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**Technical and economic performance of multilateral drilling on Russia's Arctic shelf with evidence from Siberian fields**

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**Abstract.** The liquids output of Russia is mainly in the Siberian basins with extra resources on the Arctic shelf. The conditions in these areas are difficult from both a technical and logistical perspective, which affects both well design and field planning. The study determines the case where multilateral wells offer better technical and economic performance in this situation. A PRISMA 2020 guided systematic review included English and Russian sources published between 2017 and 2025. Databases included Scopus, Web of Science, One Petro, Science Direct, eLIBRARY ru, and CyberLeninka. Economic results were standardised by price year and discount rate. Results indicate that multilateral wells are technically feasible at high latitude. Best outcomes occur when placement is accurate, junction integrity is reliable, branch level surveillance is active, and learning reduces drilling time. Economic performance improves when production targets are met with fewer surface sites and when monitoring delays costly water handling. Value is most sensitive to oil prices, water breakthrough timing and junction reliability. Post COVID shifts in markets and logistics increased the benefit of concentrating output per site and staging decisions. Recommendations follow directly from these results. Deploy multilaterals only where junction integrity and branch diagnostics can be assured. Start with a focused pilot, quantify learning, and scale after cycle time and variance decline. Standardise economic appraisal and stress test price paths, water timing, and integrity. Mitigate Arctic logistics risk through prepositioned inventories and schedules aligned to ice and weather windows.

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**Keywords:** multilateral wells, Russia's Arctic shelf, West Siberia, technoeconomic performance, junction integrity, intelligent well surveillance, learning curves

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**Анализ эффективности многостворного бурения на российском арктическом шельфе на примере месторождений Западной Сибири**

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*Аннотация.* Добыча жидких углеводородов в России осуществляется в основном в сибирских бассейнах с дополнительными ресурсами на арктическом шельфе. Условия в этих районах сложные как с технической, так и с логистической точки зрения, что влияет как на проектирование скважин, так и на планирование месторождений. Исследование определяет случаи, когда многоствольные скважины обеспечивают лучшие технические и экономические показатели в данной ситуации. Систематический обзор PRISMA 2020 включал английские и русские источники, опубликованные в период с 2017 по 2025 год. Были задействованы такие базы данных, как: Scopus, Web of Science, OnePetro, ScienceDirect, eLIBRARY.ru и CyberLeninka. Отбор и анализ данных осуществлялись по структурированному шаблону. Экономические результаты были стандартизированы по ценовому году и ставке дисконтирования. Результаты показывают, что многоствольные скважины применимы в различных вариантах. Наилучшие результаты достигаются при точном размещении, надежности соединений, активном контроле на уровне ответвлений и сокращении времени бурения за счет накопления опыта. Экономические показатели улучшаются, когда производственные цели достигаются с меньшим количеством наземных объектов и когда мониторинг позволяет избежать затратного водоснабжения. Стоимость наиболее чувствительна к ценам на нефть, срокам прорыва воды и надежности соединений. Исследования показали, что применять многоствольные скважины можно только там, где гарантированы целостность соединений и мониторинг проводки ответвлений. Следует начать с целенаправленного пилотного проекта, количественно оценить полученные знания и масштабировать после сокращения цикла и снижения отклонений. Затем необходимо стандартизировать экономическую оценку и стресс-тесты ценовых траекторий, сроков подачи воды и целостности, а также снизить логистические риски в Арктике за счет заранее размещенных запасов и графиков, согласованных с ледовыми и погодными условиями.

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*Ключевые слова:* многоствольные скважины, арктический шельф России, Западная Сибирь, технико-экономические показатели, целостность соединений, интеллектуальный мониторинг скважин, кривые обучения

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## **Introduction**

Russia remains a systemically important oil producer in the global energy economy, with liquids output that has consistently ranked among the top three worldwide [1]. In 2021, Russian crude and condensate production averaged about 10.5 million barrels per day, roughly 14 percent of global supply [2]. This production is geographically concentrated in West and East Siberia with additional resources on the Arctic shelf [3]. West Siberia is the country's core liquids province and the source of the Urals export blend. Offshore Arctic production is far less mature [4]. As of 2023, Gazprom Neft's Prirazlomnoye field in the Pechora Sea was the only Russian Arctic offshore project in commercial operation [5].

The COVID period and its aftermath created two distinct operating contexts for Russian upstream activities. In 2020, the demand shock associated with the pandemic precipitated unprecedented OPEC plus cuts, including a Russian commitment to reduce crude output by almost two million barrels per day [6]. Output partially recovered in 2021 but the post-2022 environment introduced sanctions, changing trade routes and price caps that altered investment conditions and logistics [6]. Official and agency data indicate that Russian crude output in 2024 averaged about 9.2 million barrels per day on an EIA definition, down from 9.6 million barrels per day in 2023, while broader crude plus condensate statistics reported by authorities show a decline of about 2.8 percent to 516 million tons [7]. Export destinations shifted toward Asia between 2021 and 2024, with China and India absorbing the majority of crude shipments as Europe reduced purchases [8].

Against this backdrop, operators in Siberia and on the Arctic shelf face a persistent technical and economic challenge [9]. Mature onshore reservoirs and remote offshore settings require higher recovery factors, tighter surface footprints per unit of production, and improved capital efficiency under severe climatic and logistical constraints [10]. Multilateral well architectures have been advanced in Russia as one response. Since 2018, case material from the Novoportovskoye field on the Yamal Peninsula documented the planning and execution of multiple TAML-classified branches [11]. This includes the nation's first quadruple multilateral, with reported improvements in drainage and construction efficiency relative to single laterals. Subsequent Siberian applications have emphasized intelligent surveillance to manage inflow from separate branches, including marker-based monitoring deployed during well reconstructions that preserved production on the parent bore while adding horizontal sidetracks [12]. Collectively, this engineering trajectory suggests an opportunity for multilateral designs to deliver higher initial rates, better sweep in thin oil rims, and fewer slots or wellheads for a given production target. The countervailing risks include junction integrity, completion complexity, water breakthrough management, and cost transparency, particularly in ice-window operations offshore.

Despite the strategic importance of these decisions, there is no consolidated synthesis that evaluates both technical performance and project economics of multilateral drilling in Russia's Arctic shelf and Siberian provinces using post-2017 evidence [13]. Public reporting is fragmented across conference proceedings, operator notes, trade press, and agency datasets, and the pandemic and sanctions periods complicate cross-study comparisons of costs and productivity. This study addresses that gap through a systematic review of peer-reviewed and

practitioner sources in English and Russian from 2017 onward, with an explicit focus on measurable performance indicators.

### **Study methods**

This study employs a systematic review design reported in line with PRISMA 2020. We searched Scopus, Web of Science, OnePetro, ScienceDirect, eLIBRARY ru, and CyberLeninka for records published from January 2017 to October 2025 in English and Russian. Search strategies combined terms for multilateral wells, Arctic or Siberia, and technical or economic performance, with database specific Russian synonyms. Eligible studies examined multilateral interventions of any TAML level in Arctic shelf or Siberian fields and reported technical and or economic outcomes, with single lateral wells used as comparators where available. Two reviewers screened titles and abstracts, completed full text assessments, reconciled disagreements, and collated multiple reports from the same project to avoid double counting. The study extracted field context, well architecture, drilling and completion metrics, production and water management results, surveillance methods, unit costs, and investment criteria such as net present value and internal rate of return, and contacted authors when key data were missing. Study quality was appraised with Joanna Briggs Institute tools, augmented with items on data completeness and cost transparency. Findings were synthesized narratively, with random effects models applied where metrics were commensurate, and economic results were harmonized to a common price year and Brent price assumptions under CHEERS guidance, with all logs, extraction sheets, appraisal forms, and code archived as supplementary materials.

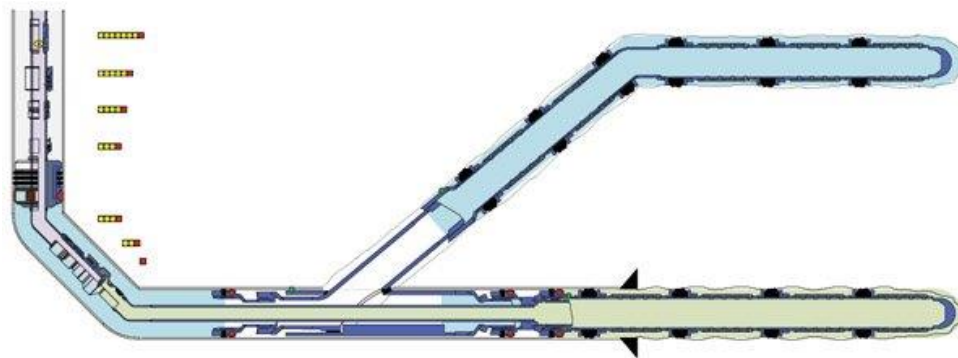
### **Theoretical framework (Techno-economic systems framework)**

This study adopts a techno-economic systems view in which multilateral architecture increases effective reservoir contact and stabilizes inflow, thereby improving recovery per surface slot and unit development cost when integrity and control are ensured. Reliability theory anchors the role of junction quality because junction integrity and branch isolation condition whether added laterals deliver sustained production rather than early water or gas entry [14]. Information economics explains how intelligent surveillance and control reduce allocation uncertainty across branches and preserve productive operating regimes through timely diagnostics and interventions [15]. Learning curve theory links program experience to drilling time and cost reductions, with evidence of measurable performance gains in recent offshore and onshore campaigns [16]. Real options thinking motivates staged branch additions, flow reallocation and intervention timing under uncertainty and offers a more realistic valuation than static

net present value for Arctic and Siberian projects [17]. Arctic logistics and supply chain resilience further shape cost levels and variance, so the value of higher per well productivity and fewer slots rises where transport and weather risks are material [18]. The integrated expectation is that multilaterals outperform single laterals in these settings when junction reliability is high, surveillance is available, and learning effects are captured [19]. This proposition consistent with Russia specific cases such as Novoportovskoye and Prirazlomnaya.

### Technical performance

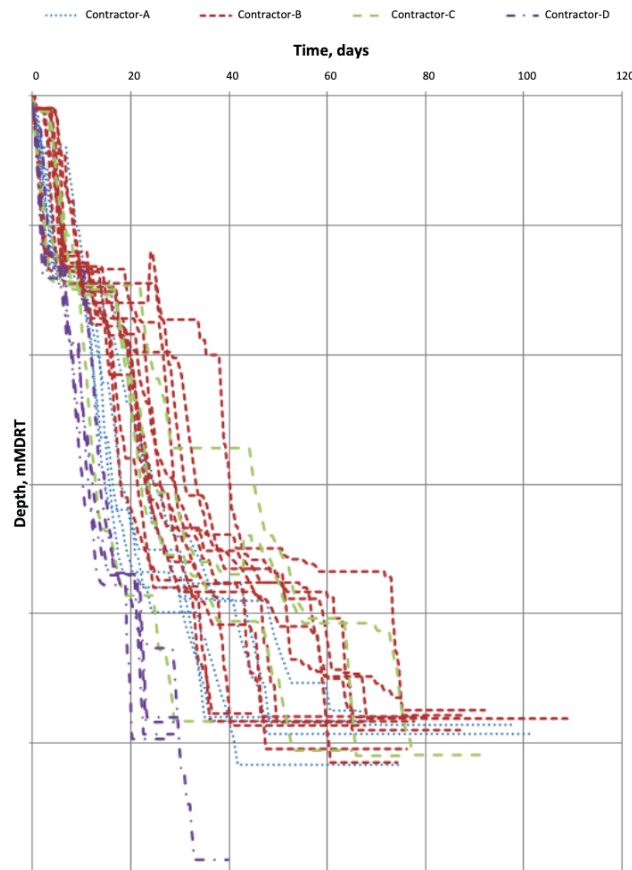
Technical performance describes the extent to which multilateral architecture improves measurable engineering outcomes in Arctic and Siberian settings [20]. It considers drilling efficiency expressed as meters advanced per day and days required per thousand meters, as well as the incidence and duration of non-productive time [21]. It also evaluates placement quality through the share of total footage landed within the intended reservoir intervals and the consistency of geosteering decisions relative to structural and facies models. Completion integrity is central because junction quality and hydraulic isolation determine whether additional laterals convert contact potential into sustained flow, rather than precipitating early ingress of unwanted fluids [22].



*Fig. 1. First intelligent multilateral TAML5 wells on the V. Filanovsky Field [29]*  
*Рис. 1. Первые интеллектуальные многосторонние скважины TAML5 на месторождении им. В. Филановского [29]*

Branch inflow stability then serves as a practical indicator of sound design and appropriate pressure management across laterals [23]. Production outcomes are read in two horizons. Initial rates reflect early contact efficiency and effective drawdown strategy, while average rates over defined periods and decline parameters reveal connectivity, pressure support and the timing of water entry [24]. Modern surveillance strengthens each of these judgments. Fiber optic diagnostics and marker based methods enable branch level allocation, rapid detection of adverse fluid trends, and informed adjustments to operating mode [25]. Learn-

ing by doing further improves performance as teams iterate on trajectory design, junction construction and completion sequencing.



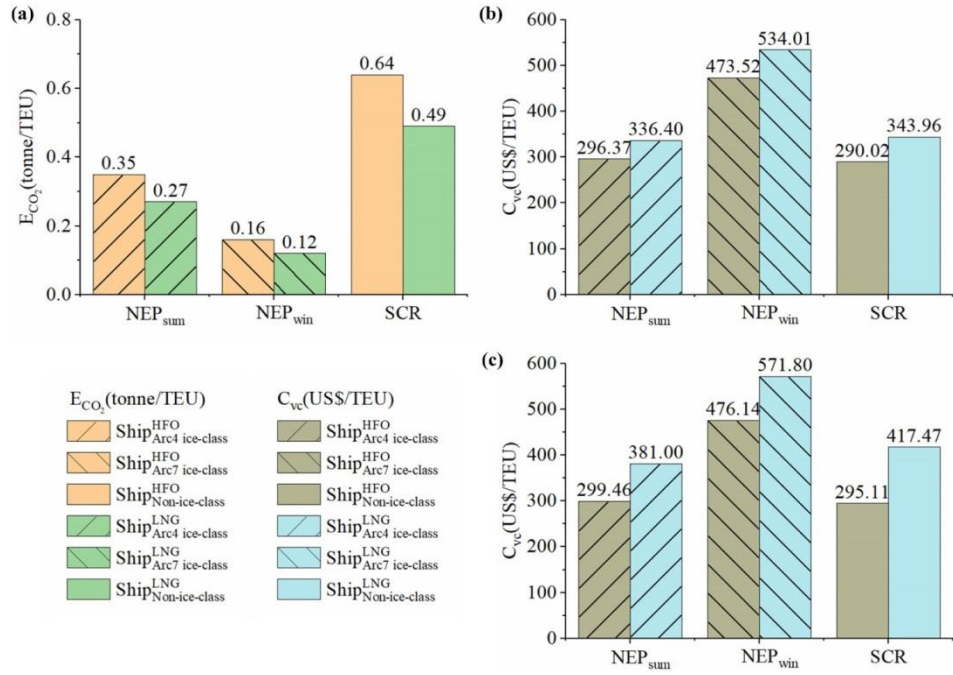
*Fig. 2. Technical drilling performance (max depth 2500 mTVD wells) [32]*  
*Рис. 2. Технические характеристики бурения (максимальная глубина скважин TVD 2500) [32]*

Programme execution and batch operations shorten cycle times and compress variability, which is crucial where weather and ice windows constrain activity [26]. Evidence from both onshore Siberia and the Arctic shelf shows that complex multilateral wells can be executed within these limits while achieving high footage in target and stable inflow when surveillance and control are embedded in the work plan [27]. Taken together, these elements define technical performance as the coordinated achievement of accurate placement, durable integrity, reliable monitoring, and progressive learning.

### **Economic performance**

Economic performance evaluates whether technical advantages convert into superior value at the project level under Arctic and Siberian constraints [30].

It begins with unit well cost and development cost per barrel, reported on a consistent price year and with an explicit statement of perspective and discounting. It then accounts for operating cost shifts that arise when a production target is achieved with fewer surface locations and fewer completions. Investment criteria such as net present value, internal rate of return, and payback time translate engineering outcomes into financial results that can be compared across alternatives and scenarios [31].

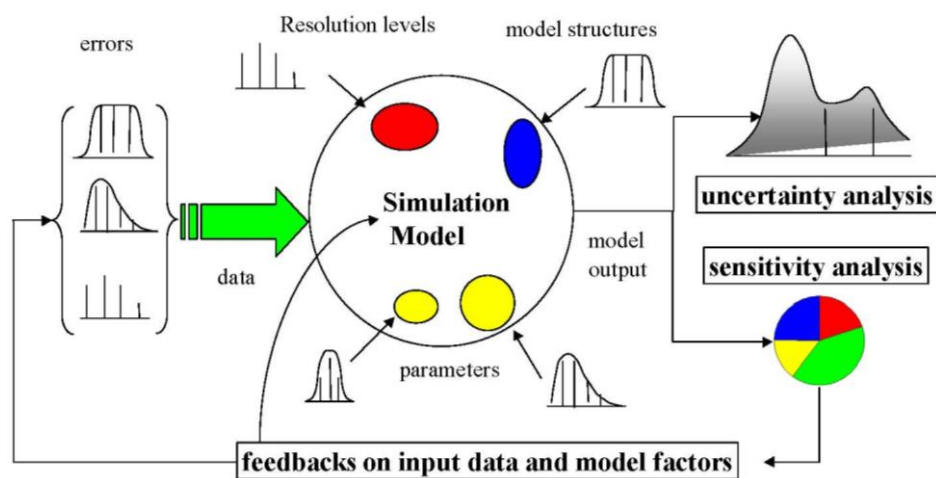


**Fig. 3.** The USE for CO<sub>2</sub> and USC per trip before and after the onset of the RUC. (a) The USE for CO<sub>2</sub> per trip of LNG- and HFO-fueled vessels (summer and winter in the graph refer to August 2022 and January 2023, respectively). (b) The USC per trip before the RUC. (c) The USC per trip after the onset of the RUC (before-RUC and after-RUC are from February 2021 to February 2022 and from February 2022 to January 2023, respectively) [33]

**Рис. 3.** USE для CO<sub>2</sub> и USC на рейс до и после введения RUC. (a) USE для CO<sub>2</sub> на рейс судов, работающих на СПГ и мазуте (лето и зима на графике относятся к августу 2022 г. и январю 2023 г. соответственно). (b) USC за рейс до введения RUC. (c) USC за рейс после введения RUC (до введения RUC и после введения RUC — соответственно с февраля 2021 года по февраль 2022 года и с февраля 2022 года по январь 2023 года) [33]

In this context, uncertainty treatment is not a formal add on but a core requirement, since price paths, logistics conditions and seasonal schedules shape both costs and timing [33]. Learning effects observed in drilling and completion reduce expected days and narrow schedule dispersion, which lowers exposure to interruption and improves the credibility of cost forecasts [34]. Surveillance that

provides timely diagnostics and branch level control protects drawdown, delays expensive water handling, and stabilizes operating cash flows. Portfolio studies consistently show that the relative advantage of multilateral programs rises as slot costs increase, as logistics premia grow with distance and climate, and as per well productivity gains become more reliable through better placement and completion [34]. Design choices regarding branch count and branch length change both the level and the timing of cash flows, while completion choices influence integrity risks that carry potential penalties if failures occur [35]. Real options thinking adds value by recognizing that branch additions and interventions can be staged as new information arrives, which improves decision quality in volatile contexts. Sensitivity analysis then clarifies which uncertainties dominate the economics in a given field, with price assumptions, water breakthrough timing, and junction reliability often emerging as the leading drivers [36].



*Fig. 4. Sensitivity analyses [36]*  
*Рис. 4. Анализ чувствительности [36]*

When these practices are combined within a transparent reporting frame, the economic case for multilateral architecture becomes both rigorous and comparable across projects.

#### **Integrated technoeconomic performance with Siberian evidence**

An integrated view connects specific engineering levers to financial outcomes within the operational realities of Siberia and the Arctic shelf. Branch count and branch length increase contacted volume and typically raise early time production, but this potential becomes durable only when junction integrity and hydraulic isolation are achieved [14]. Completion design interacts with reservoir heterogeneity to balance inflow across laterals and to manage pressure drawdown in a way that moderates coning and cross flow [17, 22]. Surveillance

quality determines how quickly and accurately operators detect deviations from expected behavior, and how confidently they can adjust choke settings, inflow devices, or lift strategies to restore favorable conditions. Learning in drilling and completion reduces cycle times and narrows uncertainty bands for both schedule and cost, while logistics reliability programs reduce the probability and impact of weather and transport disruptions along long northern supply lines [16]. These pathways do not act in isolation. They combine to shift the expected level of operating cash flows and to compress their variance, which in turn reshapes the distribution of net present value and internal rate of return. Siberian practice offers concrete illustrations of this logic [22, 23]. Reconstruction campaigns that add laterals while maintaining production on the parent bore show the importance of careful sequencing and reliable junction work [37]. Marker supported operating mode selection demonstrates how information can preserve drawdown and delay costly water handling [35]. Offshore examples confirm that multilateral geometries expand reservoir contact from a single surface location, which supports slot minimization and improves cost per barrel when integrity is maintained. Under conditions where integrity is consistent, surveillance is active, learning is captured, and logistics are stabilized, multilateral programs frequently outperform single lateral programs in both value and resilience [34]. The integrated concept therefore recommends simultaneous attention to placement, integrity, monitoring, learning and logistics, together with valuation methods that price flexibility and accommodate evolving information.

### **Conclusion**

This review synthesized post 2017 evidence on the technical and economic performance of multilateral drilling on Russia's Arctic shelf and in Siberian basins using a PRISMA guided approach and a techno-economic systems framework that integrates reliability, information, learning, real options, and Arctic logistics. The evidence shows that multilateral designs are feasible in high latitude settings and can achieve high footage in target, stable inflow across branches, and execution within weather and ice windows when placement accuracy, junction integrity, and branch level surveillance are jointly ensured. Relative to single laterals, programs that reduce slot count while expanding reservoir contact tend to lower unit development cost and improve investment indicators such as net present value, internal rate of return, and payback, especially where logistics premia and surface constraints are material. Sensitivity analyses identify price paths, water breakthrough timing, and junction reliability as dominant economic drivers, which underscores the value of disciplined monitoring and integrity management. Before COVID, expansion strategies relied on established export routes and service availability, while the post COVID period and subsequent policy constraints shifted market access and supply chains. This thereby increasing the premium on designs that deliver more output per surface site and allow staged decisions as information improves. In relation to the objectives, the

study finds that technical performance is strongest when placement, integrity, surveillance, and program learning align, that economic performance is favorable when fewer wells achieve the target and surveillance protects drawdown, and that moderating conditions linked to logistics and markets after COVID further strengthen the relative case for multilateral deployment in Siberia and on the Arctic shelf.

### **Recommendations**

Based on the study's findings, these recommendations are directed primarily to operating companies and field development planners responsible for Arctic shelf and Siberian assets. Secondary audiences are asset economists and project finance teams, service companies and technology providers, and relevant regulators and research teams. Deploy multilateral wells only where junction integrity and branch level surveillance are assured, since these conditions produced the strongest technical outcomes. Sequence developments to maximise output per site and reduce slot count, because programs that achieved targets with fewer wells delivered lower unit costs and stronger returns. Start with a well-defined pilot and measure the learning effects, then expand only when the drilling time and variance have shown continuous reductions. Use a fixed price year and discount rate to standardize the economic appraisals and carry out the stress tests on the price paths, water breakthrough timing, and junction reliability. Reduce the risk of Arctic logistics by pre-stocking the inventories and coordinating the schedules with the ice and weather windows.

### **Authors' contributions**

All authors contributed equally to the preparation of the manuscript.

### **Вклад авторов**

Все авторы внесли равный вклад в подготовку публикации.

**Conflict of interests.** The authors declare no conflicts of interest.

**Конфликт интересов.** Авторы заявляют об отсутствии конфликта интересов.

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