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# ANALYSIS OF BIOGAS USE IN A KVGM-20 WATER HEATING BOILER

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**Abstract**

An analysis of the environmental and thermal performance of the KVGM-20 water heating boiler when operating on biogas and natural gas has been carried out. The relevance of the work lies in the need to replace fossil fuels with renewable energy sources, in particular biogas.

**Keywords:** biogas, hot water boiler, natural gas, efficiency, heat balance, emissions, nitrogen oxides, heat of combustion.

## Introduction

The depletion of traditional energy resources, the growth of the negative impact of the energy industry on the environment and, accordingly, increased environmental requirements, significant fluctuations in energy prices, the desire to strengthen energy and economic security, shortcomings in the supply of energy resources and other factors have led to an urgent need to review the current state of the energy sector and find opportunities for its renewal and reboot.

One of the most comprehensive and realistic ways to address these problems and adapt to climate change, which is already underway, is to implement a complete “energy transition” ( energy transition ) from fossil energy resources to renewable ones. This is indeed possible, since today's development of high-tech and science-intensive technologies has already opened up real prospects for renewable energy [1].

$NO_x$ emissions of the KVGM-20 water heating boiler when switching from natural gas to biogas, based on data from environmental and heat engineering adjustment.

## Research results

Biogas is a renewable energy source based on light hydrocarbons produced by anaerobic digestion of organic matter. The typical composition of biogas varies depending on the composition of the feedstock and the conditions in the anaerobic reactor [2].

The chemical composition of biogas obtained from biogas plants is represented by methane and carbon dioxide with a small content of hydrogen sulfide and ammonia. Biogas also contains traces of elements such as hydrogen, nitrogen, carbon monoxide. The gas mixture is saturated with water vapor, and dust particles may also be present. The specific heat of combustion (Q) is determined mainly by the $CH_4$ content, since small amounts of $H_2$ and $H_2S$ have practically no effect on this indicator. Accordingly, the ignition temperature and ignition limit also depend on the $CH_4$ content [3].

In equivalent terms, 1000 m3 of natural gas is equal to 1500 m3 $^{of}$ biogas [4].

For the analysis, the summarized data of the ecological and thermal adjustment of the KVGM-20 boiler [5] were used. The calculation was carried out for two types of fuel: natural gas with a calorific value $Q^n_p$ = 9111 kcal/m³ and biogas with $Q^n_p$ = 5732 kcal/m³. The main comparative indicators of the boiler operation at a load of 80% are summarized in Table 1.

Table 1. Comparison of performance indicators of the KVGM-20 boiler on natural gas and biogas.

| Indicator | Unit of measurement | Natural gas | Biogas |
|---|---|---|---|
| Lower calorific value ( $Q^n_p$) | kcal/m³ | 9111 | 5732 |
| Excess air coefficient (α) | - | 1.04 | 1.5 |
| Weighted average efficiency (reverse balance) | % | 93.73 | 93.72 |
| Specific $NO_x$ emissions | g/ Gcal | 237.0 | 210.0 |
| Specific CO emissions | g/ Gcal | 30.8 | 27.0 |

Data analysis shows that despite the significantly lower calorific value of biogas and the need to burn it with a higher excess air ratio, the boiler efficiency under reverse balance remains practically unchanged. This indicates the possibility of effective fuel replacement without significant heat losses in this mode.

From an environmental point of view, switching to biogas in this configuration shows a significant improvement. The specific NOx emissions for biogas are lower than for natural gas. A similar positive trend is observed for CO emissions.

## Conclusions

Thus, the analysis showed that biogas can be used effectively (efficiency ~93.7%) in the KVGM-20 hot water boiler. This is achieved by operating with a significant excess of air (α=1.5). At the same time, an improvement in environmental indicators was established: specific emissions of nitrogen oxides and carbon monoxide per 1 Gcal of heat produced are lower than when burning natural gas.

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