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# Study Of the Efficiency of Implementing Innovative Digital Technologies and Automated Information and Measurement System of Heat Control and Accounting in The Modernization of Heat Supply Systems

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Abstract: The article analyzes various existing heat supply systems and examines the latest systems based on heat supply points, designed for more efficient use of energy resources, based on automated systems for distribution, regulation, control and management of supplied thermal energy to consumers. It is substantiated that the transition to modern, closed heat supply systems with the installation of individual heating points will ensure significant savings in thermal energy, ultimately reducing the costs of heat generation and ensuring more rational metering of thermal energy for consumers.

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# 1 INTRODUCTION

Research shows that to increase durability and reliability of heating networks The most important problem that needs to be solved is the automation of heat consumption as a whole. It is impossible to achieve an optimal supply and consumption mode through central, group, and even local (for one building) regulation. This can be achieved through the automation of specific heat-consuming devices and installations (Fortov, 2019; Maslennikov, 2021; Kudrin, Kozhichenkov, 2019; Jalilov, Kamalov, Akhmedov, 2022; Jalilov, Latipov, 2023; Jalilov, 2024; Jalilov, Kamalov, 2021; Jalilov, Sharipova, 2024; Danilov, Gariaev, Yakovlev, 2009; Jalilov, Kamalov, Akhmedov, 2023; Jalilov, Sharipova, 2024).

# 2 THE RELEVANCE OF THE PROBLEM

Currently, a pilot project is being implemented in the city of Bukhara for a program to replace outdated heat supply systems with more modern ones, based on an automated information and measurement system for heat control and accounting (*AIMSHCA*) and with the installation of individual heating points (IHP) based on the experience of other countries, where they have proven their high efficiency.
In addition, the overall energy balance of the pilot area for the future was calculated using the bottom-up principle. It should be noted that the energy balance is currently determined in the opposite way, starting from the only measured values, which represent the consumption of gas, electrical energy and water in the boiler room, and the difference between the standard consumption values for DH + DHW represents the system losses (Jalilov, Karaev, 2024; Jalilov, Sharipova, 2024; Jalilov, Kamalov, Karaev, 2024).

# 3 MATERIALS AND METHODS

Table No. 1 shows the calculations of consumption of water, electricity, gas, heat and hot water supply based on various methods, taking into account consumption and losses in the heat supply system.

Table 1: Methods for determining heat and hot water consumption.

| Current method | Consumed | TEJ |
|---|---|---|
| Regulatory framework for consumption and billing: 105 l/day per capita | warm | Based on experience from similar projects: 70 l/day per person after installation of the IHP |
| | HWS | |
| Standard consumption and billling base:0.019 Gcal/$m^2$, month | HW | Based on heat loss and energy consumption (in local climatic conditions), calculations: 43kWh per year/$m^3$ automation losses Economic potensial with ITP without structural changes and without thermostatic radiator valves automation losses 30% =>15% |
| Standard value 8% | Heat losses in CHS | Based on absolute heat losses, which are calculated using thermodynamic equations, they are modeled over the course of a year |
| - | Own needs of the boiler room | Best prectice criteria, 2% of annual own consumption |
| From a regime card (Real combustion efficiency 83%) | Boiler losses | Best preactice criteria, 95% annual effectiveness |
| Measured at Boiler House | Primary fuel=gas consumption | Calculated: from the bottom up (from the consumer to the needs) |
| Measured in the boiler room, for the entire service area. There is no information on how many leaks there are in the network per year. | Water for hot water supply | Standard, 70l/day per capita |
| Measured at the boiler house, as part of the total water supply for the entire area. There is no information on how many leaks there are in the network per year. | Make-up water | Best Practice Criteria, 1-2 fills per year Network size based on new measurements |
| Measured at the boiler room for | Electricity consumption | Best practice criteria: 6kWh Electric energy |

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| | | |
|---|---|---|
| the entire enterprise. No,heat production separation | | / MWh. Heat. |
| | Heat production. | Best practice criteria (modern pumps with frequency converters): 6kWh Electric energy / MWh. Heat. |
| | Networking pumping | Best practice criteria: DHW: 100W/24/7/365 HV:100W/heating period ⇔1000kWh. Per building. |
| | Electicity in ITP | |

## 3.1 Comparative analysis of various heat consumption systems

Below in Table No. 2 are data of various heat supply models, where the parameters of heat energy consumption are indicated depending on various connection schemes. When comparing the two schemes, it is clear that the step-by-step transition from an open classical scheme to a modern closed one will provide significant savings in heat energy due to reduced consumption and system heat losses.

**Various working models of heating systems.**

Table 2: Comparative analysis of heat consumption levels.

| Example | | Annual consumption | Comments | Territory (MWh) | Territory (Gcal) |
|---|---|---|---|---|---|
| Standart indicators | 575.0 | 100% | HWS only during the heating season, standard HW | 114999 | 98881 |
| Classical system in Uzbekistan | 769.3 | 134% | HWS 24/7/365 standard HW | 153866 | 132301 |
| Modern system | 640.6 | 111% | HWS 24/7/365 HW actual | 128128 | 110171 |
| Modern system | 490.1 | 85% | HWS 24/7/365 HW actual | 98023 | 84285 |

Analysis of various models of heat supply systems showed that the proposed scheme is optimal and most acceptable.

## 3.2 Automated information and measuring system for heat control and accounting

The automated information and measuring system for heat control and accounting (*AIMSHCA*) of “Buxoroenergomarkaz” JSC in the Bukhara region has been developed as a distributed information machine system designed for continuous operation in real time for commercial and technical accounting of thermal energy, as well as for monitoring individual parameters of automation facilities. It It is intended for the operating personnel of the systems, whose responsibilities include the supply and consumption of thermal energy of this settlement, as well as the organization and operation of means for recording the quantity and carriers of this energy.

The structure of the technical means complex of the *AIMSHCA* is presented in Fig. 1.

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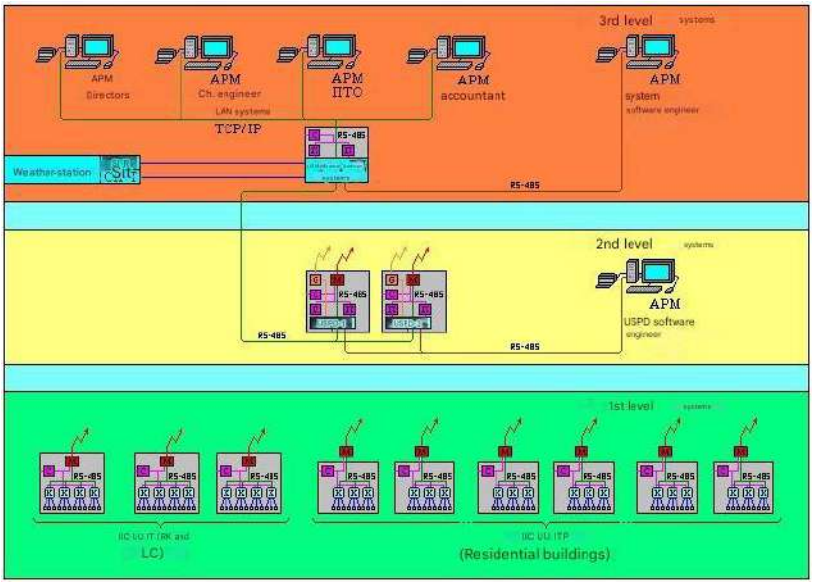


Figure 1: Structural *AIMSHCA* scheme.

The main objectives of the creation and implementation of the software and hardware complex (SHC) *AIMSHCA* are:

- increasing information support for operating personnel by providing them with the most complete and reliable information on the progress of technological processes and the condition of the relevant equipment;
- implementation of mutual financial settlements between the supplier and consumer of thermal energy;
- control over thermal and hydraulic operating modes of heat supply and heat consumption systems;
- dispatching of accounting data and controlled parameters of heat supply;
- control over the rational use of thermal energy and coolant;
- documentation of measured and calculated parameters of the coolant: thermal energy, mass (volume), temperature and pressure;
- generation of reporting forms on the parameters and amount of supplied and consumed thermal energy.

Heat consumption data are based on data provided by JSC “Buxoroenergomarkaz”, which are based on local standards and calculation methods (Table 3). For example, the standard specific heat capacity of heating in apartment buildings is 77 W / $m^2$. As indicated above, 215 residential buildings with a total heat load of 80.79 Gcal / h are connected to the heating networks of JSC “Buxoroenergomarkaz”.

The heat demand calculations are based on real buildings with the best estimates for U-values, which show that 81 W/$m^2$ would be a more accurate figure. The method for calculating DHW demand in Western Europe is completely different from the method adopted in Uzbekistan, but the heat requirements are quite close to each other.

Below in Fig. 2 is a basic diagram of the implementation of the information and measuring complex of the boiler metering unit (1st level), and Fig. 3 is a basic diagram of the implementation of the information and measuring complex of the individual heating point metering unit (1st level).

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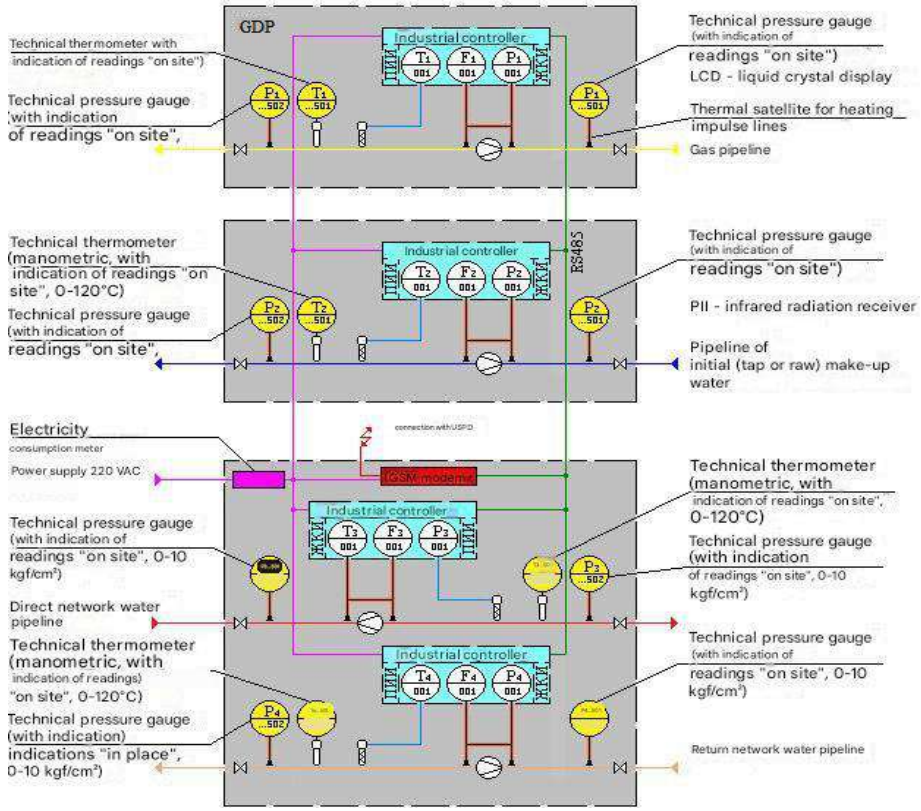


Figure 2: Schematic diagram of the implementation of the information and measuring complex of the boiler metering unit (1st level).

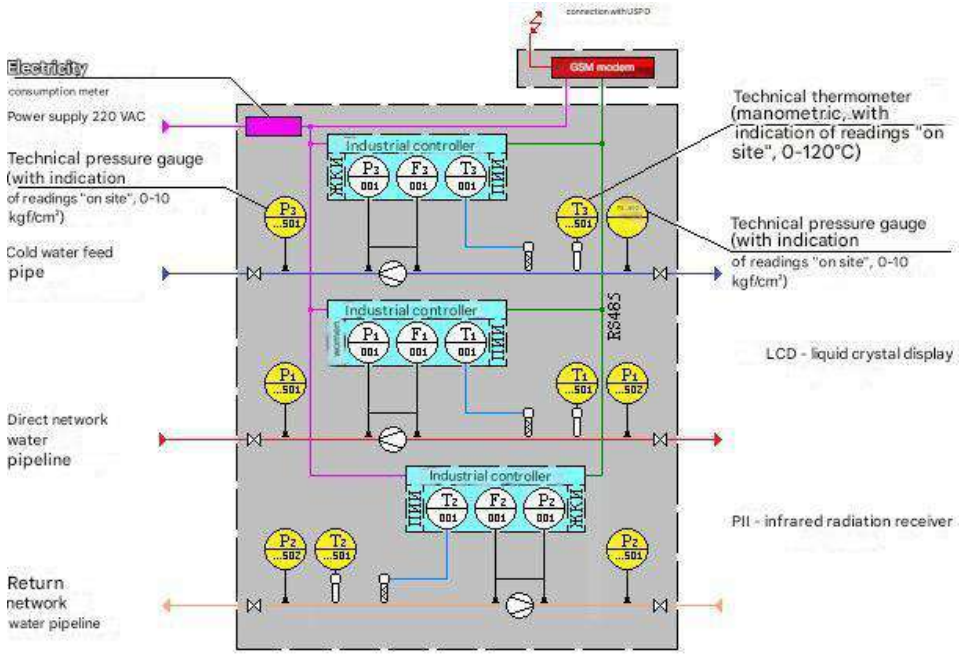


Figure 3: Schematic diagram of the implementation of the information and measuring complex of the metering unit of an individual heating point (1st level).

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Table 3: Data on heat consumption of JSC "Buxoroenergomarkaz".

| Name | Quantity (pcs.) | HW (Gcal/hour) | HWS (Gcal/hour) | Total |
|---|---|---|---|---|
| Residential buildings | 215 | 47.2 | 23,445 | 70,645 |
| Educational and preschool | 26 | 7,5725 | 0.981 | 8,5535 |
| Medical institutions | 3 | 0.76 | 0,1882 | 0.9482 |
| Other consumers | 4 | 0.5334 | 0.106 | 0.6394 |
| Total | 248 | 56,0659 | 24,7202 | 80,7861 |

Table 4: The table with the number of buildings and their loads is presented in Table 4 below. Demand for heat. Pilot zone: JSC “Buxoroenergomarkaz”.

| Consumers | Number of buildings | HW | HWS | Total |
|---|---|---|---|---|
| Residential buildings | 198 | 22.29 | 57.92 | 80.21 |
| Other | 33 | 6.71 | 3.79 | 10.50 |
| Total | 231 | 29.00 | 61,71 | 90.71 |

**The main advantages of the proposed technology:**

As studies confirm (Fortov, 2019; Maslennikov, 2021; Kudrin, Kozhichenkov, 2019; Jalilov, Kamalov, Akhmedov, 2022; Jalilov, Sharipova, 2024; Danilov, Garyaev, Yakovlev, 2009; Jalilov, Sharipova, 2024; Jalilov, Kamalov, Karaev, 2024), boiler houses are needed to meet the peak portion of heat consumption in the coldest time of the year, they can be reconstructed in the combined energy generation mode, since it does not matter where to install the steam gas plant (SGD) - at a thermal power station (TPS) or at a boiler house. It is even cheaper to install a SGD at boiler houses, because the heating networks to the boiler houses are already connected, and the heating networks to the TPS still need to be built. When reconstructing boiler houses, a lot of space is freed up from unnecessary equipment, where you can install an SGD, and at a TPS it is very problematic to find space for new equipment. In the Russian Federation, such a transformation in the cities of Moscow, Krasnoyarsk, Tomsk, etc. through the reconstruction of boiler houses is already underway.

The following trends are observed **in the world for boiler installations**:

- removal of exhaust gases through a cooling tower (elimination of the chimney and gas heat exchanger after desulphurization) allows not only to reduce investment and operating costs, but also to reduce energy consumption for own needs.

- the design of furnaces and burner systems using staged combustion, including in a fluidized bed, ensures a reduction in NOx at the boiler outlet, which simplifies the requirements for denitrification installations.

Currently, a pilot project of the program for replacing outdated heating systems with more modern ones is being implemented in the city of Bukhara, which provides for the transfer of one boiler house of the State Unitary Enterprise "Buxoro issiqlik manbai”- SUE on the SGD - on the TPS, i.e. install the SGD at the boiler house, and reconstruct the boiler house and transfer it to the mode of combined production of electric and thermal energy.

**Results of comparative technical and economic analysis:**

In works (Fortov, 2019; Maslennikov, 2021; Kudrin, Kozhichenkov, 2019; Jalilov, Kamalov, Akhmedov, 2022; Jalilov, Karaev, 2024; Danilov, Gariaev, Yakovlev, 2009; Jalilov, Sharipova, 2024) the amount of savings obtained from converting a boiler house to a combined heat and power plant mode, in the power unit of which a combined cycle power plant consisting of a steam turbine and a gas turbine part is installed, is substantiated.

**Calculation of the savings achieved when transferring the boiler house to TPS mode at a SGD unit.**

1. With an electric capacity of 0.7 MW, the generation of electricity from thermal consumption per year will be 4122.72 kW h, and the amount of base heat supplied per year is 2944.8 Gcal/year.

2. For the production of electric energy using a combined cycle method, conventional fuel of 1091 tons of equivalent fuel/year is required for the combined cycle power units.

3. On To produce the required amount of electricity per year equal to the electricity generated by a combined cycle power plant (4122.72 kWh), a thermal power station would require gas in the amount of 1447 tons of equivalent fuel /year.

4. At the boiler house, to generate base heat equal to the heat generated by the combined cycle gas plant, gas equivalent to equivalent fuel is required at 495 tons of equivalent fuel /year.

5. To generate heat and electricity using a separate method, equal to the same amount of energy using a combined method, the total gas consumption would be: 1447 + 495 = 1942 tons of equivalent fuel /year.

6. When converting a boiler house to a combined cycle gas turbine, energy losses for own needs will amount to 89 tons of fuel equivalent /year.

7. For an existing boiler house with a connected consumer load of 1 Gcal h gas savings due to covering the base load at the combined cycle plant: 1942 -1091-89 = 762 tons of equivalent fuel/year (635 thousand $m^3$ of gas per year). In percentage terms, gas savings will be = 100 · 762/1942 = 39.3%.

Thus, fuel savings when converting a boiler house to a combined heat and power plant mode with combined heat and power generation amount to at least 30 percent.

# 4 CONCLUSION

In our opinion, to increase the durability and reliability of heat supply, it is desirable to solve these problems taking into account the "fuel" feature. In the case where the share of natural gas at TPS exceeds 80%, it is advisable (Maslennikov, 2021; Jalilov, Kamalov, Akhmedov, 2022; Jalilov, Karayev, 2024; Jalilov, Sharipova, 2024):

- construction of large condensing thermal power station with combined cycle gas turbines and single-block CHP units using natural gas;
- natural gas in urban areas for environmental reasons Thermal power station with various modifications of combined- cycle technology.

It is assumed that the new SGD units will be used as a reserve for wind, solar and future nuclear power plants under construction, as well as for existing power plants. In the future, they will ensure the transition to alternative sources of green energy.

1. Thus, it is planned to create a modern resource-saving system of high-quality and uninterrupted provision of the needs of the population, social facilities in heat and hot water by modernizing the boiler house of JSC "Buxoroenergomarkaz", replacing the existing equipment with modern resource-saving technologies, introducing an automated process control system for boiler units, as well as transferring the existing open heat supply system to a closed system, which allows saving hot water up to 30% of its production .

2. As a result of the application of modern energy-saving technologies and equipment in centralized heat supply systems, the level of provision of heat supply and hot water supply services to the residential area of Bukhara will be competitive with other methods of heating premises and obtaining hot water.

3. It is expected that as a result of the project implementation, approximately 11,202 households will receive centralized heating services, which will allow approximately 36,000 residents of Bukhara to use heat and hot water supply services in accordance with established requirements.

4. According to preliminary calculations, the expected annual savings are: 13.07 million $m^3$ natural gas (30%), 1.31 million $m^3$ drinking water (40%) (3.67 billion soums), 1.12 million kW· h of electricity (20%) of the total energy savings.

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