Торайғыров университетінің хабаршысы
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
Вестник Торайгыров университета

Торайғыров университетінің ХАБАРШЫСЫ

Энергетикалық сериясы

1997 жылдан бастап шығады

ВЕСТНИК Торайгыров университета

Энергетическая серия

Издается с 1997 года

ISSN 2710-3420

№ 2 (2023)

Павлодар

НАУЧНЫЙ ЖУРНАЛ
Вестник Торайгыров университета

Энергетическая серия
выходит 4 раза в год

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агентства и сетевого издания
№ 14310-Ж
выдано
Министерство информации и общественного развития
Республики Казахстан

Тематическая направленность
публикация материалов в области электроэнергетики,
электротехнологии, автоматизации, автоматизированных и
информационных систем, электромеханики и теплоэнергетики

Подписной индекс – 76136

https://doi.org/10.48081/ABAC7746

SRSTI 50.47.00:44.29.31:49.33.29

https://doi.org/10.48081/BLJO4853

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CAPABILITIES OF NB-IOT TECHNOLOGY FOR SOLVING TASKS OF MONITORING, ACCOUNTING AND COLLECTING DATA ON ELECTRICITY CONSUMPTION

Problems with accounting, collection and correct readings of electricity meters are of great importance when preparing and invoicing for electricity, especially in neighborhoods with private households, where the process of monitoring electricity consumption is not always provided for various reasons beyond the control of the consumer of services. The development of modern information technologies, including mobile communications using the technology of NB-IoT, allows us to solve problems related to improving the efficiency of monitoring, accounting, and data collection of electricity consumption in microdistricts not only quickly and efficiently, but also increase the management efficiency of the process of collecting meter readings, as well as reducing the costs of the Service Provider for transport services, personnel and other items of expenditure. The article presents an analysis of various brands of metering devices used in the Urker microdistrict and the use of metering devices with the support of technology NB-IoT. A simulation model of access to metering devices using the technology of NB-IoT is shown. The issues related to the causes and problems of electricity theft are touched upon. The article will be useful to students, doctoral students, engineers, anyone who is related to automation and control of technological processes and productions, as well as anyone who deals with the problems of implementing the ASUE, IoT technology.

Keywords: Internet of Things technology, accounting, collection, control, metering device, mobile operator, efficiency, mobile communication, technology NB-IoT, ASKUE technology.

Introduction

Problems related to the control, accounting and collection of electricity consumption data have been studied and are being studied by many foreign and Kazakhstani scientists and the methods proposed by them are used in practice [1]. The problem of electricity theft has always been and still is, as one of the main ones in the articles of electricity transmission organizations and operators [2–6].

In 2021–22, prices for household gas and commercial coal increased significantly, and the volume of supplies of these raw materials to the regions decreased significantly. As a result, the owners of private houses were forced to use electrical appliances for heating, which caused a sharp increase in the load on the electrical networks and electricity consumption.

In this connection, the question arose about the need to obtain data from metering devices, electricity consumption in online providing the following requirements:

- quality and accuracy of transmitted electricity consumption data;
- accuracy of calculation of electricity consumption by hourly rates;
- the ability to monitor and check the readings of metering devices;
- compliance of the readings of electricity meters with the invoices issued for payment;
- the possibility of changing hourly tariff plans;
- lack of ways to steal electricity;
- reliability and safety of the system for monitoring, accounting and transmission of electricity consumption data.

Materials and methods

Application of the automated control system, accounting and collection of readings of metering devices of consumed electricity ASKUE.

Results and discussion

The Urker residential area is located in the Yesil district of Astana, (see Figure 1). The population is more than 24,000 people, 2 schools, a hospital, a military unit, 10 restaurants and cafes, 8 bath facilities, 35 shops, 2 covered bazaars, more than 3,000 residential real estate objects have been built [7].

Figure 1– Urker microdistrict (photo obtained from open sources)

Provision of the Urker microdistrict, goes along the VL-35 kV highway «Vozdvizhenka-Maksimovka-Porcelain Factory» in the Tselinograd district with a length of 42.5 km, with the possibility of connecting new consumers.

Currently, in the world, and now in Kazakhstan, there is a possibility of using the technology (standard) of remote connection and access to electricity metering devices using TI-IoN technology. In Kazakhstan, this standard is currently provided by the mobile operator Kcell (Beeline and Tele2 are working in this direction). For the technology, in the case of organizing direct access to objects, it should be possible to organize your own IP address [7].

The disadvantages of direct access include:

- the presence of a fixed ip address in the network (binding to the provider);
- limitation of connections to the device (lack of traffic, quality of mobile channels).

These disadvantages can be eliminated by storing data in cloud technologies and using Nbi technology.

The main advantages of Quieter technology are:

- the ability to connect about 100,000 iOS devices to one cellular station (higher than other standards);
- the ability to analyze IoT data using Big Data methods.
- increase the coverage area;
- improving the quality of the network [8].

Mercury 230 metering devices installed in private homes do not have the ability to keep records and control the electricity consumed remotely using mobile technologies. Readings of consumed electricity from metering devices are taken by technical personnel, once a month. Since 2015, AREK Astana JSC has started replacing Mercury 230 metering devices with Russian-made CE 303 energy meters that support the possibility of automatic metering and data collection of electricity consumption (see Figure 2).

«The CE 303 energy meter is a three-phase, universal transformer or direct connection (depending on the version) and is designed to measure active and reactive electric energy, active, reactive and full power, energy specific losses, voltage frequency, phase shift angle, RMS voltage and current strength in three-phase four-wire alternating current circuits and the organization of multi-tariff electricity metering» [9].

Technical data are given in Table 1.

The main disadvantages of the energy meter meter CE 303 include:

Figure 2 – Electric energy consumption metering devices
Energy meter CE 303

- lack of constant access and connection in automatic mode due to the low signal level of the base stations of cellular operators;

- the number of subscribers served by the sectors of each base station far exceeds the possibilities of high-quality services for consumers of the service;

- it is not possible to support the VB-IoT technology.

- In Kazakhstan, a static meter (electronic) ORMAN is produced similar in technical characteristics to the CE 303 Energy Meter device [10]. The functionality of the metering device provides for the use of various interface devices to ensure data transmission (see Figure 3).

Figure 3 – ORMAN electric energy consumption meter
(photo obtained from open sources)

The technical characteristics of the electricity consumption meter are presented in Table 1.

The analysis of the above presented metering devices shows that they all have various disadvantages and one common one is that it is not possible to use NV–IoT technology.

Table 1 – Technical characteristics of metering devices

Functions	ОРМАН	SAURES	Энергомера СЕ 303	Меркурий 230
Number of tariff zones	4+1	4+1	4+1	4
Accuracy class	1,0	1,0	05S,1	1,0
Interface	RS485, infrared port, plc, GPRS, RF-868, loRaWan	RS485 – 2шт., RS232 – 2., Ether-net – 1p., CAN – 1p., built-in GPRS модем – 1p., digital/analog input – 4p., discrete outputs (Umax=400B, Imax=100mA) – 2p.	RS485 – 2шт., RS232 – 2шт., Ethernet – 1 p., CAN – 1 p., built-in GPRS модем – 1 p. digital / analog input – 4p, optoport, plcG3	RS-485; CAN
Average operating time to failure	210000 h	200000 h	210000 h	
Verification interval	8 years	6 years	5 years	10 years
Service life	24 years	25 years	25 years	25 years
Guarantee	1,5 years	1,5 years	3 years	1,5 years

Price in tenge	46000	63000	57000	31200
Standards support	GSM	GSM, NB-IoT, LTE	GSM,	
Manufacturer	Kazakhstan	Russia	Russia	Russia

SAURES electricity meters (see Figure 4) use this standard. Technical specifications are presented in Table 1.

Figure 4 – SAURES electricity meter (photo obtained from open sources)

All SAURES devices have the ability to:

- provide information on network failures, changes in current and voltage from basic parameters;
- the possibility of disconnecting electricity transmission services for late payment by consumers;
- provision of information data, both to the consumer and the supplier, on the amount of electricity consumed for a certain period in online mode, with the possibility of choosing the optimal tariff plan (if such exist) [11].

The monitoring and accounting device has the ability to automatically upload information data to the cloud or to the mail of the Service Provider and provide the consumer with access to information data stored in the cloud.

SAURES produces controllers that allow upgrading metering devices with the following interfaces [11]:

- RS-485;
- Wi-Fi interface with support for up to 8 pulse and 8 digital channels;
- NB-IoT interface with up to 8 analog and 32 digital channels. NB-IoT.

The simulation model of the organization of access to metering devices using NB-IoT technology has been developed in the MatLab software environment, using Simulink libraries and menus. The input data for the simulation is taken into account the connection of subscribers to the sectors of the base station. We assume that the number of connections to the metering devices of the base station is carried out with an intensity of 5 subscribers per minute.

The simulation model should simulate random moments of occurrence of requests and the time of their service in the channels, taking into account the following problems:

- the ability to service subscribers with the system;
- system performance;
- system maintenance failure;
- channel occupancy;
- average channel occupancy time;
- channel occupancy;
- channel downtime;
- downtime of the entire system;
- average number of requests in the queue;

Figure 5 shows a simulation model of organizing access to metering devices from a mobile base station using NB-IoT technology.

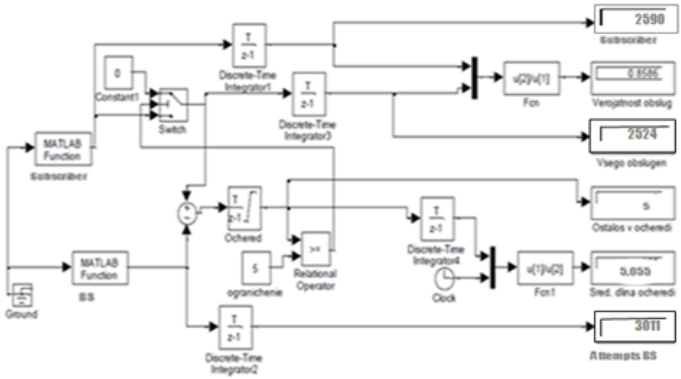

Figure 5 – Simulation model of organization of access to metering devices by a mobile base station using NB-IoT technology

The total number of base station subscribers registered in the sector of the base station is subtracted from the number of subscribers served in the «Sum» block, the remaining ones are accumulated in the «Discrete-TimeIntegrator» block.

To limit the accumulation of the «negative» queue, in the «Discrete-TimeIntegrator» block Figure 2, we check the box «Limiting output signals», then set 0 in the «Lower limit value» parameter.

The remaining «Discrete-TimeIntegrator» blocks summarize the input signals and do not require further configuration (see Figure 6).

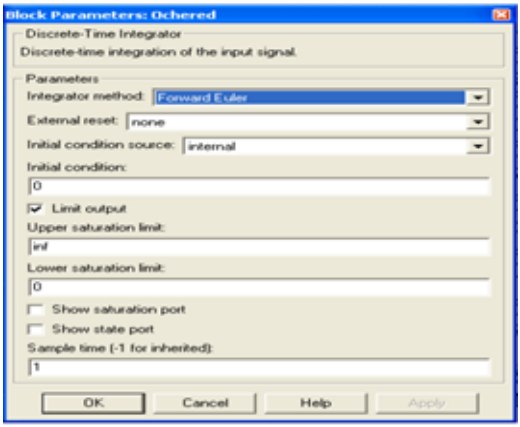

Figure 6 – Making changes to «limiting output signals»

The «RelationalOperator» block checks the dimension of the queue with a limit of 5 subscribers, if the queue is larger than 5, it sends a control signal to the «Switch» block – a switch that restricts the input, not skipping the signal from the «MATLAB Fcn» block, but skipping 0.

The results of simulation modeling of the organization of access to metering devices by a mobile base station using NB-IoT technology by a mobile base station for various time intervals are presented in Table 2.

Table 2– Results of modeling the organization of access to metering devices by a mobile base station using the NB-IoT system technology by a mobile base station for various time intervals

Simulation time	Subsriber	Verojatnostobslug	Vsegoobslug	Ostalos v ocheredi	Sred. dlinaocheredi	Attampts BS
600	2970	0,8586	2524	5	5,055	3011
1200	5940	0,8572	5049	5	5,057	6019
1800	9090	0,8541	7650	5	5,058	9024

The simulation results show that the base station provides remote access to electricity metering devices and service providers in more than 85 % of cases.

Conclusions

Metering devices with support of NB-IoT technology will allow to ensure an increase in the efficiency and quality of accounting and data collection of electricity consumption in the Urker microdistrict due to:

- accuracy, reliability, control and analysis of these indications;
- detection of cases of unauthorized interference and theft of electricity;
- the possibility of remote disconnection / connection of electricity to consumers.
- obtaining reliable bills for the consumed electricity;
- obtaining data on cases of technical losses in networks.
- saving financial costs;

With the average monthly electricity consumption of one household amounting to 400 kW/h, the introduction of metering devices with the support of NB-IoT technology, energy savings for one household will amount to 10–15 % per year or 10958 tenge (with a tariff for individuals of 15.22 tenge per 1 kW/h [12–13].

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Material received on 20.06.23.

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Материал 20.06.23 баспаға түсті.

ЭЛЕКТР ЭНЕРГИЯСЫН ТҰТЫНУДЫ БАҚЫЛАУ, ЕСЕПКЕ АЛУ ЖӘНЕ ДЕРЕКТЕРДІ ЖИНАУ БОЙЫНША МІНДЕРТТЕРДІ ШЕШУ ҮШІН NB-IoT ТЕХНОЛОГИЯСЫНЫҢ МҮМКІНДЕКТЕРІ

Электр энергиясын есепке алу аспаптарын есепке алу, жинау және дұрыс көрсету проблемалары электр энергиясы үшін төлем жасауға, әсіресе шағын аудандарда, жеке меншік үй-жайлары бар шоттарды дайындау және ұсыну кезінде үлкен маңызға ие, мұнда электр энергиясын тұтынуды бақылау әрдайым қызмет тұтынушысына байланысты емес түрлі себептер бойынша қамтамасыз етілмейді. Қазіргі заманғы ақпараттық технологияларды, соның ішінде мобильді байланысты дамыту NB-IoT технологиясын қолдану арқылы шағын аудандарда электр энергиясын тұтынуды бақылау, есепке алу, деректерді жинау тиімділігін арттыруға байланысты мәселелерді шешуге ғана емес, сонымен қатар есептеу құралдарының көрсеткіштерін жинау процесін басқарудың тиімділігін арттыруға, сондай-ақ қызметтерді жеткізушінің көлік қызметтеріне шығындарын азайтуға мүмкіндік береді. қызметкерлер және шығыстардың басқа баптары бойынша. Мақалада Үркер шағын ауданында қолданылатын есептеу құралдарының әртүрлі маркаларына талдау және NB-IoT технологиясын қолдайтын есептеу құралдарын қолдану ұсынылған. NB-IoT технологиясын қолдана отырып, есептеу құралдарына қол жеткізудің модельдеу моделі көрсетілген. Электр энергиясын ұрлаудың себептері мен проблемаларына байланысты мәселелер қозғалды. Мақала студенттерге, докоранттарға, инженерлерге, технологиялық процестер мен өндірістерді автоматтандыру мен басқаруға қатысы бар барлық адамдарға, сондай-ақ ЭКЕАЖ, IoT технологиясын енгізу мәселелерімен айналысатын барлық адамдарға пайдалы болады.

Кілтті сөздер: интернет заттары технологиясы, есепке алу, жинау, Бақылау, есепке алу аспабы, ұялы оператор, тиімділік, ұялы байланыс, NB-IoT технологиялары, ЭКЕАЖ технологиясы.

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Материал поступил в редакцию 20.06.23.

ВОЗМОЖНОСТИ ТЕХНОЛОГИИ NB-IoT ДЛЯ РЕШЕНИЯ ЗАДАЧ ПО КОНТРОЛЮ, УЧЕТУ И СБОРУ ДАННЫХ ПОТРЕБЛЕНИЯ ЭЛЕКТРОЭНЕРГИИ

Проблемы с учетом, сбором и корректными показаниями приборов учета электроэнергии, имеют большое значение при подготовке и выставлении счетов на оплату за электроэнергию, особенно в микрорайонах, с частными домовладениями, где процесс контроля за потреблением электроэнергии не всегда обеспечивается по различным причинам не зависящим от потребителя услуг. Развитие современных информационных технологий в том числе мобильной связи с использованием технологии, NB-IoT, позволяет решать задачи связанные с повышением эффективности контроля, учета, сбора данных потребления электроэнергии в микрорайонах не только оперативно и качественно, но и повышают эффективность управления процесса сбора показаний приборов учета, а также снижение затрат Поставщика услуг на транспортные услуги, персонал и по другим статьям расходов. В статье представлен анализ различных марок приборов учета используемых в микрорайоне Уркер и применение приборов учета с поддержкой технологии NB-IoT. Показана имитационная модель доступа к приборам учета с использованием технологии NB-IoT. Затронуты вопросы, связанные с причинами и проблемами хищения электроэнергии. Статья будет полезна студентам, докторантам, инженерам, всем, кто имеет отношение к автоматизации и управлению технологическими процессами и производствами, а также всем, кто занимается проблемами внедрения технологии АСКУЭ, IoT.

Ключевые слова: технология интернета вещей, учет, сбор, контроль, прибор учета, мобильный оператор, эффективность, мобильная связь, технологии NB-IoT, технология АСКУЭ.

Теруге 20.06.2023 ж. жіберілді. Басуға 30.06.2023 ж. қол қойылды.
Электрондық баспа
17,5 Mb RAM
Шартты баспа табағы 22,67. Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген: А. Мыржикова
Корректор: А. Р. Омарова
Тапсырыс № 4103

Сдано в набор 20.06 2023 г. Подписано в печать 30.06 2023 г.
Электронное издание
17,5 Mb RAM
Усл. печ. л. 22,67. Тираж 300 экз. Цена договорная.
Компьютерная верстка: А. Мыржикова
Корректор: А. Р. Омарова
Заказ № 4103

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