UDC 620.9:656.71

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OPTIMIZATION AND IMPLEMENTATION OF ENERGY SAVING PROGRAMS AT AIRPORTS

Airports are considered from the point of power consumption for the provision of technological processes. The study is aimed to define the potential for energy conservation at airports of Ukraine and for the improvement of environment quality at the adjoined area. The major reasons of energy losses at airports are defined. The best practices of energy saving solutions in European countries are analyzed and recommended for application in Ukrainian airports on the example of the International Airport "Kyiv". The environmental effects and economic efficiency of energy conservation projects and prospects of their implementation are considered for the International Airport "Kyiv".

Keywords: airport, energy efficiency, energy conservation opportunities, environmental efficiency.

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ОПТИМІЗАЦІЯ ТА ВПРОВАДЖЕННЯ ПРОГРАМ ЕНЕРГОЗБЕРЕЖЕННЯ В АЕРОПОРТАХ

У статті розглядаються аеропорти з точки зору споживання енергоресурсів для забезпечення технологічних процесів. Дослідження спрямоване на визначення енергозберігаючого потенціалу в аеропортах України і можливостей підвищення якості навколишнього середовища на прилеглих територіях. Визначені основні причини втрат енергії в аеропортах. Проаналізовані кращі практики енергозберігаючих рішень в Європейських країнах і рекомендовані для застосування в українських аеропортах на прикладі Міжнародного аеропорту "Київ". Розглянуті екологічні переваги і економічна ефективність проектів енергозбереження і перспективи їх впровадження для Міжнародного аеропорту "Київ".

Ключові слова: аеропорт, енергоефективність, енергозберігаючі заходи, екологічна ефективність.

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ОПТИМИЗАЦИЯ И ВНЕДРЕНИЕ ПРОГРАММ ЭНЕРГОСБЕРЕЖЕНИЯ В АЭРОПОРТАХ

В статье рассматриваются аэропорты с точки зрения потребления энергоресурсов для обеспечения технологических процессов. Исследование направлено на определение энергосберегающего потенциала в аэропортах Украины и возможности повышения качества окружающей среды на прилегающей территории. Определена основная причина потерь энергии в аэропортах. Проанализированы лучшие практики энергосберегающих решений в европейских странах и рекомендованные для применения в украинских аэропортах на примере Международного аэропорта "Киев". Рассмотрены экологические преимущества и экономическая эффективность проектов энергосбережения и перспективы их внедрения для Международного аэропорта "Киев".

Ключевые слова: аэропорт, энергоэффективность, энергосберегающие мероприятия, экологическая эффективность.

Introduction. At present, energy conservation occupies a key position in the development of economy and markets of consumer services and materials. The use of alternative energy sources, energy-saving materials and technologies become increasingly popular, providing additional and primary energy sources, thus releiving the user's dependence on centralized energy networks and reducing the consumption of fuels and energy.

Energy saving and energy efficiency issues are also connected with environmental safety. The life of humans in modern urban systems is under the constant threat of negative influences, caused by technogenic environment pollution. This pollution is produced mostly by power generating facilities and facilities of fuel consumption. From this point, reduction of power resources consumption is the direct way to improve the environment quality at urban areas. From the other point, implementation of new technologies in the field of power economy optimization is limitted with environmental safety of the relevant equipment, materials, alternative fuels etc. Moreover, the energy efficiency is first of all conditioned by the need to reduce the anthropogenic pressure on the environment and provide the needs of future genrations.

So, energy efficiency is currently one of the main trends of both domestic and global economy. Therefore for Ukraine, which was not properly engaged into the process of energy saving during long period, the trend is now a major motion vector of economic development. An important participant of the energy saving technologies implementation is transport of all kinds, and especially air. This is because the aviation industry combines two components: capital construction (construction of airports), extensive infrastructure and strong volumes of energy consumption, including fuel.

Thereby, the **purpose of the research** is to define the potential for energy conservation at airports of Ukraine and for the improvement of environment quality at the adjoined area.

The development of energy efficiency technologies in Ukraine. Acting Ukrainian legislation on energy efficiency is quite imperfect. In order to create sufficient legal basis and ensure the appropriate level of energy efficiency in all sectors of economy production, the Office on Energy Efficiency Regulation has carried out work on preparation and amendment of 25 draft legal acts and provided comments on 40 regulations and legal acts.

Legislation in the field of energy efficiency, as a branch of the national legislation was initiated by the Law of Ukraine "On energy saving". This law was developed in the midst of the economic crisis of 1994. It was supposed to provide the system of institutional, regulatory and incentive measures to implement the mode of rational use of fuel and energy resources, but this law, like most others adopted at the time, is not the law of direct action and most of its provisions are declaratory and have referential character.

At the same time many scientists have paid attention to the development of theoretical grounds for energy optimization of Ukrainian economy and experience of their application. Thus, the leading specialists on energy efficiency in this field B.S. Stogniy, M.M. Kulik, V.A. Zhovtyansky have published a fundamental work "Energy Conservation Strategy in Ukraine: Analytical and Reference Materials" in two volumes. The first book summarizes the first experience of public administration in the field of energy saving in Ukraine compared with the achievements in the other countries. The second book contains practical materials primarily related to power management methods in manufacturing, financial and economic mechanisms of energy conservation, information and international experience in this field.

Among other important works in the field there are studies by A. Shcherbina, A.K. Shydlovsky, G.T. Vasyukov, G.M. Kaletnik, I.P. Vasilyev, V.S. Samokhvalova, Korchevoy Yu.P, Maystrenko A.Y, Topal A.I, Rozen V.P. dealing with management fundamentals of energy conservatiom, alternative fuels application on transport, environmental efficiency of non-conventional power generating facilities, secondary energy resources and energy efficiency.

The issues of energy consumption optimization at airports were considered by Rozen V.P., Sokolova N.P., Zakharchenko V.P., Leschynsky O.L., Konovalyuk V.N., Velychko Yu.K., Kozlov V.S. and others [1-4]. They have highlighted the major problems and opportunities for the im-

provement of energy efficiency at airports. Thus, according to their experience, the analysis of power management at the world airports, especially those within the same climatic zone with Ukraine, can not be provided with adequate assessment due to closed access to the information on power consumption. Based on the statistical data on power consumption collected at airports in Ukraine during 2002-2013 years by Zakharchenko V.P. and Sokolova N.P. despite the stable trend to growing volume of electricity consumption for all airports, there are considerable variations of power consumption characteristics in time and regions [1]. One reason is the lack of clear system of energy economy management.

Issues of airports energy economy. Practically, the major energy consumers in airports are illumination, steam and heating systems, climate control systems and comfort provision systems. The specific trait of airport energy economy is the need to support constantly the activity of certain systems, decisive for airport functioning. This is first of all related to the illumination of runways, aprons and terminals, climate control systems provision, power supply of navigation and routing systems, as well as safety control systems, heating of terminals and fuel supply systems. It is impossible just switch off these systems, as it will ruin all the work at an airport. In much the same way it is not possible to reduce the intensity of illumination without increasing accidents risks or change productional capacities of an airport without reduction of its ecomonic characteristics.

Nevertheless, accurate planning, control and management of technological processes, their thorough distribution creates opportunities for the reduction of energy consumption. Improving energy efficiency of production, services and maintenance sectors of airport activity, requires a well thought out and clearly defined specific goals and methods of achieving them, which can be the basis of energy efficiency programs. Practical implementation of the program to a large extent may find support in direct material benefitsipants. Comparative characteristics of energy-saving materials allow making the best choice given the necessary properties and qualities when planning work to improve energy efficiency of airports.

Energy conservation opportunities for airports. To address the problem of energy losses at airports efficiently it is necessary to use complex automated systems of power management based on the latest developments from the leading equipment manufacturers such as Danfoss, ABB, Carrier, Siteco. These solutions must be integrayed into the structure of airports starting from the project design stage or as a result of major reconstruction. In particular, the use of interface design method provides adaptation of all the engineering systems to each other, and to architectural, construction and technological parts of the project as well. This improves the efficiency and reliability of systems, reduces tion duration and cost of design and value of the facility. As a result, airport buildings are built with modern European standards of energy efficiency.

Thus, energy efficient solutions for illumination include installation of daylight reflection systems, allowing redirection of the most of light into the premises during the daytime. Besides the obvious energy savings, it helps create a soft even illumination in the rooms, comfortable for visitors. Although the intensity of this daylight illumination depends on the level of natural light and must be adjusted automatically or supplemented with electric illumination.

Centralized illumination control system also allows the operator manage apron illumination, litting it and adjacent areas when the platform is occupied with aircraft, boarding on or off is carried out and other operations are performed. In the airport waiting areas and terminals lighting is automatically scheduled and adjusted to the timetable of arrivals and departures.

Equally interesting solutions can be used to optimize the management of microclimate. The airport interior is excessively heated by the direct sunlight, illumination, various technological equipment and people within. So, to neutralize the excess heat effectively the special circuits with variable cooling media flow are used. It is supplied only to those areas where and when sensors record the air temperature rise above the level comfortable for visitors or staff, for example - in the terminal area under daylight. The extracted heat is also a valuable resource and must be reused, which is performed with the systems of heat recuperation. Thus, 85% heat energy, present in the exhaust air, is returned through the energy recovery equipment to the heating system - at present the most efficient energy-saving technology [5].

Efficient heating system is essential for complete climate control of airport in temperate latitudes. Its stable operation should be provided by two or more independent sources of heat, as this allows running them separately if required level of heat is insignificant, and thus reducing energy consumption for the functioning of heating system. To ensure efficient distribution and use of thermal energy systems, both heating and refrigerating, the terminal must be equipped with automatic balancing valves providing balanced flow of coolant in different parts of the building.

Climate control systems also involve management of ambient parameters in terminal buildings by means of electronics, computer network related to the airport. This allows implementing the principle of preventive climate control, when ventilation and air conditioning system are adjusted automatically to increase or decrease the intensity of work based on the analysis of information coming from the CO_2 sensors and data about passenger traffic in a particular area of the terminal. The heart of these technologies is the dynamic modeling of heat transfer processes.

Electricity must be also supplied to terminals from several independent energy centers, which airport is connected through several transformer substations. It is necessary for the organization of uninterrupted electricity supply of security, telecommunication and navigation systems and should not turn off for a second, even in cases of accidents. Redundant power systems provide airport needs even in the case of complete disabling of the entire electrical system. However, it is possible to find the way to saving costs and resources by optimizing the project solutions and using energy-saving equipment electrical system – the result may achieve 20% reduction in energy losses. This result is provided by the implementation of reactive power compensation, which reduces the total load on transformers and power lines. The use of lighting equipment with electronic adjustment reduces power losses by 10% [5].

Dispatching and control over the operation of all engineering and information systems in terminals using automated system of supervisory control also contributes to reducing energy losses. The system controls the operation of cooling, heating, electricity, illumination, heat stations, water stations, water cooling, ventilation systems, transformer substations, switching centers. All mechanical, electrical, telecommunications systems and airport security have to work automatically, and their centralized control and operation management is performed by control center.

Automation control equipment opens the way to reducing the number of necessary operations and terminal personnel, minimize errors caused by human factor, increase the reliability and safety of all engineering information infrastructure at the airport.

In addition to these management functions, centralized controlling system software is able to collect and process data on power consumption, allowing operators to monitor energy use, identify trends, make appropriate decisions and implement corrective measures to improve energy efficiency, especially in terms of electricity.

Case studies of energy efficiency projects for airports. The pioneering representatives of the branch in energy saving solutions are the Heathrow Airport, Great Britain, Munich Airport, Germany, and Vnukovo Airport, Russian Federation [5].

Thus, Heathrow Airport has developed complex program on energy conservation, approved by the state government and airport managers. The certain points of the program to improve energy efficiency in Heathrow Airport include regulation of illumination to cover only the areas being used, heat and cold recovery, power disabling for the equipment not used.

HVAC systems and operations at Munich Airport include the classic management functions for energy saving in combination with a number of specially developed intelligent functions. CPS implements energy optimization program for remote buildings, as well as areas of outputs, including lighting and temperature control. Individual controllers in premises regulate temperature and ventilation in approximately 1,700 rooms throughout the airport, allowing operators to accurately manage energy use and support comfort levels of ambient parameters.

At the Terminal A at Vnukovo airport, all large premises are equiped with the system of daylight reflection, allowing the best use of it in the daytime. Besides the split system of heat generation, the systems of heat recovery provide regulation of microclimate parameters and formation of energy reserve for heating. The intensity of power supply for ventilation and lighting depends on the level of terminals traffic load and number of passengers and services provided [5].

The main air gate of Ukraine, the Boryspil airport, has begun to implement the energy saving technology trying to reduce power and natural resources consumption. Thus, easy to operate systems for the daylight reflection are installed in all major halls, allowing minimal use of artificial illumination during the most of daytime. The expected reduction of energy consumption will be 12-15% [5]. Application of such systems has also decent payback period which is said to be 4-5 years at the most.

Prospects for energy conservation in the International airport "Kyiv". Kyiv International Airport (Zhuliany) is one of the two passenger airports of the Ukrainian capital Kiev. It is owned by the municipality of Kiev and located in the southern Zhuliany neighborhood of the city. Aside from facilitating regular passenger flights, Kyiv International Airport is also the main business aviation airport in Ukraine, and one of the busiest business aviation hubs in Europe.

After Ukraine gained independence in 1991, "Kyiv" airport began receiving international flights from nearby countries, but in 2011, when Wizz Air, the locally-pioneering low cost airline, had moved all its operations to "Zhuliany" from the Boryspil Airport, the new era of around-the-clock flights at the airport started and the passenger traffic increased by 1520% [6]. The new "A" terminal opened in 2012, now receives all international and some domestic flights. Projects for expanding Zhuliany's taxiways and aircraft parking lots considered as well, unfortunately, the issues of energy conservation are not sufficiently covered in these plans.

However, our investigations have showed that the following measures will be highly efficient:

- installing energy efficient lighting with motion sensors throughout the airport;
- natural illumination indoors for passengers in terminals;
- double glass windows and solar shading devices, providing natural light penetration into the building, but minimizing heat received from the sun;
- turn off escalators and baggage lines at night;
- turn off peripheral illumination in daytime.

The overall effect of this complex of activities will lead to reduction of energy consumption by 19-27%, depending on the intensity of energy conservation opportunities implementation. Even under the minimal scenario, the manetary value of the project will be equal to 627 kW of energy capacity, which a dramatic improvement. In applied presentation this volume of energy can provide heating for two 16-storey residential buildings. The payback period for the corresponding capital investments will range from 7 to 11 years, but considering the the instability on energy resources provision typical for current economicand political situation in Ukraine, the need to invest in energy efficiency improvement turns to be the need of survival importance.

Environmental efficicency of energy conservation activities. Energy saving makes it possible to reduce the pressure both on the energy economy and environment. Environmental effect is not limited merely to the decreased consumption of natural resources. Each saved calory of heat or kilowatt-hour of electricity also provide significant environmental benefits at all previous stages of energy generation, associated with fuel extraction, enrichment, processing and transport; production, transportation of electrical and thermal energy to the consumer and its distribution [7].

For example, every saved thousand of kilowatt-hours on average prevents emission of 4.2 kg of solid particles, 5.65 kg of sulfur oxides, 1.76 kg of nitrogen oxides and saved Gcal of heat - 2,2 kg of solid particles and 3 kg of sulfur oxides and about 1 kg of nitrogen oxides emissions [7]. Given this, the perspective reduction of energy consumption at Kyiv International Airport, based on our calculations, will be equivalent to the emissions of solid particles decreased by 9.48 t, sulfur oxides emissions decreased by 12.75 t and nitrogen oxides emissions decreased by 3.97 t every year. The resulted effect will include lower contribution of airports activity to greenhouse effect enhancement, atmosphere dimming and intensity of acid rains formation.

Conclusions. The potential development of energy-saving technologies and energy efficiency in all areas of human activity can be compared as a whole with the potential to increase economic performance of the country and its resource base, which is especially important for Ukraine.

Among the barriers to the development of energy saving and energy efficiency in our country is mostly the lack of motivation, including among government authorities, insufficient information support, lack of experience in financing energy efficiency projects, lack of organization and coordination of implementation. Such a barrier as technology drawback is, to date, substantially removed, including through the investments from the developed countries. Currently the market has a very wide range of energy efficient equipment, energy-saving materials and a range of consulting services on energy conservation and efficiency, creating a strong infrastructure base. This is also valid for airports as they are the facilities with extremely high and expensive energy consumption, conditioned in many cases by safety and functionability. Nevertheless, leading airports of Europe show strong potencial of energy conservation, which could be applied in Ukraine for major airports. The investigations show that implementation of the basic set of energy saving recommedation releases energy capacity enough to provide the needs of residential blocks and leads to reduction of emissions related to greenhouse effect enhancement, atmosphere dimming and intensity of acid rains formation.

Список літератури

1. Захарченко В.П. Модель управління ефективністю споживання обсягу електричної енергії аеропортами / В.П. Захарченко, Н.П. Соколова // Восточно–Европейский журнал передовых технологий. – 2014. – №5 (71). – С. 9–15.

2. Величко, Ю. К. Електроснабжение ааропортов / Ю. К. Величко. – К.: КМУГА, 1996. – 312 с.

3. Лещинський, О. Л. Модель прогнозування обсягу споживання електричної енергії світлосигнального обладнання аеропорту / О. Лещинський, В. Коновалюк, Н. Соколова // Технологический аудит и резервы производства. – 2014. – Т. 2, № 1 (16). – С. 27–31.

4. Розен, В. П. Управління режимом електроспоживання промислового підприємства / В. П. Розен // Промелектро. – 2005. – № 6. – С. 35–41.

5. Авіаційна екологія / С.В. Бойченко, М.М. Радомська, Л.М.Черняк, О.В. Рябчевський, Л.І. Павлюх. – К. : НАУ, 2014. – 160 с.

6. Офіційний сайт Міжнародного аеропорту «Київ» (Жуляни) [Електронний ресурс] / Режим доступу: www.airport.kiev.ua. – Назва з екрану.

7. Самохвалов В. С. Вторинні енергетичні ресурси та енергозбереження / Самохвалов В. С. – К.: Центр учбової літератури, 2008. – 224 с.

References

1. Zakharchenko, V.P., Sokolova, N.P. (2014), “The model of power consumption efficiency management at airports”. Eastern-European Journal of Enterprise Technologies, vol. 5, no 71, pp. 9–15.

2. Velichko, Yu. K. (1996) *Elektrosnabzhenie aeroportov* [Power supply of airports]. National Aviation University, Kyiv, Ukraine.

3. Leshchinskiy, O. Konovalyuk, V., and Sokolova, N. (2014), “Model of prognosis of power consumption volumes by the illumination equipment of airport”. Tekhnologicheskiy audit i reservi proizvodstva, vol. 2, no. 1 (16), pp. 27–31.

4. Rozen, V. P. (2005), “Management of power consumption mode of industrial enterprise”. Promelektro, no. 6, pp. 35–41.

5. Boychenko S.V., Radomska M.M., Chernyak L.M., Ryabchevskiy O.V., and Pavlyukh L.I. *Aviatsiyna ekologiya* [Aviation ecology], National Aviation University, Kyiv, Ukraine.

6. The official site of International airport «Kyiv» (Zhulyani) [Digital resource] / Access mode: www.airport.kiev.ua.

7. Samokhvalov, V. S. Vtorinni energetychni resursy ta energozberezhennya [Secondary power resources and energy conservation]. Tsentr uchbovoi literatury, Kyiv, Ukraine.

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