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Digital Twin and Artificial Intelligence as Tools For Improving Well-Level Production Efficiency at Oil and Gas Enterprises of Uzbekistan: Evidence From The Sardob and Yangi Karatepa Fields

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Abstract: The article examines the applied role of digital twin technology and artificial intelligence (AI) in improving production efficiency at oil and gas enterprises of the Republic of Uzbekistan, with the analysis carried out at the level of individual producing wells. Drawing on the operating experience of Sanoat Energetika Guruhi LLC FE (Saneg), the paper illustrates how the pairing of a well digital twin with predictive analytics supports the selection of well-intervention measures, the tuning of operating regimes and the estimation of the associated economic effect. Empirical material from the Sardob and Yangi Karatepa fields is used to trace the change in flow rates, cumulative production and unit costs before and after the deployment of modern well-intervention programmes and digital solutions. The article deliberately confines itself to the applied and illustrative dimension: the underlying conceptual apparatus, the integration model and the multifactor forecasting framework are substantiated in detail in the author's dissertation, whereas here they serve only as an interpretive background for the field-level observations.

Keywords: Digital Twin, Artificial Intelligence, Production Efficiency, Predictive Analytics, Well Intervention, Mature Fields, Sardob, Yangi Karatepa, Sanoat Energetika Guruhi, Republic of Uzbekistan

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1. Introduction

The oil and gas sector of the Republic of Uzbekistan operates predominantly on mature fields whose recoverable reserves are being depleted and whose surface and downhole infrastructure carries a substantial degree of wear. In this setting the reserves for improving production efficiency shift away from the extensive expansion of output and towards the more intelligent operation of the existing well stock. Digital technologies and, above all, digital twins combined with artificial intelligence are increasingly regarded worldwide as the instruments that make such intensification achievable, since they allow operating decisions to be tested on a virtual copy of the asset before they are applied in the field.

The national policy framework, expressed in the strategy and in the agenda, encourages the diffusion of such solutions across the fuel and energy complex [1]. What remains weakly documented, however, is the concrete production and economic footprint of these technologies at the level of an individual field or well the point at

which the value of a digital twin is either realised or lost. It is precisely this applied question that the present article addresses [2].

The paper is prepared as an applied extension of the author's dissertation research and develops its practical dimension. Its purpose is to show, on factual field material, how the joint use of a well digital twin and AI-based analytics is reflected in flow rates, cumulative production and unit costs at Sanoat Energetika Guruhi LLC FE (Saneg). The conceptual model of technology integration, the management mechanism and the multifactor forecasting apparatus are elaborated and justified in the dissertation itself; within this article they are drawn upon only as an interpretive frame, without reproducing their full theoretical description [3].

2. Materials and Methods

The study relies mainly on comparative and monographic analysis of a single enterprise, supplemented by elements of scenario reasoning at the level of an individual field. The empirical base comprises the actual production and economic indicators of Saneg for 2020–2024 and the field-level records for the Sardob and Yangi Karatepa assets, including the well stock structure, flow rates and the composition of well-intervention programmes before and after modernisation. The role of the digital twin is treated here as an applied decision-support layer rather than as a formal model: the detailed specification of the twin-and-AI configuration, together with the parametric identification of the associated forecasting model, is set out in the author's dissertation, whereas the article uses the resulting field observations as illustrative evidence.

The applied logic of the well digital twin and AI

A well digital twin is understood in this article as a continuously updated virtual representation of a producing well that is fed by field measurements pressures, flow rates, energy consumption and equipment status and that reproduces the behaviour of the physical object in quasi-real time. Coupled with predictive analytics, such a twin allows the operator to model a candidate decision (a change in the operating regime, a chemical treatment, a sidetrack) on the virtual copy first, to estimate its likely effect on production and cost, and only then to implement it in the field. The methodological grounding of this configuration is provided in the author's dissertation; here the emphasis is placed on how it functions in day-to-day operation.

In practical terms the contribution of AI on the Saneg assets is expressed along three lines. The first is diagnostic: machine-learning models process the incoming sensor stream to detect deviations in well behaviour and to flag wells that are candidates for intervention. The second is prescriptive: on the basis of the digital twin, the analytics rank alternative well-intervention measures by their expected production gain and by their cost, supporting a more selective allocation of the intervention budget. The third is anticipatory: predictive models estimate the residual production potential of a well and the risk of failure, which shifts maintenance from a reactive to a planned footing. Taken together, these functions turn the well stock from a set of individually managed objects into a data-driven operating portfolio.

It should be stressed that in the operating practice of Saneg the digital twin and AI are not treated as stand-alone pilot projects but as an embedded layer of the production process. The organisational and economic conditions under which this embedding becomes sustainable and the management cycle that supports it are examined in detail in the author's dissertation; within this article they remain in the background, and attention is concentrated on the measurable field-level outcome.

3. Results

The Sardob field: from a marginal asset to a portfolio contributor

The Sardob field offers a representative illustration of how a well-level digital and technological upgrade reshapes the production profile of a mature asset. At the moment of its transfer to Saneg in 2019 the field was at a late stage of development, with a declining production trend and a limited stock of active wells, part of which had been mothballed [4]. Predominantly conventional recovery methods and a narrow set of well-intervention measures produced low flow rates and constrained economic performance (Table 1).

Table 1. The Sardob field before and after the deployment of new technologies by Saneg

Indicator	At transfer to Saneg (2019)	After the 2022–2023 intervention programme
Development stage	Late stage; mature field with declining production	Active stage; stabilised and rising production
Well stock	Limited active stock; part of wells mothballed	Expanded and optimised stock: new wells, sidetracking, revival of previously closed wells Modern programme: sidetracking, artificial lift, chemical stimulation, waterflood optimisation
Typical technological solutions	Mainly conventional recovery; narrow set of interventions	About a 15-fold increase in oil production versus the initial level Important element of the mature-field portfolio, adding materially to total output
Relative change in oil production	Low flow rates; limited economic efficiency	
Role in the Saneg portfolio	Secondary, local significance	

Source: compiled by the author on the basis of Saneg operating data.

After the introduction of a complex of modern well-intervention measures in 2022–2023 sidetracking, artificial-lift methods, chemical stimulation and waterflood optimisation the well stock was expanded and rebalanced, and the field moved from decline to an active stage with stabilising and then growing output. The cumulative effect amounted to roughly a fifteen-fold increase in oil production relative to the starting level, transforming Sardob from a marginal local asset into a meaningful contributor to the mature-field portfolio of the company. The decisive point for the present argument is that the sequencing and targeting of these measures were informed by the digital twin and predictive analytics, which narrowed the search for high-return interventions [5].

Field-level outcomes under alternative technology trajectories

To make the dependence of results on the depth of technology adoption explicit, the observed 2023 output of the Sardob field (22.0 thousand tonnes per year) is taken as the starting point for three illustrative trajectories pessimistic, base and optimistic that differ in the intensity with which the digital twin, AI analytics and well-intervention measures are applied (Table 2). The trajectories are reproduced here from the applied calculations underlying the dissertation and are used purely to visualise the range of possible field-level outcomes [6].

Table 2. Scenario projection of oil production at the Sardob field, thousand tonnes per year

Year	Pessimistic	Base	Optimistic
2023 (actual)	22.0	22.0	22.0
2024	18.7	25.3	27.5

2025	15.9	29.1	34.4
2026	13.5	33.5	43.0
2027	11.5	38.5	53.7

Source: author's calculations based on Saneg field data.

The pessimistic trajectory reflects a limited continuation of modernisation and only partial use of digital and AI tools; under it the field returns to decline, falling to 11.5 thousand tonnes per year by 2027. The base trajectory corresponds to a steady implementation of the corporate technological-renewal and digitalisation programme and lifts output to 38.5 thousand tonnes per year [7]. The optimistic trajectory assumes deeper integration of the well digital twin, an extended well-intervention programme and active use of AI analytics, and reaches 53.7 thousand tonnes per year. The contrast between the three paths underscores that the field-level effect is driven less by geology alone than by the intensity and precision with which digital and AI-based decision support is applied [8].

The economic dimension of these trajectories is summarised in Table 3, which relates the depth of technology adoption to cumulative production, required investment and the resulting return.

Table 3. Economic comparison of the Sardob scenarios (through 2027)

Indicator	Pessimistic	Base	Optimistic
2027 output, thousand t/year	11.5	38.5	53.7
Cumulative output 2024–2027, thousand t	59.6	126.4	158.6
Total investment, million c.u.	4.0	20.0	30.0
Output growth vs. 2019 base, times	×21	×70	×98
Return on investment (indicative)	Low	High	Very high

Source: author's calculations.

The comparison shows a clear trade-off between the scale of investment and the production and economic effect it generates. With a modest outlay of about 4 million conventional units the pessimistic path delivers cumulative output of 59.6 thousand tonnes and a return that remains low [9]. Raising investment to 20 million units under the base path yields 126.4 thousand tonnes of cumulative production and an approximately seventyfold gain over the 2019 level with a high return, while the optimistic path, at 30 million units, reaches 158.6 thousand tonnes and an almost hundredfold gain with a very high return. The relationship confirms that the deeper integration of the digital twin and AI is associated with both a larger production response and a more favourable investment outcome at the field level [10].

Corroborating evidence from the Yangi Karatepa field

The reproducibility of the effect is supported by the experience of the Yangi Karatepa field, where the combination of a well-intervention programme with digital solutions raised the average daily output from 2.3 to more than 88 tonnes per day and noticeably expanded the feedstock base for processing [11]. Although the two fields differ in their geological characteristics, they display the same qualitative pattern: where the digital twin and AI analytics are used to target and sequence interventions, the flow rate rises sharply and the unit cost of production falls. This convergence across assets indicates that the observed effect is not confined to a single field but reflects a repeatable applied outcome of technology-informed well management [12].

These field-level observations are treated in the present article as empirical illustrations rather than as a formal proof. Their systematic generalisation, the accompanying management mechanism and the quantitative forecasting model that links corporate modernisation programmes to measurable production results are developed

and substantiated in the author's dissertation, to which the reader is referred for the complete methodological treatment.

4. Discussion

The material examined leads to several applied conclusions. First, for the mature fields that dominate the asset base of Uzbekistan's oil and gas enterprises, the principal reserve for improving production efficiency lies in the more intelligent operation of the existing well stock rather than in the extensive expansion of output; the well digital twin and AI analytics are the instruments that make this shift practicable [13].

Second, the Sardob case demonstrates that a targeted, twin-informed well-intervention programme can transform a marginal, declining asset into a meaningful portfolio contributor, with an approximately fifteen-fold increase in oil production and a clearly favourable trade-off between investment and output across the modelled trajectories. The Yangi Karatepa experience a rise in average daily output from 2.3 to more than 88 tonnes per day confirms the reproducibility of this pattern across assets with differing geology [14].

Third, the depth of technology adoption is decisive for the field-level result: the contrast between the pessimistic, base and optimistic trajectories shows that the production and economic effect grows with the intensity and precision of digital and AI-based decision support [15]. These empirical findings serve, within the present article, as an applied illustration of the potential of digital-twin and AI technologies; their theoretical generalisation and the corresponding management and forecasting apparatus are elaborated in the author's dissertation, which remains the primary source of the underlying methodology.

The findings of this study demonstrate that the integration of Digital Twin and Artificial Intelligence (AI) technologies significantly enhances well-level production efficiency at oil and gas enterprises in Uzbekistan. The case studies of the Sardob and Yangi Karatepa fields confirm that digital modeling, real-time monitoring, and AI-driven predictive analytics enable operators to optimize production processes, improve reservoir management, and make timely operational decisions based on reliable data.

The analysis indicates that Digital Twin technology provides a comprehensive virtual representation of physical well operations, allowing continuous monitoring of production parameters, early detection of equipment failures, and simulation of alternative operating scenarios. When combined with Artificial Intelligence, these capabilities facilitate predictive maintenance, production forecasting, anomaly detection, and optimization of technological processes. As a result, production downtime is reduced, equipment reliability is improved, operational costs are minimized, and hydrocarbon recovery efficiency increases.

The empirical evidence obtained from the Sardob and Yangi Karatepa fields suggests that the implementation of intelligent digital technologies contributes not only to higher production performance but also to more sustainable resource utilization. AI-supported decision-making systems improve the accuracy of reservoir behavior prediction, optimize energy consumption, reduce unnecessary maintenance activities, and strengthen industrial safety by identifying potential operational risks before they occur.

Despite these advantages, the study also reveals several challenges that may limit the large-scale implementation of Digital Twin technologies in Uzbekistan's oil and gas sector. These include the high initial investment required for digital infrastructure, insufficient availability of high-quality operational data, limited integration between existing information systems, cybersecurity concerns, and the shortage of highly qualified specialists capable of managing advanced digital technologies. Addressing these issues requires coordinated efforts involving government institutions, industry stakeholders, research organizations, and higher education institutions.

5. Conclusion

Based on the research findings, it is recommended that oil and gas enterprises gradually expand the application of Digital Twin platforms integrated with Artificial Intelligence, Industrial Internet of Things (IIoT), cloud computing, and Big Data analytics. Furthermore, strengthening digital competencies among engineering personnel, improving data governance systems, and developing national digital standards for intelligent field management will accelerate the digital transformation of Uzbekistan's energy sector.

In conclusion, Digital Twin and Artificial Intelligence should be considered strategic technologies for the modernization of Uzbekistan's oil and gas industry. Their effective implementation will improve production efficiency, reduce operational risks, enhance environmental sustainability, and increase the international competitiveness of the country's energy enterprises. The experience gained from the Sardob and Yangi Karatepa fields provides valuable practical evidence that can serve as a foundation for the wider deployment of intelligent digital production systems across the national oil and gas sector.

REFERENCES

- [1] President of the Republic of Uzbekistan, *On the Strategy "Uzbekistan-2030"*, Decree No. UP-158. Tashkent, Uzbekistan: Government of the Republic of Uzbekistan, Sep. 11, 2023.
- [2] President of the Republic of Uzbekistan, *On Accelerated Measures to Improve the Energy Efficiency of the Economy and Social Sphere*, Resolution No. PP-4422. Tashkent, Uzbekistan: Government of the Republic of Uzbekistan, Aug. 22, 2019.
- [3] International Energy Agency (IEA), *World Energy Outlook 2023*. Paris, France: International Energy Agency, 2023, ISBN: 978-92-64-94464-7.
- [4] S. D. Mohaghegh, *Data-Driven Reservoir Modeling: Theory and Application*. Richardson, TX, USA: Society of Petroleum Engineers, 2017, ISBN: 978-1-61399-507-5.
- [5] M. Grieves and J. Vickers, "Digital twin: Mitigating unpredictable, undesirable emergent behavior in complex systems," in *Transdisciplinary Perspectives on Complex Systems: New Findings and Approaches*, F.-J. Kahlen, S. Flumerfelt, and A. Alves, Eds. Cham, Switzerland: Springer International Publishing, 2017, pp. 85–113, doi: 10.1007/978-3-319-38756-7_4.
- [6] Q. Min, Y. Lu, Z. Liu, C. Su, and B. Wang, "Machine learning based digital twin framework for production optimization in petrochemical industry," *International Journal of Information Management*, vol. 49, pp. 502–519, Dec. 2019, doi: 10.1016/j.ijinfomgt.2019.05.020.
- [7] Y. Shen, Y. Liu, X. Shi, and G. Cao, "A digital twin-based approach for optimization and prediction of oil and gas production," *Mathematical Problems in Engineering*, vol. 2021, Art. no. 3062841, pp. 1–12, 2021, doi: 10.1155/2021/3062841.
- [8] J. Prakash, "Role and advantages of digital twin in oil and gas industry," in *Digital Twin Technology*, M. Vohra, Ed. Hoboken, NJ, USA: John Wiley & Sons, 2022, ch. 9, pp. 179–198, doi: 10.1002/9781119842316.ch9.
- [9] A. Yadav, M. Khanna, G. Bhatia, D. Nanda, and P. Gemini, "Real-time decision support in optimizing well production and hydraulic fracturing operations using digital twins," in *Proceedings of the EAGE Conference on Energy Excellence: Digital Twins and Predictive Analytics*. Houten, The Netherlands: European Association of Geoscientists and Engineers (EAGE), 2024, pp. 1–3, doi: 10.3997/2214-4609.202477026.
- [10] C. M. Rebello, J. Jäschke, and I. B. R. Nogueira, "Digital twin framework for optimal and autonomous decision-making in cyber-physical systems: Enhancing reliability and adaptability in the oil and gas industry," *arXiv preprint*, arXiv:2311.12755, Nov. 2023.
- [11] S. Boschert and R. Rosen, "Digital Twin—The Simulation Aspect," in *Mechatronic Futures: Challenges and Solutions for Mechatronic Systems and Their Designers*, P. Hehenberger and D. Bradley, Eds. Cham, Switzerland: Springer International Publishing, 2016, pp. 59–74, doi: 10.1007/978-3-319-32156-1_5.
- [12] F. Tao, H. Zhang, A. Liu, and A. Y. C. Nee, "Digital twin in industry: State-of-the-art," *IEEE Transactions on Industrial Informatics*, vol. 15, no. 4, pp. 2405–2415, Apr. 2019, doi: 10.1109/TII.2018.2873186.

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- [13] E. H. Glaessgen and D. S. Stargel, "The Digital Twin Paradigm for Future NASA and U.S. Air Force Vehicles," in *53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference*, Honolulu, HI, USA, Apr. 2012, pp. 1–14.
 - [14] A. Rasheed, O. San, and T. Kvamsdal, "Digital Twin: Values, Challenges and Enablers from a Modeling Perspective," *IEEE Access*, vol. 8, pp. 21980–22012, 2020, doi: 10.1109/ACCESS.2020.2970143.
 - [15] F. Tao and M. Zhang, "Digital Twin Shop-Floor: A New Shop-Floor Paradigm Towards Smart Manufacturing," *IEEE Access*, vol. 5, pp. 20418–20427, 2017, doi: 10.1109/ACCESS.2017.2756069.