IMPROVING ECONOMIC MECHANISMS FOR ENSURING THE SUSTAINABLE DEVELOPMENT OF NATURAL GAS PROCESSING ENTERPRISES

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Abstract: This thesis examines the economic mechanisms for ensuring sustainable development of natural gas processing enterprises, with particular attention to Uzbekistan. The relevance of the research is determined by the strategic importance of natural gas for the national economy, declining domestic gas production, increasing requirements for energy efficiency, and the need to reduce methane emissions throughout the gas value chain. According to Uzbekistan's National Statistics Committee, natural gas production decreased from 46.71 billion m³ in 2023 to 41.52 billion m³ in 2024, while national natural gas consumption amounted to 47.06 billion m³ in 2024 [1]. These trends increase the importance of improving resource efficiency and the economic management of gas-processing enterprises. The study proposes an integrated economic mechanism based on energy-efficiency incentives, investment prioritization, digital metering, methane-emission reduction, environmental economic instruments, cost optimization, and performance-based management. International evidence indicates that methane reduction and energy-efficiency measures can generate both environmental and economic benefits. The thesis argues that sustainable development of gas-processing enterprises requires a transition from predominantly resource-intensive production toward economically efficient, technologically modern and environmentally responsible processing systems.

Keywords: natural gas processing, sustainable development, economic mechanism, energy efficiency, methane emissions, investment, digitalization, resource efficiency, Uzbekistan, industrial sustainability.

Introduction

Natural gas processing occupies an important position in the energy and industrial system because gas-processing enterprises transform extracted natural gas into commercially valuable products and prepare gas for further transportation, consumption and industrial use. The economic sustainability of such enterprises depends not only on production volumes but also on the efficient use of raw materials, energy, capital, infrastructure and environmental resources.

The relevance of improving economic mechanisms is particularly significant for Uzbekistan. Official statistics indicate that natural gas production declined from 65.96 billion m³ in 2010 to 41.52 billion m³ in 2024 [1]. At the same time, natural gas consumption reached 47.06 billion m³ in 2024 [2]. The difference between domestic production and consumption demonstrates the growing importance of efficient resource management and reliable supply mechanisms.

The World Bank's Uzbekistan Country Climate and Development Report emphasizes that the energy sector accounts for approximately 75% of Uzbekistan's greenhouse-gas emissions and identifies energy efficiency and renewable-energy development as important measures for reducing dependence on declining natural-gas reserves and strengthening energy security [3]. This makes the sustainable modernization of gas-processing enterprises not only an environmental objective but also an economic necessity.

International evidence reinforces this conclusion. The International Energy Agency estimates that approximately 200 billion m³ of methane was emitted globally by the fossil-fuel sector in 2024. It further estimates that methane-abatement measures could potentially make nearly 100 billion m³ of

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natural gas available to markets [4]. This demonstrates that reducing losses can simultaneously produce environmental benefits and increase the economically usable quantity of gas.

Therefore, the central research problem is the formation of an economic mechanism that connects technological modernization, energy efficiency, investment activity, environmental responsibility and financial performance.

Methodology

The research uses a combination of comparative analysis, statistical analysis, system analysis and economic interpretation. Official statistical data from Uzbekistan's National Statistics Committee were used to evaluate changes in natural-gas production and consumption [1; 2]. International evidence was obtained from the International Energy Agency, World Bank, IPCC and UNIDO.

The methodological framework considers sustainable development as the simultaneous achievement of three interconnected objectives: economic efficiency, environmental responsibility and long-term resource security.

The proposed economic mechanism consists of the following interconnected components:

- resource-efficiency incentives;
- investment and financing mechanisms;
- energy-efficiency management;
- methane-loss reduction;
- digital measurement and monitoring;
- environmental-economic instruments;
- technological modernization;
- performance-based management.

Particular attention is given to economic indicators that can be applied at enterprise level: energy consumption per unit of processed gas, production cost per unit of output, gas losses, methane-emission intensity, equipment utilization, return on investment and operating profitability.

Results

The analysis demonstrates that declining domestic gas production increases the economic value of every unit of gas entering processing facilities. Uzbekistan's natural-gas production amounted to 41.5237 billion m³ in 2024, compared with 46.7104 billion m³ in 2023 [1]. At the same time, consumption reached 47.0574 billion m³ in 2024 [2]. Consequently, the sustainable development of gas-processing enterprises increasingly depends on productivity and resource efficiency rather than simply expanding the physical volume of raw-gas processing.

The first major direction for improving the economic mechanism is **energy-efficiency stimulation**. Processing enterprises consume energy for compression, separation, heating, cooling, dehydration and other technological operations. Reducing energy consumption per unit of processed gas can lower operating costs and increase competitiveness.

The IEA reports that global energy-efficiency progress remained relatively weak in 2024, with primary-energy intensity improving by approximately 1%, while investment in end-use energy efficiency was estimated at around USD 660 billion [5]. These findings demonstrate that efficiency investment has become a significant component of modern energy economics.

For gas-processing enterprises, energy-efficiency projects should therefore be evaluated through measurable economic indicators. Priority should be given to projects that reduce energy consumption, increase equipment reliability and generate measurable operating-cost savings.

The second direction is **methane-loss reduction**. Methane leakage represents both an environmental externality and an economic loss. The IEA reports that downstream natural-gas operations, including processing, transmission, distribution and storage, produced nearly 13 Mt of methane emissions in 2024 [4]. The IEA further estimates that available technologies could reduce average methane intensity of downstream natural-gas operations from more than 0.4% to below 0.2% if deployed comprehensively [4].

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This supports the introduction of economic incentives for leak detection and repair, improved equipment, vapor-recovery systems and digital monitoring. Such investments should be considered not merely environmental expenditures but mechanisms for recovering economically valuable gas.

The third direction is **digitalization of resource accounting**. Uzbekistan adopted measures in 2023 to improve accounting for natural gas and liquid hydrocarbons, including the introduction of online electronic meters at natural-gas receiving and transmission points and integration with tax information systems [6]. This creates an institutional basis for increasing transparency throughout the gas value chain.

Digital accounting can reduce information asymmetry between producers, processors, distributors and regulators. It can also improve the accuracy of production-cost calculations and identify technological losses.

The fourth direction is **investment prioritization**. Investment decisions in gas-processing enterprises should increasingly be based on life-cycle economic efficiency rather than only initial capital expenditure. Projects should be evaluated using net present value, internal rate of return, payback period, energy savings, avoided gas losses and environmental benefits.

The fifth direction is **environmental-economic regulation**. The IPCC reports that approximately 50–80% of methane emissions from fossil-fuel production and transport could potentially be avoided using currently available technologies at costs below USD 50 per tonne of CO_2-equivalent [7]. This provides an economic rationale for combining regulatory requirements with market-based incentives.

Analysis and Discussion

The proposed mechanism can be represented as a closed economic cycle:

investment → technological modernization → resource efficiency → lower operating costs → increased profitability → reinvestment → sustainable development.

The effectiveness of this mechanism depends on whether enterprises have sufficient incentives to undertake modernization. If energy and environmental costs are not adequately incorporated into managerial decisions, enterprises may postpone investments even when technologies are economically beneficial in the long term.

One of the most important principles is therefore **internalization of resource losses**. Gas leakage, excessive energy consumption and inefficient equipment should be reflected in enterprise-level economic indicators. A reduction in physical gas losses should produce measurable financial benefits for the enterprise.

The second important principle is **performance-based investment support**. Enterprises implementing projects that demonstrate verified reductions in energy consumption or methane losses could receive preferential financing, accelerated depreciation or other economic incentives, subject to applicable national legislation.

The third principle is **digital transparency**. Accurate measurement is a prerequisite for economic optimization. Without reliable data on input gas, processed gas, output products, energy consumption and losses, management cannot accurately determine technological efficiency.

UNIDO emphasizes that industrial energy efficiency requires continuous improvement, appropriate policy and regulatory support, technological modernization and capacity development [8]. Its research also identifies energy-efficiency improvements as capable of producing economic, social and environmental benefits [9].

The international experience of the Caspian region is also relevant. The IEA estimates that efficiency improvements could reduce natural-gas demand in the Caspian region by more than 45 billion m^3 by 2035 under its Accelerated Policy Scenario, equivalent to approximately 80% of the region's total exports [10]. The IEA identifies modernization of compressor stations, leak detection and repair, digital flow optimization and predictive maintenance among important measures [10].

These findings are directly relevant to gas-processing enterprises because compressor stations, pipelines, processing equipment and monitoring systems constitute interconnected elements of the gas value chain.

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Another important issue is financing. Modernization projects may require significant initial capital investment, while their economic benefits are distributed over several years. Therefore, traditional short-term investment evaluation may underestimate their long-term value. Economic evaluation should incorporate avoided energy expenditure, avoided gas losses, maintenance savings, increased equipment reliability and environmental compliance.

For Uzbekistan, this approach is especially important because the country is simultaneously pursuing energy security and long-term decarbonization. The World Bank concludes that achieving carbon neutrality by 2060 requires significant transformation of the energy system and emphasizes energy efficiency as a major component of this process [3].

The sustainable development of gas-processing enterprises should therefore not be interpreted as the immediate elimination of natural gas from the economy. Rather, it should involve increasing the economic value generated from each unit of gas while reducing unnecessary energy consumption, leakage and environmental damage.

Conclusion

The research demonstrates that improving the economic mechanisms of sustainable development in natural gas processing enterprises requires a transition from resource-intensive management toward efficiency-oriented economic management.

For Uzbekistan, the issue is particularly relevant because official statistics show a decline in natural-gas production to 41.52 billion m³ in 2024, while consumption remained at approximately 47.06 billion m³ [1; 2]. Under such conditions, reducing technological losses and improving processing efficiency become economically important sources of additional resource availability.

The proposed mechanism should integrate energy-efficiency incentives, investment prioritization, digital accounting, methane-loss reduction, environmental-economic regulation and performance-based management.

The most important practical directions are:

- introducing measurable energy-efficiency indicators at enterprise level;
- linking investment decisions with life-cycle economic efficiency;
- expanding digital gas accounting and monitoring;
- implementing systematic methane leak detection and repair;
- stimulating modernization of energy-intensive equipment;
- incorporating environmental costs into economic decision-making;
- directing savings from efficiency improvements toward further modernization.

The principal conclusion is that sustainable development of gas-processing enterprises should be based on the integration of **economic efficiency, technological modernization and environmental responsibility**. Such an approach can increase enterprise competitiveness while simultaneously contributing to Uzbekistan's energy security and long-term sustainability objectives.

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