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# Digital Wellsprings: How Intellectual Property Rights Power the Data-Driven Transformation of the Energy Industry

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**KEY POINTS**

- Deployment of AI, IoT, digital twins, and 5G-connected devices in oil and gas operations has shifted the industry's most valuable IP from hardware patents to AI models, proprietary datasets, and software platforms.
- Under U.S. law, there is no property right in raw operational data, making contractual allocation of data ownership, use restrictions, and post-termination obligations the primary mechanism for protecting oilfield data generated by IoT and connected devices.
- Energy joint ventures involving shared digital platforms and co-developed AI tools require explicit background IP identification, foreground IP allocation frameworks, and trade secret marking protocols to prevent ownership disputes.
- By October 2025, more than 66,000 active 5G patent families had been granted globally, and the energy sector — deploying 5G in wellhead controllers, pipeline sensors, and smart meters — now faces the same standard-essential patent (SEP) licensing exposure that reshaped the automotive industry in the early 2020s.
- Energy companies can manage 5G SEP risk through pre-deployment exposure assessments, SEP indemnification provisions in technology procurement contracts, evaluation of patent pool licenses such as Avanci, and active participation in standards-development organizations.

**ABSTRACT**

*The energy sector is undergoing a rapid digital transformation as operators deploy artificial intelligence (AI) for system optimization, internet of things (IoT) devices for real-time field monitoring, advanced drones and robotics for drilling and remote surveys, and high-fidelity digital models for predictive maintenance and asset integrity management. These technologies are reshaping upstream, midstream, and downstream operations by generating vast streams of data and enabling unprecedented analytical and operational capabilities.*

*This article examines how IP rights — specifically patents, trade secrets, and copyrights — apply to the digital transformation of the energy industry, with particular focus on the allocation of data ownership among operators, service companies, and technology vendors, and the emerging risk of standard-essential patent (SEP) disputes arising from the integration of 5G wireless connectivity into oilfield equipment. The article also provides a strategic roadmap for energy companies, oilfield service providers, and technology vendors seeking to protect, manage,*

*and monetize their digital innovations.*

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**SECTION I: INTRODUCTION**

The oil and gas industry has long rested on a technical foundation of physical engineering: deepwater drilling, high-pressure/high-temperature reservoirs, long-distance pipeline transmission, and complex refinery operations. Today a parallel infrastructure is taking shape: the digital transformation of every segment of the energy value chain. Operators are deploying AI to optimize production and reduce downtime, IoT sensor networks to monitor assets in real time, autonomous drones and robotics to perform inspections and surveys in hazardous environments, and digital twin platforms to simulate and manage the behavior of physical infrastructure.

Investment in data analytics and AI in the oil and gas sector alone is estimated to exceed $7.1 billion by 2026.[1] The global IoT market in oil and gas was valued at $2.3 billion in 2024 and is projected to reach $5 billion by 2034, growing at a compound annual growth rate (CAGR) of 8.1%.[2] The digital twins market in oil and gas, valued at approximately $138.69 million in 2024, is forecast to reach $911.72 million by 2032, representing a CAGR of 26.54%.[3]

These numbers reflect a structural shift in what forms of IP matter most in the industry. In prior generations, the most valuable IP in oil and gas consisted of patents covering downhole tools, completion techniques, seismic processing methods, and catalytic refinery processes. Today, a commercially significant innovation may be an AI model trained to predict equipment failures with 95% accuracy, a proprietary dataset of subsurface sensor readings accumulated over a decade, a software platform integrating operational data across dozens of facilities, or a control algorithm embedded in a 5G-connected wellhead device.

This article examines how patents, trade secrets, and copyrights apply to the digital transformation of the energy industry. It also addresses the emerging risk of SEP disputes arising from the integration of 5G wireless connectivity into oilfield equipment and energy infrastructure — a conflict that has already reshaped the mobile handset and automotive industries and is now moving into the industrial IoT space. The article provides a strategic roadmap for energy companies, oilfield service providers (OFS), and technology vendors seeking to protect, manage, and monetize their digital innovations.

**SECTION II: THE DIGITAL TRANSFORMATION OF THE ENERGY VALUE CHAIN**

## A. Upstream Operations

In upstream oil and gas — encompassing exploration, drilling, and production — digital technologies are driving efficiency gains and safety improvements that would have been difficult to anticipate a decade ago.

***AI and Machine Learning***

AI-driven analytics platforms are now being used to optimize drilling parameters in real time, predict reservoir performance, and manage production across large fields. Integrated sensor networks and AI systems can predict equipment failures, reducing downtime and boosting operational efficiency. Production downtime can cost oil and gas companies an average of $149 million per plant annually, or nearly $500,000 for every hour a facility is offline, making AI-driven predictive maintenance one of the highest-return investments available to operators.[4]

***Digital Twins***

A digital twin is a high-fidelity virtual replica of a physical asset or system, continuously updated with real operational data. In the upstream context, digital twins are being applied to drilling operations, where they act as real-time simulators that provide early warnings for issues such as drill bit wear or lost circulation.[5] In subsea environments and pipeline systems, digital twins enable predictive integrity management, helping operators identify corrosion, fatigue, and other failure risks before they result in costly incidents. The digital twin market for oil and gas is growing at a CAGR of approximately 26.54%.[6]

***Autonomous Drones and Robotics***

Remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and surface drones are being deployed for wellbore surveys, pipeline inspections, and facility security monitoring. These systems generate continuous streams of high-resolution imagery, acoustic data, and sensor readings that feed into AI-powered anomaly detection platforms.

***IoT Sensor Networks***

The deployment of IoT sensors across upstream operations enables continuous, real-time monitoring of wellhead pressures, temperatures, flow rates, and equipment health. The integration of these sensors with edge computing platforms enables rapid response to operational anomalies.

## B. Midstream Operations

In the midstream sector — which encompasses the transportation, storage, and conditioning of hydrocarbons — digital technologies are being applied to pipeline integrity management, compressor station optimization, and leak detection.

Digital twin platforms are being used to create virtual replicas of pipeline networks, enabling operators to simulate the effects of changes in pressure, flow rate, or temperature before implementing them in the field. AI-powered anomaly detection systems analyze acoustic sensor data and flow measurements to identify leaks and other integrity anomalies earlier than conventional inspection methods. IoT connectivity enables remote monitoring and control of compressor stations, reducing the need for personnel in remote or hazardous locations.

## C. Downstream Operations

Refineries, petrochemical plants, and liquefied natural gas (LNG) facilities represent some of the most complex industrial environments in the world. Digital twin technology has emerged as a significant tool in this sector, offering operators the ability to replicate, simulate, and optimize complex physical systems through high-fidelity virtual models.[7] In downstream operations, digital twins are being applied to reactor management, heat exchanger optimization, and process safety management. AI-driven process optimization platforms continuously adjust operating parameters to maximize yield and energy efficiency.

Proprietary digital platforms have become core enterprise infrastructure for downstream operators. The integration of these platforms with legacy distributed control systems (DCS) and safety instrumented systems (SIS) raises questions about IP ownership and data access rights addressed below.

## SECTION III: DATA OWNERSHIP AND CONTROL – THE CENTRAL LEGAL CHALLENGE OF THE CONNECTED OILFIELD

The deployment of IoT sensors, autonomous vehicles, and connected devices across global oil and gas infrastructure generates an immense and continuously growing stream of operational data. This data — which can include pressure readings, flow rates, equipment vibration signatures, inspection imagery, and emissions measurements — is valuable for operational optimization, predictive maintenance, regulatory compliance, and AI model training.

The legal framework governing the ownership and control of this data remains unsettled. Unlike patents or trade secrets, raw data generated by connected devices does not fit neatly into any existing IP category. Under U.S. law, there is no property right in raw data as such. The value of operational data is therefore protected — to the extent it is protected at all — through contract, through trade secret law where the data qualifies as a trade secret, and through access controls.

### A. The Operator-Vendor Data Relationship

In the typical oilfield digital services transaction, an operator deploys sensor equipment and connectivity infrastructure managed by an OFS company or technology vendor. The device generates data transmitted to a cloud platform operated by the vendor, which provides the operator with analytics, dashboards, and recommendations derived from that data.

This arrangement raises several questions that must be addressed in the governing service agreements:

- Who owns the raw data generated by the sensor device? The answer is not obvious. The device may be owned by the operator, but the communication protocols and transmission infrastructure may be provided by the vendor. In the absence of clear contractual allocation, disputes can arise.
- Can the vendor use the operator’s operational data to train AI models for other customers? Vendors routinely seek broad data rights to aggregate and anonymize customer data for model training. Operators are often reluctant to permit their proprietary operational data to contribute to products that will be used by competitors.[8] Service agreements must explicitly address these data use rights.
- Who retains the data after the service agreement terminates? Service agreements should specify data retention, return, and destruction obligations upon termination, particularly where the vendor has stored operator data in a proprietary cloud environment.

### B. IP Allocation in Joint Ventures and Multiparty Arrangements

The oil and gas industry conducts a significant portion of its upstream operations through joint ventures (JVs). As these structures increasingly involve shared digital platforms, joint data repositories, and co-developed AI tools, the question of IP ownership in new digital innovations becomes important.

Sound IP allocation in energy JVs addresses the following:

- Background IP: Each party’s pre-existing IP — including proprietary datasets, trained models, and patented technologies — should be identified and defined as background IP that remains solely owned by the contributing party. Cross-licenses of background IP should be limited in scope to the purposes of the JV and should not automatically extend to improvements or derivative works.

- Foreground IP: IP created in the course of the JV — including jointly developed AI models, sensor fusion architectures, or workflow methods — should be allocated pursuant to an agreed framework. Common approaches include joint ownership with clearly defined independent exploitation rights, sole ownership by the dominant inventive contributor, or ownership by a dedicated JV entity.
- Identifying and marking trade secrets: Identifying trade secrets clearly at the beginning of a joint venture minimizes the risk that JV partners will later claim to have contributed to their development or that the information is not valuable or secret.[9] Documents containing trade secret information should be consistently marked.
- Post-JV IP: The JV agreement should address ownership and revenue-sharing for post-venture IP monetization. In some cases a separate entity may be warranted to manage ongoing royalty arrangements.

**SECTION IV: THE 5G FRONTIER – STANDARD-ESSENTIAL PATENTS AND THE COMING WAVE OF ENERGY INDUSTRY IP DISPUTES**

## A. 5G and the Digitalization of Energy Infrastructure

The deployment of private 5G wireless networks in industrial environments — including oil refineries, offshore platforms, and pipeline infrastructure — is accelerating. 5G offers capabilities well-suited to the demands of energy operations: ultra-low latency for real-time control applications, massive machine-type communications (mMTC) for dense IoT deployments, and enhanced reliability for safety-critical applications. The energy sector has been identified as one of the top industries for private 5G deployments.[10]

As operators embed 5G wireless modules into field equipment — including wellhead controllers, compressor station automation systems, smart meters, and pipeline integrity sensors — they are necessarily implementing patented technologies essential to the 5G wireless standard. This creates exposure to SEP licensing demands that most energy companies have not yet confronted.

## B. What Are Standard-Essential Patents?

A standard-essential patent (SEP) is a patent that a patent owner has declared to a standards-development organization (SDO) — such as the European Telecommunications Standards Institute (ETSI), the Institute of Electrical and Electronics Engineers (IEEE), or the Third Generation Partnership Project (3GPP) — as being essential to the implementation of a technical standard. In exchange for the incorporation of their patented technology into the standard, SEP owners commit to license those patents on fair, reasonable, and nondiscriminatory (FRAND) terms.

The 5G standard is subject to an enormous and growing body of SEPs. By October 2025, more than 66,000 active 5G patent families had been granted globally, up from 53,000 in 2024.[11] By October 2024, 5G-related technical contributions to 3GPP surpassed 80,000 — an all-time high.[12] US SEP litigation has risen from 118 cases in 2014 to 223 in 2024, with Patent Assertion Entities (PAEs) now driving more than 40% of disputes.[13]

## C. The Migration of 5G Disputes Into Industrial IoT and Energy

The pattern of SEP licensing disputes has followed a predictable trajectory: first smartphones, then connected vehicles, and now industrial IoT. When 4G and 5G cellular modules began to be embedded in connected vehicles, automotive manufacturers found themselves subject to SEP licensing demands for which they were unprepared.

The Avanci patent pool was established to address this problem. Launched in 2020 to serve the automotive IoT market, Avanci aggregates 5G SEPs from multiple holders and offers unified licensing at fixed, transparent rates.[14] In March 2026, Avanci expanded into Wi-Fi SEP licensing with the launch of its Avanci Wi-Fi 6 Vehicle program, with Mercedes-Benz as the first licensee.[15]

The energy sector is now entering the same phase of SEP exposure that the automotive sector navigated in the early 2020s. A LexisNexis IP analysis of the role of SEPs for smart energy applications concluded: "Connectivity in the energy sector has the potential to fundamentally change the energy industry value chain. To cope with these challenges, the energy industry needs to face the complex licensing world of the telecommunications industry."[16] The analysis further observed that industries outside the smartphone world "have yet little experience with licensing SEPs."

Specific energy-sector IoT use cases identified in the SEP licensing landscape include smart metering, pipeline monitoring sensors, compressor station automation, and EV charging infrastructure. Avanci has already launched a dedicated platform for cellular connected smart EV chargers (Avanci EV Charger), signaling the SEP licensing ecosystem's movement into energy-adjacent use cases.[17]

## D. The FRAND Framework and Its Discontents

The FRAND commitment is designed to balance the interests of SEP holders in obtaining fair compensation with the interests of implementers in accessing standard technologies on commercially viable terms. In practice, FRAND negotiations are frequently contentious. Since most SDOs do not specify what constitutes FRAND terms, SEP holders and implementers face inherent challenges in reaching agreement.[18]

When FRAND negotiations fail, litigation follows. Courts in the U.S., UK, Germany, and China have all asserted jurisdiction to determine global FRAND rates.[19] The Unified Patent Court (UPC) issued its first SEP-related decision in September 2024, granting an injunction to Philips against Belkin. The Mannheim Local Division issued its first FRAND ruling in October 2024.[20]

## E. Strategic Responses for Energy Companies

Energy companies, OFS firms, and energy technology vendors can take several concrete steps to manage SEP exposure:

1. **Assess 5G SEP Exposure Before Deployment.** Before deploying 5G-connected field devices or signing long-term service agreements that include 5G connectivity, companies should conduct an SEP exposure assessment to identify the major SEP pools, the key holders, and the likely royalty costs associated with the intended use cases.
2. **Negotiate Data and SEP Provisions in Technology Procurement Contracts.** Service agreements and equipment purchase contracts should clearly allocate SEP licensing responsibility. Vendors that embed 5G modules in their products are often well-positioned to obtain licenses from relevant SEP pools and should warrant that their products are licensed for the operator's intended use case.
3. **Pursue Domain-Specific Patent Protection for 5G-Enabled Applications.** Energy companies and OFS firms that develop innovative applications of 5G technology — such as novel architectures for 5G-connected wellhead control systems or 5G-enabled pipeline integrity monitoring methods — should pursue patents on those domain-specific applications.
4. **Participate in Standards-Development Organizations.** Companies deploying 5G at scale in the energy sector

have strategic interests in the further development of industrial 5G standards, including the Release 18 and beyond 5G Advanced specifications targeted at industrial IoT use cases.[21] Active participation in SDOs allows energy-sector stakeholders to shape technical requirements, propose implementations that reflect operational realities, and, where patentable innovations result, declare SEPs and participate in the licensing ecosystem rather than simply be subject to it.

5. **Evaluate Patent Pool Participation.** The Avanci model has demonstrated that patent pools can efficiently resolve SEP licensing for industrial use cases. Energy companies implementing 5G-connected IoT at scale should evaluate whether a pool license provides a cost-effective pathway to licensing compliance.
6. **Develop FRAND Negotiation Capabilities.** When SEP licensing disputes arise, the FRAND framework provides certain negotiating constraints that implementers can leverage. Courts in the U.S. and UK have recognized that global portfolio licensing is standard industry practice and that FRAND-compliant licenses can be negotiated on a worldwide basis.[22]

**SECTION V: STRUCTURING AN IP STRATEGY FOR THE DIGITAL ENERGY ENTERPRISE**

## A. The IP Audit – Taking Stock of Digital Assets

The starting point for any effective IP strategy in the digital energy context is a comprehensive IP audit: an inventory of the company's existing digital assets and an assessment of how those assets are currently protected. Key questions include:

- What proprietary datasets does the company possess, and are they adequately protected by trade secret measures?
- What software platforms and AI models has the company developed or co-developed, and who owns the IP in those tools?
- What patents cover the company's proprietary technologies, and are there valuable innovations that remain unpatented?
- What third-party IP does the company rely upon, and are the relevant licenses adequately documented?
- What SEP exposure does the company have arising from its use of 5G, Wi-Fi, Bluetooth, and other standardized wireless technologies?

## B. Building a Patent Portfolio with Commercial Purpose

A patent portfolio is only valuable if it is aligned with the company's commercial strategy. For energy companies building digital capabilities, this means focusing patent investment on innovations that: (i) represent genuine competitive differentiators; (ii) are difficult to design around; (iii) can be detected in competitor products or services; and (iv) have broad applicability across the value chain or across multiple customer industries.

Broad claim coverage at the system level should be complemented by narrower, more specific claims at the implementation level that cover particular technical architectures, training methodologies, or sensor fusion approaches. This layered claiming strategy provides defense-in-depth and increases the commercial value of the portfolio.

## C. Monetization Pathways

Digital IP in the energy sector can be monetized through several pathways:

- Licensing: Energy companies and OFS firms with strong digital patent portfolios can generate licensing revenue by offering nonexclusive licenses to operators, technology vendors, or companies in adjacent industries.

- Joint development and technology transfer: Collaborative R&D arrangements can allow energy companies to leverage their operational expertise and proprietary data to co-develop commercially valuable digital tools, with carefully negotiated IP ownership and licensing terms.
- Platform development: OFS companies and technology vendors that develop proprietary digital platforms can build durable competitive positions if the underlying IP is effectively protected and the platform creates switching costs or network effects for customers.
- Defensive use: A strong patent portfolio provides defensive value in the event of IP disputes with competitors or PAEs, enabling cross-licensing negotiations and reducing the risk of injunctive relief.

**SECTION VI: CONCLUSION**

The digital transformation of oil and gas operations has changed what IP assets matter most. Patents on downhole hardware and refinery chemistry remain important, but the innovations generating competitive advantage today — predictive AI models, proprietary operational datasets, integrated digital twin platforms, and 5G-connected control systems — require a different kind of IP attention.

Three issues warrant particular focus. First, the contractual allocation of data rights among operators, service companies, and technology vendors is still handled inconsistently across the industry. Companies that do not address data ownership, use restrictions, and post-termination obligations explicitly in their service agreements are accepting legal and commercial risk that is avoidable. Second, trade secret protection for AI models and operational datasets is only as durable as the access controls, confidentiality agreements, and data governance practices that support it. Third, 5G SEP exposure is no longer a future concern — the licensing infrastructure that reshaped the automotive sector is already expanding into smart meters and EV charging, and energy-sector field equipment is a logical next target.

Companies that treat IP strategy as a routine part of their digital investment decisions — rather than an afterthought — will be better positioned to protect what they build, negotiate from strength, and avoid the disputes that arise when rights are left undefined.

For questions about IP strategy in the energy sector, data ownership agreements, SEP licensing exposure, or patent portfolio development, contact Troutman Pepper Locke's Intellectual Property Practice Group or Energy + Infrastructure Practice Group. Our attorneys advise operators, oilfield service providers, and technology vendors on the full spectrum of IP issues arising from the digital transformation of the energy value chain.

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**FOOTNOTES**

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