Intellectual measurement of electrical energy consumption - monitoring device and software

Narzullo Mirzoyev[1*]

[1]Bukhara Institute of Engineering and Technology "Energoaudit Department", 200117, Uzbekistan, Bukhara, Kayum Murtazoyev St. 15

Abstract. The article presents the principle scheme and software of the intelligent measurement - control device that allows determining the efficiency of electricity consumption and the energy efficiency of electrical devices. Mathematical expressions and calibration coefficients of the device for measuring electrical quantities were calculated. Electronic devices for converting and amplifying analog signals to digital signals were selected and their communication circuits with Arduino microcontroller were developed. Based on the C++ programming language, the software that integrates with the device has been developed. The software determines the efficiency indicators of electricity consumption on 4 interfaces at the same time. Based on this software tool and device, it was possible to create a control system based on cloud technologies, which allows determining the energy efficiency indicators of a certain area. At the same time Algorithm of the program of regulation of fuel energy resources for the measurement and control system of the efficiency of electric power consumption, and, The Cloud Meters model of the electricity consumption efficiency measurement and monitoring system has been developed.

1 Introduction

To calculate the root, mean square value for each phase voltage, the following formula is used [1-3]:

$$U_f = K_{kU}\frac{\sqrt{\sum_{i=1}^{n} U_i^2}}{n}, \text{[V]}, \qquad (1)$$

Here: - calibration coefficient for the measured phase (entered during calibration)); i is the value of the current sample; n - number of samples; - sample voltage value, V.$K_{kU} U_i$

The following formula is used to calculate the root-mean-square value of the current for each phase current [4-6]:

$$,I_f = K_{kI}\frac{\sqrt{\sum_{i=1}^{n} I_i^2}}{n} \qquad \text{[A]}, \qquad (2)$$

Here: - calibration coefficient for phase (entered during calibration)); i is the value of the current sample; n - number of samples; - sample current value, A.K_{kI} I_i

The active power in each phase is calculated according to the following formula [7-10]:

$$P_f = K_{kU} \cdot K_{kI}\frac{\sqrt{\sum_{i=1}^{n} U_i I_i}}{n}, \text{[W]}, \qquad (3)$$

The total active power is determined by the following formula:

$$P_\Sigma = P_{fA} + P_{fB} + P_{fC}, \text{[W]}, \qquad (4)$$

Here: – active power for each phase.P_{fA}, P_{fB}, P_{fC}

The total power in each phase of a three-phase network is calculated according to the following formula [11-13]:

$$S_f = I_f \cdot U_f \quad , \qquad \text{[kVA]}, \qquad (5)$$

Here: – mean-square value of the current in the corresponding phase determined by the formula (2), A; – value of the mean square voltage in the corresponding phase determined by the formula (1), V.$I_f U_f$

The total full power is determined by the following formula [14-15]:

$$S_\Sigma = I * U, \qquad \text{[kVA]}, \qquad (6)$$

Here: I line currents, U line voltage – full power of each phase determined by the formula (5), VA.

The reactive power for each phase is determined by the following formula [16-18]:

$$Q_f = \sqrt{S_f^2 - P_f^2}, \text{[VAr]}, \qquad (7)$$

Here: – (5) full power in each phase determined by the formula, VA; – (4) active power in each phase determined by the formula, W. $S_f P_f$

The total reactive power is determined by the following formula [18-20]:

$$Q_\Sigma = Q_{fA} + Q_{fB} + Q_{fC}, \text{[VAr]}, \qquad (8)$$

Here: – reactive power in each phase determined by the formula (7), VAr.Q_{fA}, Q_{fB}, Q_{fC}

* Corresponding author: ilider1987@yandex.com

The relative energy loss in a three-phase circuit is calculated by the following formula [21-23]:

$$A = R_{fA} \cdot I_{fA}^2 + R_{fB} \cdot I_{fB}^2 + R_{fC} \cdot I_{fC}^2, \text{ [W*h]}, \quad (9)$$

Here: – (2) amperage determined by the formula, A; – active resistance of power lines for each phase, Ohm.$I_{fA}, I_{fB}, I_{fC} R_{fA}, R_{fB}, R_{fC}$

The active power coefficient formula is expressed as follows [24]:

$$\cos\varphi_A = \frac{P_{fA}}{S_{fA}}, \cos\varphi_B = \frac{P_{fB}}{S_{fB}}, \quad \cos\varphi_C = \frac{P_{fC}}{S_{fC}}, \quad (10)$$

Here: – active power determined by the formula (3), W; – (5) full power determined by the formula, VA .$P_{fA}, P_{fB}, P_{fC} S_{fA}, S_{fB}, S_{fC}$

Reactive power coefficients are determined by the following formula [25-27]:

$$\sin\varphi_A = \frac{Q_{fA}}{S_{fA}}, \sin\varphi_B = \frac{Q_{fB}}{S_{fB}}, \quad \sin\varphi_C = \frac{Q_{fC}}{S_{fC}}, \quad (11)$$

Here: – (7) reactive power determined by the formula, VAr.Q_{fA}, Q_{fB}, Q_{fC}

Active and reactive energy is calculated based on the value of active and reactive power determined in 1 second. Current and voltage are determined from the values of active and reactive power coefficients based on vector diagrams.

Based on the calculation of active and reactive energy, the MC sends signals about the consumption of electricity to the external interface, the signals of electricity consumption data are sent to the fuel energy resources regulation program or the user's software product [28-30].

MC collects energy parameters and stores energy parameters that are required to be held for a moment in a flash memory device and calculates the time.

In order to reduce the cost of the product, data input and display - a device for visualization of measurement results and a keyboard for data input were abandoned. Information about network parameters, power consumption, load temperature and user parameters is transmitted to the cloud database via the Internet. The information is displayed on the computer or phone of the service worker. The program interface shows the graph of electricity consumption, the operating status of the load, the main indicators of the calculated electricity.

To configure the device, using the configurator program, digital coefficients are used, which are written to the non-energy memory and loaded into the microcontroller registers when the device is started.

To add load to the device, the device provides a pre-designed 100 A current relay for the electrical energy monitoring system we offer. The relay can be controlled manually.

A 1.2 V uninterruptible power supply (UPS) is used to power the device.

The metrological indicators and descriptions of the device are presented in Table 1.

Table 1

Measurement error	smaller than 1%
Voltage measurement range in a three-phase network	0 - 400 V
Current measurement range	50 mA - 100 A
Maximum power at the output to be controlled	30 kW
Consumption capacity	1.2 W
Communication protocol	Wireless, IEEE 802.11
Data update interval	5 sec
Frequency	45-65 Gs
Maximum data storage time on the device itself	10 days
The specified operating temperature	-10 ºC to +60 ºC
Dimensions	90 x 67 x 52 mm
Mass	1.2 kg

According to the conditions of the measurement-control system, it is possible to automate the controlled output values of the checked electricity consumption or to obtain information about them. It is possible to adjust the parameters of electricity consumption. Based on the conditions of energy availability, the relay disconnects or connects the electrical network based on the control signals coming from above. If the values of the extracted data match the conditionally defined values and the condition, the device initiates one of the following actions: sends messages about energy efficiency by e-mail; turns on the relay; turns off the relay. Conditions are automatically checked every 5 seconds. If the specified conditions are met,

Status checks may be limited by time. If you activate the time interval, the condition will be executed only during the specified time [1-3].

The comparison symbols ">" or "<" are used to reset the condition. Also, types of energy efficiency quantities are selected and correction values are entered for comparison, as well as one of the necessary operations for data recalculation is selected [1-3].

Example: If the network voltage is higher than 240 V, two conditions must be met to turn off the load relay and to turn on the load relay when the network voltage reaches 230 V (Figure 1):

1) $U_{ph} > 230$ KBR "turn off",

2) $U_{ph} < 220$ KBR "on".

*KBR-Adjustment for voltage management

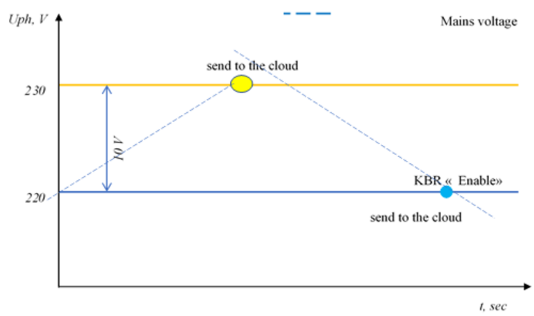


Fig. 1. Automation of verification of compliance with specified conditions.

The event notification function allows you to activate the sending of e-mail messages about selected events that occur on the device [1-3].

The setting conditions are available in the WEB interface of the device in the "Conditions" section.

2 Materials and Methods

One of the means of increasing the efficiency of electricity consumption is to organize a system of continuous monitoring of the volume of electricity consumption in the production units of the enterprise, taking into account production indicators and climatic factors, as well as to warn about possible malfunctions in the operation of the equipment and thus make possible predictions. One of the important tasks for the development of such systems is the creation of special measurement and control devices and control algorithms that allow comprehensive analysis of the potential of saving electricity. This allows for moderation of technical and commercial waste and consumption of reactive power, as well as rational use of energy.

The proposed measurement and measurement system is designed for continuous measurement of power grid quantities and electrical energy. Measurement and monitoring are carried out for the purpose of further analysis and implementation of efficiency indicators aimed at normalizing electricity consumption.

The device directly measures the following electrical energy quantities:

1. Tension, V;
2. Current strength, A;
3. Active power, W;
4. Reactive power, VAr;
5. Active energy, W*h;
6. Reactive energy, VAr*hour;
7. Power factor
7. Network frequency, Gs;
8. Temperature, °C.

Communication with the measuring system is carried out via wireless Wi-Fi. The measurement system transmits the collected data to the "CLOUD" server for further analysis and visualization.

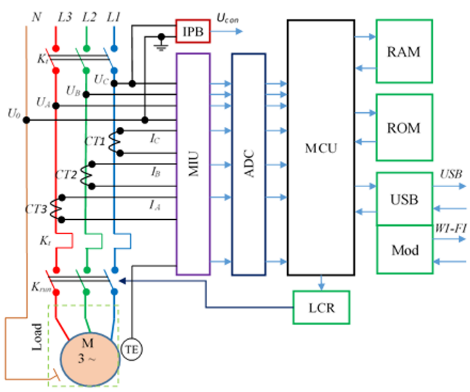


Fig. 2. Structural scheme of the electrical energy monitoring system.

The proposed device includes the following main elements (Figure 2): measurement and interface unit (MIU), analog-to-digital converter (ADC), microcontroller (MCU), Random Access Memory (RAM), Read-only memory (ROM), Universal Serial Bus (USB), WI-FI modem (Mod), load control relay (LCR), current transformers (CT), temperature sensor (TE), impulse power block (IPB) [4] [1-3].

Using a three-phase current converter installed in the network, the phase currents are changed into an output signal in the form of voltage. These signals are fed to the O'BB inputs, the signals received from the O'BB network are divided into current voltage and frequency signals at the phase section, and the analog signals are transferred to the serial synchronous port of the MK for conversion into a digital code. MK calculates the average arithmetic values of currents and voltages, total, active, reactive power, power coefficient and consumed electric energy, as well as the shift angles and frequency of the main harmonic of voltage signals, and enters the obtained data into the cloud database by day, month and year.

Arduino Uno integrated circuit is widely used for control and management of technological processes. In this thesis work, the Arduino Uno integrated circuit shown in Figure 2 was chosen for the energy efficiency measurement controller. The basis of the integrated circuit is the ATmega328 microcontroller. The size of the used controllers is easy to install, as well as being reprogrammable. Arduino Uno integrated circuit architecture is open. It has its own programming environment and board. In addition, it is possible to design various schemes of a number of accessories. Table 2 shows the parameters of Arduino Uno.

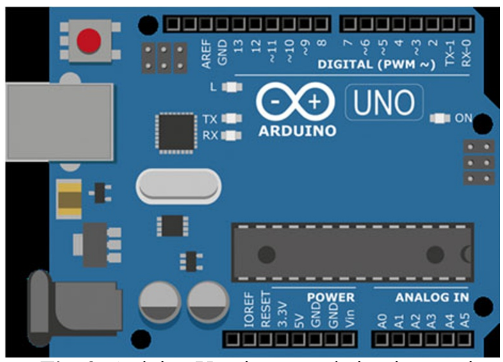


Fig. 3. Arduino Uno integrated circuit overview

Table 2. Arduino Uno specs

Type of microcontroller	ATmega328
Operating voltage	5 Volt
Supply voltage	7-12 Volt
Voltage range	6-20 Volt
Digital inputs and outputs	14, of which 6 are for PWM
Analog inputs and outputs	6
Fixed current in one output channel	40 mA
Memory	32 kB, of which 0.5 kB is for programming
SRAM	2 KB
EEPROM	1 kB
Frequency	16 MHz

Measuring and connecting block resistance bridgeAMC1100 amplifier and it consists of ADE7752 integrated circuits. AMC1100 galvanically isolated amplifiers were used in the created energy efficiency measurement controller. In order to eliminate electromagnetic interference in this isolation amplifier, its input and output cascades are isolated with silicon dioxide. AMC1100 protects each circuit of small value voltages from high value input voltage, and also filters electrical signals that are required to be removed from the network. The AMC1100 integrated circuit is mainly used in electricity meters. AMC1100 inputs enable the adaptation of small voltage consumers to accurate measurement of current and voltage signals as shown in Figure 4.

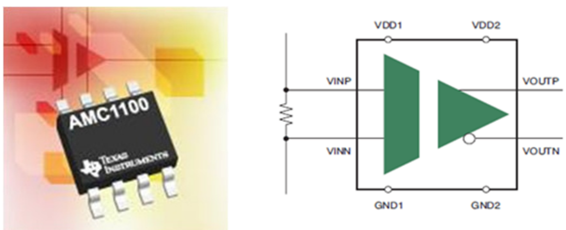


Fig. 4. Adaptation of AMC1100 integrated circuit inputs and small voltage consumers to accurate measurement of signals in the form of current and voltage.

ADE7752 was used as an element of a high-precision three-phase consumer measurement control system. The integrated circuit enables the measurement of electrical signals based on the IEC1036 standard, and it consists of analog-to-digital converter circuits. Processing of electrical signals is carried out digitally, filtering and summing. This measure provides accurate measurement of power grid magnitudes under various conditions. ADE7752 F1 and F2 generate signals that enable the determination of electrical quantities of electrical consumers with a frequency of 50 GHz [139].

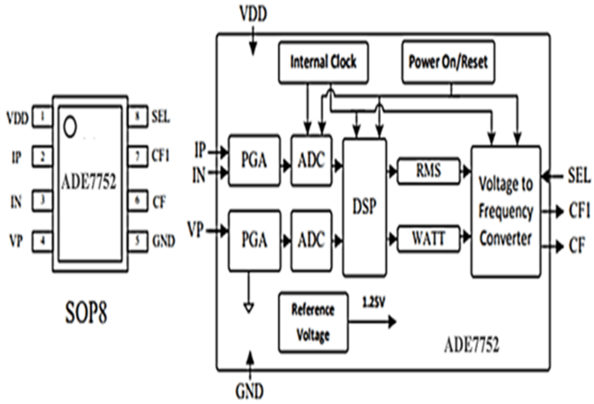


Fig. 5. ADE7752 is a high-precision three-phase consumer measurement control system element

Principle of operation of the ADE7752 chip

IP is the voltage signal coming from the converter.

IN - two ends of the winding of the transformer, i.e. phase and zero.

Vp - the maximum and minimum values of the phase voltage are obtained.

ADC is an analog-to-digital converter.

Internal clock – time interval (tactical frequency of the controller).

Voltage to Frequency Converter – voltage frequency converter.

Set <- signal to the chip.

CF1 -> active power value is obtained.

A digital signal is received from the CF -> ports. The signals are used to connect the power supply and database to the microcontroller used for measurement control. Each logic output in an integrated circuit has its own function. The supply voltage of the ADE7752 integrated circuit is 4 Volts and is provided by the VDD control circuit. If the voltage is less than 4 volts, no signal is generated from logic outputs F1, F2 and CF. In addition, even when there is no consumer in the electrical network, only the electrical parameters of the network are signaled according to voltage and frequency.

Connection block of measurement and control and Arduino Uno the connection diagram of the integrated circuit is presented in Fig. 6.

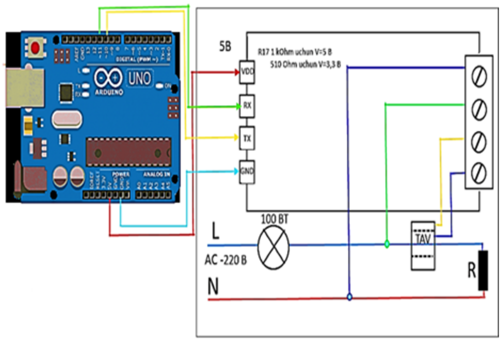


Fig. 6. Connection diagram of measurement and control unit and Arduino Uno integrated circuit

In the general scheme, as one phase of the electrical network is connected, the remaining phases are connected in the same order (Figure 6). The circuit shown in Figure 7 shows the connection of the measuring connection block and Arduino Uno integrated circuit for three-phase power monitoring.

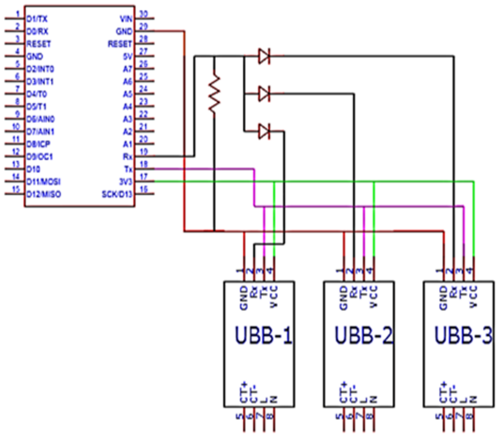


Fig. 7. Measuring connection block for three-phase electricity monitoring and Arduino Uno integrated circuit connection diagram.

The measuring connection block designed for three-phase electric power monitoring is mainly assembled based on the above elements, its schematic diagram is shown in Figure 8.

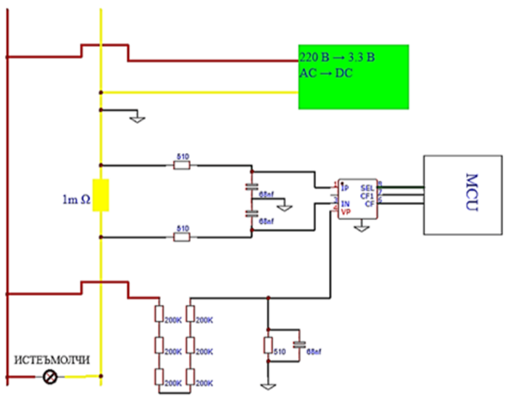
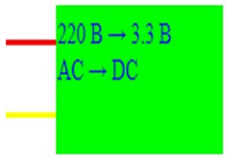
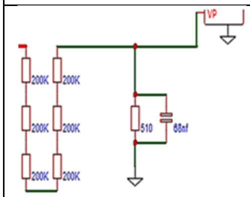
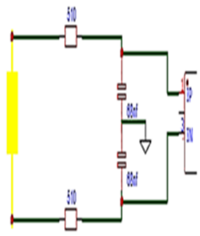
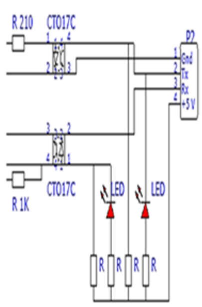


Fig. 8. Structural diagram of the measurement connection block

Each circuit presented in the diagram performs a certain task. Tasks and descriptions of measurement chains presented in the scheme are presented in Table 3.

Table 3

	Supply unit for the device. By connecting a capacitor, resistor and diode in series, the voltage is reduced. This circuit is used to power the device
	The voltage pulses in the determined phase are directly received by the resistors, and thereby extract the amplitude value, length and frequency of the voltage.
	In this scheme, the analog signals measured from the electrical network are converted into digital signals.
	This circuit is considered a structural circuit of the MCU, which is a device for transmitting digital signals to a controller or a computer. It consists of 2 optocouplers and works on the basis of TTL technology.

3. Results and Discussion

At present, in production enterprises, mostly all money is directed to the one-sided narrow services of the organization's leaders. It is rarely used to provide information to other levels of management than the axopods to develop acceptable general management decisions. Other employees simply need to know how their unit is performing and whether energy efficiency is improving or deteriorating.

These are the main directions of solving problems is the development of energy resources standardization programs that allow determining and evaluating energy efficiency. The structural schemes and software dependencies of this program are in the second chapter of the research work given. The program provides information on the measurement and calibration of the power supply system in four formats. The program was implemented in the C++

programming language. The program has the ability to provide the data format on phones, tablets and computers.

The 1st data presentation format (interface) of the program is presented in Figure 9. In this section, data on electricity consumption in the months are provided from the cloud database. The amount of electricity consumed for the production of products is monitored and financial costs for electricity are calculated automatically. Later, this information is used to calculate the program's other software parameters [1-3; 14-20].

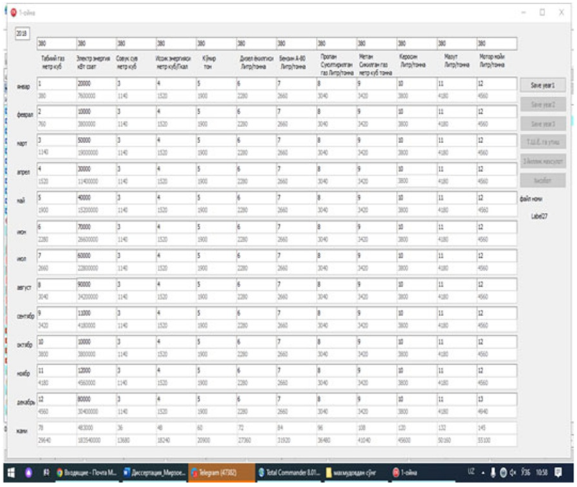


Fig. 9. Indicators of electric power monitoring

The program's 2nd data presentation format is shown in Figure 10. Data presentation format 2 of the program is given from the data presentation format part of the program 1. In this window of the program, indicators of electricity monitoring and consumption costs of electricity are presented. Based on these monitoring indicators, in the next calculation sub-block of the program, technical wastes are calculated and energy resource consumption balances for product production and for own needs are drawn up. If various fuel and energy resources are needed for product production, the program automatically changes the physical value of fuel and energy resources into a single unit of conventional fuel and makes an energy balance on the consumption of fuel and energy resources.

The program's 3 data presentation format is shown in Figure 11. In this part, graphs of the dynamics of consumed and wasted electricity are drawn. Data presentation format 3 of the program is provided from the cloud database and data presentation format 1 of the program [1-3; 14-20].

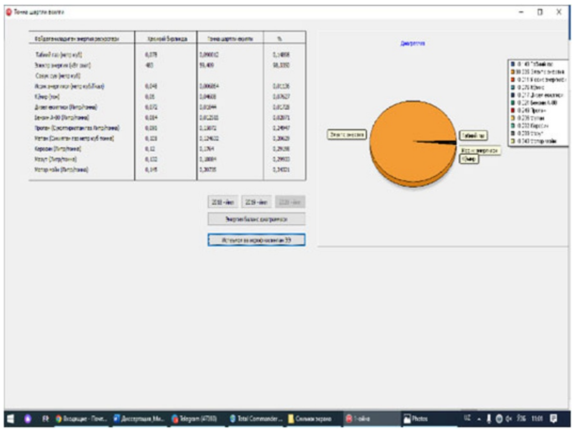


Fig. 10. A single unit of measurement and energy balance indicators

Also, in this part of the program, electric energy losses are calculated by determining the loading coefficient of electric energy consumption obtained from the billet, and by entering the constant values necessary for the calculation of losses, the full power of the transformer, the number, the active power coefficients in the short-circuit and idle modes, the distance of the power transmission lines, the relative resistance of the conductor, the errors of the measuring sets and other values. Calculations of electrical energy losses are made on the basis of algorithms written for the program [1-3; 14-20].

Fig. 11. Dynamics of electricity consumption and indicators of technical waste

Figure 12 shows the program's 4 data presentation format. The 4th data presentation format is automatically transmitted to the cloud by means of special consumption meters that are set on technological scales, and the dynamics and volume of product production are presented on the basis of the data received from the cloud. the comparative cost of electricity used for product production is calculated using data from electricity monitoring indicators [1-3; 14-20].

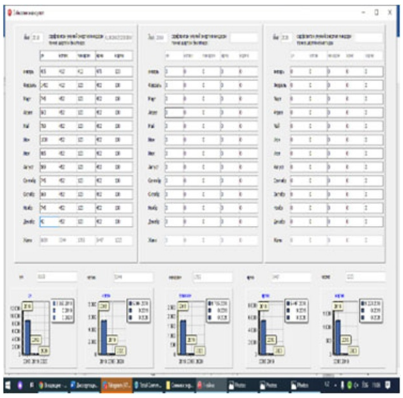


Fig. 12. Product dynamics and energy capacity indicators

This program It is widely used in scientific research to determine and evaluate energy efficiency indicators of technological devices [1-3; 14-20].

Standardization of fuel and energy resources the software calculates the standards of electricity consumption of technology and equipment for product production and determines their efficiency classes. At the expense of optimizing the operating modes of technology and equipment, for example, for different operating modes, it defines the norms of energy consumption according to the passport indicators. Determines specific energy efficiency indicators for the types of products manufactured in production enterprises. On the basis of the stored data, it is possible to carry out an internal energy audit in the enterprise. Generates energy efficiency reports automatically.

Application of Cloud computing technology in measuring, transmitting and processing efficiency data of electric energy devices

Production and people's way of life goes hand in hand with the wide use of information technologies. Currently, there are many issues in the energy sector that cannot be solved by using advanced technologies. Because industry-specific information technologies and software are very expensive in the information technology market. According to the latest estimates, the use of advanced technologies in the global energy sector is increasing, and at the same time, their prices are also increasing. In our republic, the introduction of information technologies in the energy sector has not accelerated compared to other sectors of the economy. However, electricity sales organizations are looking for ways to increase their efficiency with advanced technologies.

It is considered necessary to create a concept of automated measurement, taking into account the specific features of the organization of the energy industry of foreign countries, in the use of cloud services in the measurement and management of energy efficiency and the introduction of cloud services for determining the efficiency.

Due to the fact that the price of electricity is not expensive in our republic, as well as the lack of software and devices for monitoring and controlling the electricity consumption, manufacturing enterprises do not want to use the services of cloud technologies in our republic and in developed countries. Although Cloud services can be used in electricity generation, transmission, distribution, consumption and electricity consumption monitoring services, traditional methods of data storage and processing are being used in the automation of electricity consumption calculations. Given that this requires additional costs for digital technologies and high-paid specialists in the enterprise.

Cloud technologies are really cost-effective, besides, scientific research conducted in our country on cloud technologies positively evaluates several of its features:

1. Economy of scale in data storage;
2. Variety of services;
3. Flexibility with different systems;
4. Not requiring organizational issues.

Based on the results of the analysis of Cloud technologies and services, we have developed a model of Cloud Meters, a system for measuring the efficiency of electricity consumption.

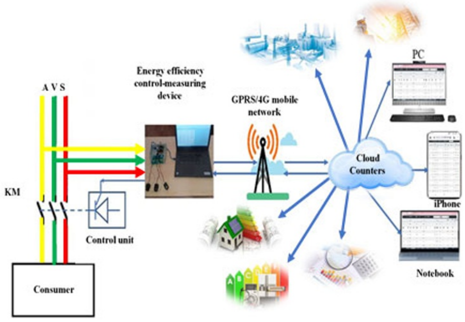


Fig. 13. Cloud Meters model of the electricity consumption efficiency measurement and analysis system

The need for cloud technologies and services in the energy sector is increasing. The growing demand is explained by the advantages of its services. Use of Cloud technologies and services ensures strategic development of any enterprise. There is a number of advantages of the Cloud Meters model of the electricity consumption measurement and monitoring system offered by us, which is the compatibility of the software. Cloud Meters model allows to estimate the energy efficiency in real time and to determine the standard energy capacity of the product. Also, Cloud Meters have data transfer and storage capabilities.

A number of problems are encountered in the use of cloud technologies offered by foreign manufacturers. First of all, they require large expenses for the creation of cloud technologies for the production enterprise. Secondly, innovations and changes in the field of foreign electric energy do not always take into account the needs of the electric energy sector of Uzbekistan. Thirdly, the data security of the production company's electricity consumption figures is not fully ensured. Fourthly, access to cloud technologies and services depends on the Internet speed for their use, including the reliability of communication. Because the communication channels of their data processing systems are integrally interconnected.

Cloud services are provided in the following Cloud Meters in the electric power system:

1. Service of monitoring electricity monitoring indicators and their consumption costs;
2. Prepares monthly and annual reports of electricity consumption for the energy industry;
3. Makes balances of electricity consumption, electricity waste and electricity savings;
4. Performs energy efficiency control and internal energy audit services;
5. Measure electrical network sizes and store them in the cloud;
6. Determination of energy efficiency classes of technology and equipment.

The implementation of these possibilities provides the enterprise with documents and reports from any location, it creates the possibility to monitor the efficiency of fuel and energy resources and electricity consumption in all production processes of the enterprise online, paper reports are avoided. The Cloud Meters model of the electricity consumption efficiency measurement and analysis system developed by us shows that Cloud Meters optimize all operations in the field of electricity.

It is possible to assess and increase the energy efficiency of regions in the electric energy sector of our Republic based on the capabilities of Cloud Meters model and IT structure services. The structure of IT services for the assessment of efficiency of electricity consumption in the electric power system is presented in Fig. 14.

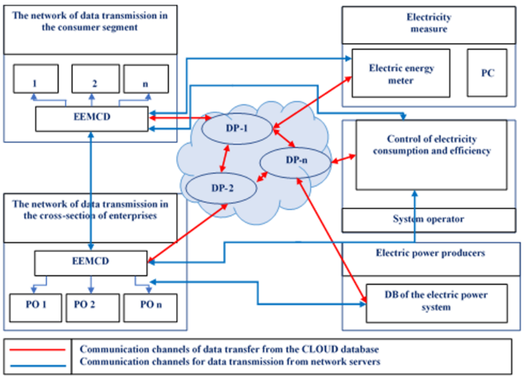


Fig. 14. The structure of cloud services for the assessment of efficiency of electricity consumption in the electric power system

Conclusion

Based on the nature of the IT structure of the cloud services of the electricity consumption efficiency measurement developed on the basis of the electricity consumption efficiency measurement system and the cloud technologies, it is possible to solve a number of problems between industry enterprises in the electric power system, for example:

1. integration of cloud data processing systems in the field of electric power into a single integrated database of cloud technologies of electric power;
2. It is necessary to integrate different clouded technologies in the field of electric energy into a single integrated electric power system within individual clouds [6-13].

The information processing system of the IT environment, shown in Figure 13, works on a single integrated electricity billet. In addition, each of these data processing systems is capable of mutual data processing and exchange. The structure of the IT environment of cloud technologies for the electric power system implements various services of cloud technologies. In the field of electric energy, measurement operators of organizations on electricity generation, transmission, distribution, consumption and energy monitoring simultaneously study the data of efficiency indicators in a mutually integrated manner. Moreover, on the basis of these interconnections, all work activities in the field of electric power are integrated and coordinated.

The Cloud Meter model of the electricity consumption measurement system developed and described by us above, as well as the use of modern technologies such as the IT structure of the cloud technologies for the electric power system, is also shown in the ISO 50001 standard and the decision of the President of the Republic of Uzbekistan No. PQ-4422 dated 22.08.2019.

References

1. Mirzoyev N.N. Chemical Technology. Control and Management. Tashkent, Vol. 2021. No. 5, pp. 68-75. DOI:https://doi.org/10.51346/tstu-02.21.5-77-0044.(05.00.00;No. 12).
2. Mirzoyev N.N. The American Journal of Engineering and Technology. USA Texas, 2020. Vol. 02, pp. 55-61.
3. Mirzoyev N.N. Chemical Technology. Control and Management. Tashkent, Vol. 2020. Special issue 5-6, pp. 172-181. DOI:https://doi.org/10.34920/2020.5-6.172-180.(05.00.00;No. 12).
4. Mirzoyev N.N., Sayfiyev O.H., Temirov T.O. ResearchJet Journal of Analysis and Inventions, 2022. 3/10, pp.130-143.
5. Maxmudov M.I., Mirzoyev N.N. Energiya samaradorlikni boshqarish va nazoratning axborot dasturiy ta’minoti va qurilmalari. «Energiya va resurs tejash muammolari» jurnali, Toshkent, 2021. № Maxsus son, 101-109 betlar.
6. Mirzoyev N.N. Avtomatik nazorat-o‘lchov tizimlarida iqtisodiyotni modernizatsiyalash negizi // «O‘zbekiston iqtisodiyoti tarmoqlarini raqamlashtirish sharoitida elektr tarmoqlari korxonalarini innovasion rivojlantirish” mavzusida respublika ilmiy-texnika anjumani. (Xalqaro mutaxassislar ishtirokida). Toshkent. 2021 yil 8 sentyabr. 48-50 b.
7. Siddikov I.X., Mirzoyev N.N. Smart energy efficiency monitoring device // Vserossiyskaya nauchnaya konferensiya molodix issledovateley s mejdunarodnim uchastiem «Sotsialno-gumanitarnie problemi obrazovaniya i professionalnoy samorealizasii» Sotsialniy injener-2021 sbornik

materialov. Rossiya, Moskva, 6-10 dekabrya 2021 g. Chast 3. S. 237-240.
8. Mirzoyev N.N. Razrabotka intellektualnoy sistemi izmereniya dlya monitoringa i kontrolya energoeffektivnosti // Vserossiyskaya konferensiya molodix issledovateley s mejdunarodnim uchastiem «Sotsialno-gumanitarnie problemi obrazovaniya i professionalnoy samorealizasii» Sotsialniy injener-2020 sbornik materialov. Rossiya, Moskva, 6-10 dekabrya 2020 g. Chast 3. S.20-25.
9. Mirzoyev N.N., Shoboyev A.X., Temirov O.T. «Yoqilg`i energetik resurslarni tonna shartli yoqilg`iga o`zgartirishning mobil ilovasi» / O‘zR EHM uchun dasturlar davlat reesrida 07.01.2022 yilda Toshkent shahrida ro‘yxatdan o‘tkazilgan, № DGU 14066.
10. Mirzoyev N.N. «Elektr energiyasini monitoringining aqlli tizimi uchun hisoblagichlar dasturiy ta`minoti» / O‘zR EHM uchun dasturlar davlat reesrida 11.11.2021 yilda Toshkent shahrida ro‘yxatdan o‘tkazilgan, № DGU 13002.
11. Mirzoyev N.N. «Energiya samaradorlikni boshqarish va nazorat qilish uchun HISOBLAGIChLAR tizimining ma`lumotlar bazasi» / O‘zR EHM uchun dasturlar davlat reesrida 09.11.2021 yilda Toshkent shahrida ro‘yxatdan o‘tkazilgan, № BGU 462.
12. Maxmudov M.I., Mirzoyev N.N. «Energiya samaradorlikni boshqarish va nazorat qilish qurilmasi uchun ta`minot dasturi» / O‘zR EHM uchun dasturlar davlat reesrida 11.11.2021 yilda Toshkent shahri, № DGU 13003.
13. Siddikov I.X., Mirzoyev N.N. «Energiya samaradorligini nazorat va boshqarishning avtomatlashtirilgan dasturiy-axborot ta’minoti» / O‘zR EHM uchun dasturlar davlat reesrida 10.03.2020 yilda Toshkent shahrida ro‘yxatdan o‘tkazilgan, № DGU 07874.
14. Siddikov I.X., Abdumalikov A.A., Mirzoyev N.N. «Energiya samaradorlikni nazorat va boshqaruvi elementlarini ishonchlilik va ish holatlarining ko‘rsatkichlarini tadqiq etish dasturiy ta’minoti» / O‘zR EHM uchun dasturlar davlat reesrida 27.03.2020 yilda Toshkent shahrida ro‘yxatdan o‘tkazilgan, № DGU 08003.
15. Toirov O., Sadullaev T., Abdullaev D., Jumaeva D., Ergashev Sh., Sapaev I.B. *E3S Web of Conferences* 383, 01029 (2023).
16. Erejepov Madiyar and ofters. 2021 International Conference of Young Scientists Energy Systems Research, ESR 2021. https://10.1051/e3sconf/202128907018
17. Toirov O., Pirmatov N.B., Khalbutaeva A., Jumaeva D., A. Khamzaev. *E3S Web of Conferences* 401, 04033 (2023).
18. Toirov O., Khalikova M., Jumaeva D., Kakharov S. *E3S Web of Conferences* 401, 05089 (2023).
19. Khalikov S. *E3S Web of Conferences* 377, 01004 (2023).
20. Alimkhodjaev K., Toirov O., Taniev M. Journal of Critical Reviews, 2020. Vol. 7, Issue 15.
21. Toirov O.Z., Khalikov S. *E3S Web of Conferences* 365, 04010 (2023).
22. Toirov O.Z and others. *AIP Conference Proceedings* 2552, 040021 (2022).
23. Toirov O.Z and others. E3S Web of Conferences 216, 01119 (2020) RSES 2020.
24. Jumaeva D. and others. *E3S Web of Conferences,* SUSE-2021, 288, 01041 (2021).
25. Afrisal H., Setiyadi A.D. *International Journal on Advanced Science, Engineering and Information Technology*, Vol. 12 No. 6, p. 2258-2265, (2022).
26. Toirov O., Khalikov S.S. *E3S Web of Conferences* 365, 04013 (2023).
27. Hoshimov U.H., Ishnazarov O.Kh., and others. Journal of Physics: Conference Series, *Conf. Ser.* **2094** 052051, (2021).
28. Hoshimov U.H., Ishnazarov O.Kh., and others. E3S Web of Conferences 264, 04088 (2021) https://doi.org/10.1051/e3sconf/202126404088
29. Hoshimov U.H., Khushiev , and others. IOP Conference Series: Earth and Environmental Science, (2023).https://iopscience.iop.org/article/10.1088/1755-1315/1142/1/012030
30. Muratov Kh., Ishnazarov O.Kh., Isakov A., Nuritov I, and others. E3S Web of Conferences 365, 04005 (2023).
31. Pirmatov N.B., and others. E3S Web of Conferences, 2023, 383, 04046.
32. Pirmatov N.B., and others. AIP Conference Proceedings, 2023, 2612, 050005.
33. Pirmatov N.B., and others. AIP Conference Proceedings, 2022, 2432, 020020.
34. Pirmatov N.B., and others. AIP Conference Proceedings, 2022, 2552, 070009.
35. Pirmatov N.B., and others. E3S Web of Conferences, 2021, 264, 04028.