-driven predictive and prescriptive maintenance
- Drives digital twins
- Helps manufacturers to continuously improve operations and designs

Wind power data information informs power pricing agreements, influences governmental incentives and subsidies, and impacts customers, pricing, and investors. The price for wind-generated power is declining, reducing revenues. Operators strive to increase production and efficiency to combat falling rates.

Many wind turbine installations are decades old and new insights help "repower" wind farms, guiding upgrades or replacement turbines to continue leveraging these installations. Frost & Sullivan research shows that land constraint is the top market constraint and will worsen over time.

Onshore wind adds 50 to 55GW/year with
\$40 to 45 billion
in revenues yearly. Offshore wind is expected to grow from just over 4 GW to nearly 20GW by 2025 and may be a \$30 billion industry by 2025.



OFF-SHORE WIND HAS GREAT POTENTIAL: turbines can be larger, generate much more power, and have more high, consistent wind speeds than on land. They are also not restricted by noise or siting regulations if placed out of view. **HOWEVER, THEY ARE EXTREMELY EXPENSIVE AND RISKY TO OPERATE AND MAINTAIN.**

Source: Frost & Sullivan

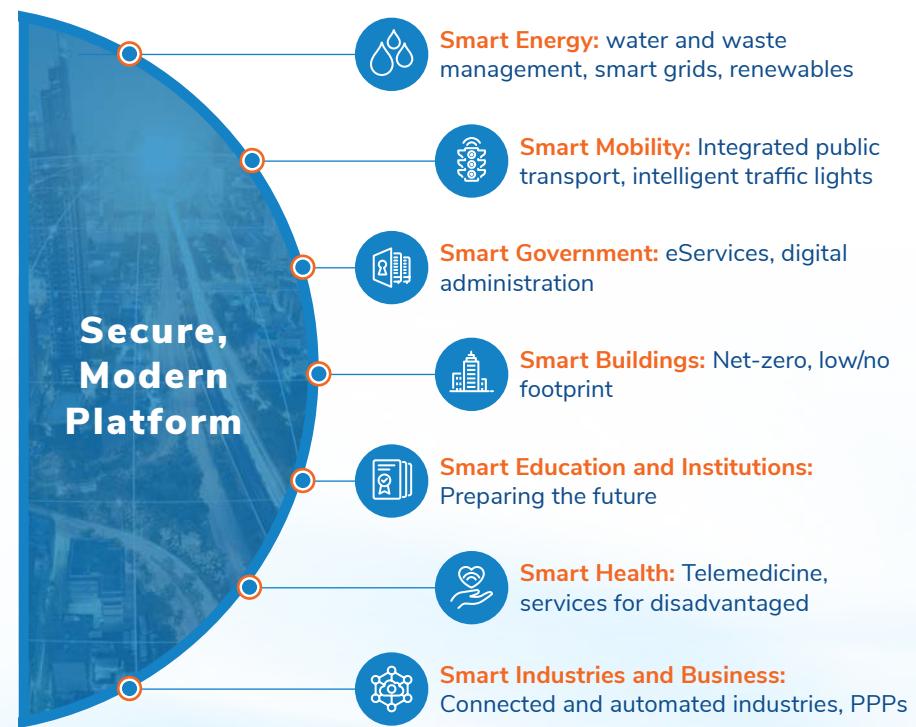
Sustainability measures promote a circular economy of renewables, smart cities, and the private sector

Private Sector: The private sector is a rapidly growing player in the solar power market. For example, private sector solar power ownership in the United States has grown 1,500% in the last 10 years*. Globally, over 300 major businesses have signed the RE100 initiative, pledging 100% renewable power by 2050. Participation spans industries as diverse as chemicals, electronics, hospitality, and finance.

Global businesses with operations in dozens of countries need to determine the best locations for renewable power installations based on geographic conditions, service availability, regional incentives, and local power prices. Additional challenges include:

- Integrating energy storage, electric vehicle charging, and smart building solutions
- Engaging value chain partners to expand sustainability goals

Public Sector: Sustainability is one facet that data-driven, digital smart cities strive to attain. Other areas of improvement include upgrading infrastructure, reducing traffic and crime, and enhancing resident and visitor experiences. Frost & Sullivan's definition of a "smart city" incorporates connectivity across areas of mobility, education, energy, buildings, health, industries/businesses, and government services.***



Possibly more than any other entity, a Smart City needs to connect the broadest type of connected devices and systems across the widest universe of businesses, organizations, institutions, and individuals. Successfully leveraging a diverse sea of data sources and goals can only be accomplished with a modern, secure open platform.

*Sources: SEIA, MIT, and Frost & Sullivan **PV = photovoltaic, i.e., solar panels

***Frost & Sullivan's Global Benchmarking of Select Cities and their Data and Digital Strategies, June 2021

The issue is not cloud, it is ensuring the right cloud

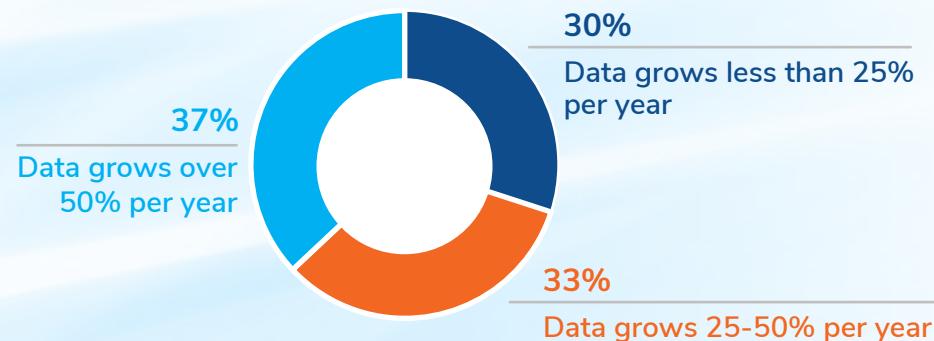
Growing data generation and utilization all but compels businesses to turn to the cloud for better scaling, agility, and computational power. However, it causes issues if not implemented correctly.

Cloud implementation challenges include:

- **Cybersecurity responsibility**, which rests with the customer unless they have a partner to provide support
- **Needs vary by business** and there is no one-fits-all cloud or configuration, whether that be a hyperscaler, multi-cloud, or hybrid scenario
- **Cost**, which can still rise above a businesses' tolerance if they lack the skillsets to manage its use despite clouds enabling use-based fee structures that can scale up and down



AMOUNT BUSINESS DATA GROWS EVERY YEAR



MAKING THE RIGHT CLOUD WORK FOR UTILITIES, O&G COMPANIES, AND OTHER ENERGY BUSINESSES

Gaining the benefits of cloud use and addressing its challenges hinge on creating smart partnerships that help build and execute risk-mitigating strategies. The right partner can enable an organization to go well beyond its current capabilities, including:

- Identifying and migrating to the right infrastructure scenario, ensuring the solution is right-sized, reducing repatriation risk, and mitigating the capital costs associated with on-premises use and expansion
- Segmenting, protecting, and automating data appropriately to improve data utilization and security (not all apps and processes are the same, some need more robust security or computational power)
- Providing an open and secure platform that creates more productive value chain partnerships and efficient internal processes
- Creating a flexible, future-proof framework that enables an organization to get ahead of and remain ahead of evolving markets, socio-economic upheavals, growing cybersecurity threats, and ever-changing global regulatory demands

Source: Amount Business Data Grows Every Year, Global, 2020



Growth is a journey. We are your guide.

For over six decades, Frost & Sullivan has provided actionable insights to corporations, governments and investors, resulting in a stream of innovative growth opportunities that allow them to maximize their economic potential, navigate emerging Mega Trends and shape a future based on sustainable growth.
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