ECONOMIC AND TECHNOLOGICAL FACTORS OF IMPROVEMENT OF BUILDING AIR CONDITIONING SYSTEMS

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ABSTRACT: The article considers the economic and technological factors of improving the air conditioning systems of commercial and office facilities. It analyzes both electric and other 'green' air conditioning systems. Engineering systems and networks wear out to a much greater extent than buildings, due to the phenomena of material and moral deterioration. Traditional buildings, especially old ones, require an individual approach to the construction of air conditioning systems. The synergistic effect in air conditioning systems can be extracted by combining various power units that make up such systems and using alternative energy sources in them. The development of information technology contributes to the effective solution of the problems of conditioning buildings based on control computer programs.

Keywords: ecology, economic efficiency, heat transfer, wind generators, solar cells, geothermal plants.

INTRODUCTION

The modern information society is focusing more and more on improving the quality of interaction between participants in socio-economic practice. In a broad sense, this implies not only the optimal use of resources, but also the most complete respect for the interests of participants. The range of such interests includes both ensuring proper working conditions for direct workers, as well as visitors to premises, and environmental protection (population). Every year, sanitary requirements for sports and entertainment, retail, office, industrial and other buildings are tightened not only to maintain a favorable internal microclimate, but also to neutralize their aggressive impact on nature - primarily air and water basins. The result of the interaction of an operating facility and the surrounding area should be the achievement of the maximum socio-economic effect. Together, this interaction falls under the definition of "synergy" (cooperation, joint activity). G. Haken defines synergetics as the science of interaction, engaged in the study of systems consisting of a very large, huge number of parts, components or subsystems, in a word, parts that are in a complex interaction (Haken, 2003). A territorial economy, where there are close dependencies of functioning objects and the environment regarding the use of natural, labor, energy and other resources, has increasingly strident manifestations of synergetics in the reproductive process. An imbalance in such interactions can cause a decrease in the stability of the system. With the development of engineering and technology, production complications, requirements for working conditions, service conditions and, in general, the quality of the corresponding ecosystems increase; at the same time, the spectrum of energy sources suitable for use is expanding (Beliaev, 2003). The essence of synergetics is manifested in the rational combination of not only macro formations, but also the elements (components) of internal systems. With regard to air conditioning systems of buildings (premises), this can be manifested in the rational selection (by the principle of complementing functions) of high- and low-performance equipment (large and small air conditioners).

Currently, one of much-debated topics in the scientific community and public life is the “sustainable development” of the world economy, continents, countries, large and small territories. At the micro level, this is manifested in the achievement of the stable functioning of large- and small-scale enterprises, which is the basis for the well-being of their workers and members of their families. Ideological views about the integral unity of the earthly, as a kind of "noosphere", were put forward in the works by academician V.I. Vernadsky. The fundamental principles of the theory and methodology of the stable functioning of territorial economic systems are formed in the works by the American researcher W. Isard (Isard, 1966), as well as Russian scientists A.G. Aganbegian, A.G. Granberg, N.N. Nekrasov, and V.M. Polterovich. O.V. Inshakov, Iu.S. Kolesnikov, and V.N. Ovchinnikov in their works study the active function of regional institutions in the sustainable functioning and development of territories in the context of an increasing environmental factor. (Ovchinnikov & Zhuk, 2009). The works by G.G. Vukovich, A.A. Gavrilov, V.A. Sidorov, I.V. Shevchenko are devoted to the achievement of the stable functioning of business entities at the macro and micro levels, and the development of appropriate management tools. Economic and environmental factors of various technologies are investigated in the works by Iu.M. Beliaev, and S.E. Shmelev (Beliaev, 2003). The problems of the balanced use of natural resources are considered in the works by A.R. Popov (Popov, 2011). Issues of improving the energy source application technology associated with the regulation of ecosystems are described in the works by O.I. Viitovich, and V.G. Teleshov (Viitovich & Teleshov, 2010). The use of wind energy is considered in the works by E.M. Fateev, and Iu.M. Beliaev (Fateev, 1948). Modern technologies for the use of heat pumps based on the use of secondary energy resources are considered in the works by G.P. Vasiliev, L.V. Khrustachev (Vasiliev et al., 2001). Issues of the cold storage battery application efficiency are covered in the works by A.A. Krainev (Krainev et al., 2012). Building air conditioning technologies through the use of solar energy are considered in the works by A.I. Alifanov, K.V. Plotnikov, and A.S. Seminenko (Plotnikov et al., 2014).

Nevertheless, technological progress, the high variability of the conditions for the functioning of socio-cultural and production facilities, the tightening of requirements for the sustainable development of spatial systems determine the need for additional research on a number of related scientific and applied aspects. Issues of a rational combination of society, production and ecology, additional engineering and economic research in efficient air conditioning of buildings as an important factor in positing positive industrial and living conditions of people require further research (Sidorov, 2011; Ivanov, 2019; Ivanov & Muminova, 2016; Volkov et al., 2017; Karpanina et al., 2018; Mikheev et al., 2019; Stepanov et al., 2019; Sekisov et al., 2019; Soleymani, et al 2014). The study of the problem of improving the air conditioning systems of buildings was carried out in terms of the dialectical, reproductive, and system-synergetic approaches. As the main object of study, the production and economic processes for ensuring the specified climate parameters of large rooms are determined; the subject of the study was the relationship of individuals and organizations regarding the implementation of the above practices and its trends. The scientific and educational literature, regulatory documents, SNiPs, SanPin, articles in periodicals, data from state statistical reports, information from enterprises, and personal observations of authors serve as an information base for analyzing the state and processes in the studied area of public practice. The study of the state and processes was carried out by methods of comparison, extrapolation, structural, functional-cost, deductive and inductive analysis (Merkibayev et al, 2018).

RESULTS

The study of the scientific and applied problem of ensuring the balanced functioning and development of technological systems for air conditioning of buildings in combination with the interests of their owners, management, staff, visitors, as well as the surrounding society found that it is advisable to carry out its solution in terms of a system-synergetic and reproductive approach. The need to improve air conditioning machines and equipment from the standpoint of increasing its energy efficiency and environmental friendliness is becoming more relevant. According to the Hygienic requirements for the microclimate of industrial premises (SanPiN 2.2.4.548-96 of 12.29.10), the air temperature at workplaces should be in the range of 18-24°C, relative air humidity should be 40-60%, air velocity should not exceed 0.1 m/s. As for sports and entertainment facilities, the boundaries of permissible deviations are somewhat wider - it depends on the type of their purpose. The above-mentioned parameters of the indoor microclimate should be ensured by air conditioning systems (cooling, heating, humidification, ventilation). In terms of the economic and technological approach, air conditioning systems of buildings should meet the requirements of productivity and economic efficiency that are maximally achievable at the modern level of technical development. This comprehensive indicator is crucial in the choice of conditioning technology (physicochemical processes and equipment) in each case, given that the latter meets the requirements of environmental protection (social interests).

Comprehensive reproductive focus on the public economy has been accentuated by the world community since the 1960s, when unilateral (non-renewable) consumption of natural resources reached its economic and technological maximum and environmental problems became more acute. A resolution of the UN Stockholm Conference on this issue (1972) noted that maintaining and improving the quality of the human environment is an important issue affecting the welfare of peoples and the economic development of all countries of the world (Stockholm Declaration, 1972; Baykalova, et al 2018). In 1987, the “Our Common Future” Report, prepared by the UN Commission on Environment and Development, used the term “sustainable development” and formulated the following definition: “Sustainable development is a development that meets the needs of the present time, but does not jeopardize the ability of future generations to satisfy their own needs” (UNCED, 1989). Agenda 21, adopted by the United Nations Conference on Environment and Development in Rio de Janeiro (1992), notes that an integrated approach to environmental and development issues will help meet basic needs and increase living standards of the entire population, more effective protection and rational use of ecosystems, ensuring a safe and prosperous future (Agenda 21. UN Document A). Modern technologies are developing towards the increase in the efficiency of machines and assemblies, in parallel with a decrease in their aggressive effect on the environment; an active search is underway for new sources of energy, methods for their involvement in the economy. Thanks to the work carried out, emissions of harmful substances into the atmosphere are reduced: in Russia this indicator decreased from 32.4 million tons in 2000 to 31.6 million tons in 2016; the volume of used and neutralized waste increased during this period from 46.0 million tons to 3243.7 million tons (Russian Statistical Yearbook. 2017). For example, in the Krasnodar Territory, current (operational) environmental protection costs increase annually and in 2018 amounted to 14,579.5 million rubles (in 2017 11755.2 million rubles), or about 3 thousand rubles per person; the costs of protecting the air and preventing climate change in the region annually amount to about 1 billion rubles (Krasnodar Territory in figures, 2018; Barreto, & Alturas, 2018). Climate requirements are increasing for residential premises. One of the pressing technical and economic problems is a favorable indoor climate, mainly cooling and heating within the required temperature range. Maintaining a given microclimate in large rooms is complicated by the presence of complex systems of air distribution, air exchange, as well as increasing requirements to neutralize the products of their functioning. An important aspect of the problem of air conditioning is the fact that engineering systems and networks are subject to wear much more than buildings. Under the influence of technological progress, engineering systems also undergo obsolescence, which entails their depreciation, lower use and exchange value. This makes it advisable to partially or completely update such systems for at least five years.

In sports and entertainment, retail and office premises, the conditioning problem requires its comprehensive solution: on the one hand, it is necessary to provide favorable conditions for the efficient work of staff, and on the other, to create a sufficient microclimate for visitors. Naturally, the boundary climate parameters for these groups of individuals can vary significantly. For the visitor, certain temperature limits are mostly important - quite different depending on the purpose of the room - and ventilation. The climate requirements for the staff are quite uniform: the workplace should aim for work, increase its productivity, and optimize the processes of labor activity. This is called comfort in the workplace. Observations show that the air, as a rule, contains a large amount of dust and, microorganisms that adversely affect the lungs and the body in general. The human body has a constant temperature - +36.6 degrees. The body works best only when the heat of the body goes into the environment through evaporation and radiation. In an excessively dry room, the mucous membranes of the body evaporate moisture and dry out, microbes get into small cracks, and the inflammatory process begins. Salts that retain moisture in the cells leave the body together with water; dehydration impairs the functioning of the intestines and kidneys, thickens blood, heart function becomes difficult, blood vessels become clogged. To avoid dehydration, the humidity of the air in the workrooms should be within 40-70%. In turn, excessive air humidity also depresses the body, reduces its immune resistance.

The aggregates of the above requirements are designed to meet such air conditioning systems of buildings, which are capable of differentiated (selective) mode to maintain the proper microclimate for both employees and visitors. This is due to both social and technical and economic imperatives. The level of technical development reached to date allows involving both traditional and new sources of energy in the use. For example, according to experts, the Krasnodar Territory has the following resources per year: geothermal energy - 750 million standard fuel, solar energy - 0.3 million tons, wind energy - 0.4 million tons of fuel equivalent. In total, it is about 30-40 times more than what the economy of the region currently consumes (Beliaev, 2003). The Republic of Adygea has approximately the same energy resources per unit area of the territory. The traditional heating methods for large rooms include the use of air heaters that operate on hot water, steam, as well as other sources of air-transferred heat. As for the cooling and ventilation of rooms, a wide variety of machines and equipment have been created that operate on electricity and other energy sources (gas, sunlight, thermal waters and stones, the atmosphere, etc.). In terms of technical and economic feasibility, their use requires a differentiated approach, depending on the nature of the social and production problem being solved. In general terms, it seems possible to distinguish the following internally homogeneous groups of building air conditioning systems:

Compression air conditioners

The principle of operation of such air conditioners is exactly the same as of refrigerators. These air conditioners consist of the same elements - evaporator, condenser, compressor. A low-boiling freon is used as a refrigerant and ensures cooling of the air in the room. As with any other liquid, the boiling temperature of freon directly depends on pressure. The lower the pressure is, the lower the boiling point is. Liquid freon boils in the evaporator, where the pressure is so low that vaporization occurs at a temperature of +10°C to +18°C. In this case, heat is taken from the air passing through the heat exchanger. The vaporized freon heated from it enters the compressor, is compressed, condensing into a liquid, and returned to the evaporator. The cycle repeats endlessly. Such air conditioners are available in two types - local monoblocks and split systems. There are window and floor-standing local monoblocks. In window air conditioners, both heat exchangers (condenser and evaporator) and compressor are located in one compact unit. The refrigeration circuit is sealed. Floor air conditioners, like the previous model, consist of one unit; warm air from the air conditioner condenser is removed outdoor from the room into a specially prepared hole or window (door). During its operation, the noise level is increased, since the compressor is in a single monoblock with a heat exchanger; the unit's productivity is also relatively low, since the exhaust duct, as a rule, is not thermally insulated, and warm air "from the street" freely flows through the window (door). However, both of these types of air conditioners have the lowest cost, are easy to install and maintain, and quite efficiently solve the problems of cooling small rooms, as well as individual zones in large rooms) Simamora et al., 2019) .A more sophisticated variety of local air conditioners are split systems that, unlike monoblocks, consist of two units: internal and external. Its compressor is located in an external unit, so the noise level is much lower than in a monoblock. The outdoor and indoor units are interconnected by a control cable and pipes through which the coolant (freon) circulates. If there are two or more indoor units, then this may be called a multisplit system. Selected observations show that multisplit systems are more effective; they less clutter up facades of buildings. However, the limiter in this case is the permissible length of the heat-conducting hoses (in order to prevent heat loss). Such devices are an effective complement to large installations in the construction of air conditioning systems for large rooms ("cover" local areas).

Geothermal plants

These include the so-called "heat pumps" - machines for transferring thermal energy from a source of low potential thermal energy (with a low temperature) to the user - to a place with a higher temperature. The thermodynamic heat pump is similar in operation to a refrigeration machine (1). However, if in the chiller the condenser performs the discharge of heat into the environment, then the reverse process takes place in the heat pump. The condenser acts as a heat exchanger emitting heat for the consumer, and the evaporator acts as a heat exchanger emitting low potential heat, namely: secondary energy resources and (or) non-traditional renewable energy sources. Comparative indicators of the thermodynamic efficiency of some types of compressors used in modern heat pumps, shown in Table 1, indicate the preference for the use of more powerful machines in air conditioning systems.

Table 1. Efficiency of some types of compressors used in heat pump systems

Power, kW	Compressor type	Efficiency (degree of thermodynamic perfection) h, fractions of units
300–3000	Open centrifugal	0.55-0.75
50-500	Open piston	0.5-0.65
20-50	Semi-sealed	0.45-0.55
2-25	R-22 Sealed	0.35-0.5
0.5-3.0	R-12 Sealed	0.2-0.35
<0.5	Sealed	<0.25

Like a conventional refrigerator, a heat pump consumes energy for its thermodynamic cycle. The conversion coefficient of the heat energy of the heat pump (the ratio of the heat output of the unit to its power consumption) depends on the temperature level in the evaporator and condenser. The temperature control limits using heat pumps are 35-55°C; energy efficiency reaches 70%. Based on the principle of operation, heat pumps are divided into compression and absorption. Compression heat pumps use mechanical energy to change the level of thermal energy (usually lower the temperature), and absorption change one level of thermal energy to another (usually lower). In recent years, semiconductor heat pumps have appeared, built on other physical principles. Depending on the source of heat extraction, heat pumps are subdivided into: geothermal - thermal energy is taken from soil or water; air - heat is extracted from the atmosphere; - using secondary heat (air, water, sewage). The heat pump is a universal air conditioning system - both heating and cooling (condensation); it operates automatically according to a preset program. It is relatively economical: the heating system to receive 1 kWh of thermal energy needs to spend 0.2-0.35 kWh of electric energy. The reserves of increasing the efficiency of air heat pumps include the development of a technology that provides an increase in the heat conversion coefficient (this is due to the low boiling point of the refrigerant in an external "air" evaporator).

Cold storage systems

The cold accumulator is a container filled with a substance with high heat capacity.

There are two types of cold accumulators: artificial cold accumulator - accumulates cold during operation of the refrigeration machine, which transfers heat from the battery to the outside; natural cold accumulator - uses the natural cold accumulated during winter; such an accumulator saves energy spent on accumulating cold, since it uses the natural energy of the cold season, but also requires the cost of thermal insulation of the refrigerant. The use of such systems is advisable in places with an uneven time need for energy (Krainev et al., 2012). In this case, excess power can be used when the required amount of energy exceeds the power of the source. The most common storage tanks are "displacement" and "emptying" types. Their use assumes the spatial distribution of the source and the storage tank. Reducing the geometric dimensions of the battery tanks is achieved by using the heat of phase transition. The most common cold accumulators are those using the heat of the "water - ice" phase transition; at the same time, the most saving technology is the freezing of flake ice, which allows maintaining the temperature of the refrigerant in the range of 5-7°C and saving electricity for this technological operation. Negative in the use of cold accumulators with frozen ice is the kinetics of its melting. The cold accumulated in this way is difficult to fully use when there is a sharp change in demand. This is reflected in the fact that it is not possible to stabilize the temperature level of ice water and thereby guarantee the cooling of liquids and products to the required temperature.

Solar-based systems

In principle, two groups of air conditioners directly using solar radiation can be distinguished - active and passive. The first group uses thermal solar energy, the second converts the solar energy into electrical energy. Currently, part of such equipment provides for the partial use of solar energy. At any time, the split system is ready to switch to backup power from the network. In the future, manufacturers plan to fully adapt equipment for solar power. Such equipment consists of three units: a solar panel, an indoor unit, and an outdoor unit. The indoor unit is responsible for converting sunlight into electrical energy using a special collector. The outdoor unit is a photo panel that absorbs solar energy and converts it into electrical energy. Recently, air conditioners have appeared that directly use solar energy to cool rooms. Such a technique is expected to be improved and become widely used, especially in most insolated areas.

The Krasnodar Territory has some experience in building solar energy-based facilities: in the Seversky district in the 80s of the last century, a group of cottages was built, equipped with photovoltaic solar cells (PVS) manufactured at the Krasnodar Saturn plant on the roof. The houses were arranged so that one of the sides of the gable roof was maximally exposed to sunlight during the day. Electrochemical batteries were used as energy storages, which made it possible to use the stored solar energy in the dark. The operation of these facilities revealed a number of technical problems, including the need for constant care of photovoltaic batteries, battery monitoring and prevention, etc. However, the long-term operation of this settlement contributed to the improvement of the technique and technology for the production of photovoltaic batteries and pushed designers to new technical ideas; variants with rotating PVS panels, design schemes that combined PVS with water heating panels directly from sunlight, were developed. According to experts, the economic effect of the PVS is achieved when solar radiation (energy exposure) on a horizontal surface is 1200-1400 kWh per 1 m^2 (2, p. 116). Practice shows the effectiveness of combining PVS with other sources of energy: hot water, wind, river runoff, biogas, and thereby obtaining a synergistic effect of building air conditioning.

Evaporation air conditioners

The principle of operation of evaporation air conditioners is extremely simple: the design includes an open tank filled with water; a vertical air filter is installed, which consists of several layers of porous gaskets. Water from the tank is fed with a small pump into a spray device mounted above the air filter. From the spraying device, the water, separated into small drops, enters the air filter through which warm air is supplied by the fan. This air, passing through the filter gaskets, captures drops of water and evaporates them very quickly due to their extremely small size. At the same time, the air passing through the filter is not only cooled, but also moistened. The advantages of this type of air conditioner include its low cost, ease of operation, low power consumption, the presence of the function of cleaning and humidifying the air. The disadvantages include the need for periodic replenishment of water supplies consumed by the humidification of the filter gaskets. It should be added that such an air conditioner is ineffective for rooms with high humidity. The combination of an evaporator type plant with a wind generator and a solar battery will make it possible to create a closed-loop air conditioning system (medium-power, but also relatively inexpensive system).

Wind power generators

Air conditioning of buildings can use wind energy, - either by direct ventilation or through passage through heat exchangers, or by conversion to electricity and its use in cooling equipment (machines). Air currents above the earth's surface carry a huge amount of energy, which is currently successfully used in both industrial and small wind turbines for home use. Since the key indicators for household consumers are the reliability and stability of power supply, so many land owners prefer this kind of energy source. There are autonomous wind generators and network plants. The former provide power to consumers remote from central electric networks. The latter can include several tens / hundreds of “windmills” that form a single system and transfer energy to a common network. The power of autonomous units rarely exceeds 75 kW, while the power of network units starts from 100 kW. Depending on the type of construction, wind power generators come with either a vertical axis of rotation or a horizontal axis of rotation. The most common models are with a horizontal axis; such units show high efficiency (about 40%), simple power control and low price. At the same time, they are characterized by a high level of generated noise and vibration. To install a wind turbine with a horizontal rotor, approximately 120 m of free space and a mast with a height of at least 8 m are needed. Wind generators with a vertical axis of rotation have a more compact design and are less susceptible to environmental factors; they operate in light winds and are independent of the direction of air flow. The reduced level of generated noise (up to 30 dB) allows the installation of vertical wind turbines on the roofs of buildings. However, the efficiency of such generators is only 15%, and their cost is about three times higher than of models with a horizontal axis of rotation. According to experts, the construction of wind power plants is considered economically viable at an average annual wind speed of 5-6 m/s. (2, p. 114). Only in this case, the installation of a structure with a wind generating turbine will be economically justified. When considering wind energy through the prism of ecology, it should be noted that rotating wind wheels pose a threat to flying birds. Wind power plants produce noise comparable to the noise of vehicles when driving at a speed of about 70 km/h. The increased noise level not only scares away animals but also causes discomfort to people. Another significant minus of wind turbines for domestic use is the high cost: for example, wind generators of Russian manufacturers with a vertical axis with a rated power of up to 2 kW cost 100-300 thousand rubles, and with a power of 5-7 kW it will be 3-4 times more expensive.

Chiller-fancoil system

The “chiller-fancoil” system is a multi-zonal climatic structure designed to create comfortable conditions inside a large building (Belova, 2003). This is a constantly operating combined-type system that supplies with cold in summer and with heat in winter. Its main elements are a cooler and a heat exchange device. The role of the cooling device is performed by the “chiller” - an external power unit producing and supplying cold through pipelines with water or ethylene glycol circulating through them. In terms of ecology, this distinguishes this air conditioning system from other split systems, where freon is used as a heat carrier. An advantage of such a system is the fact that its work is little affected by the outside temperature, while split systems with freon lose their working capacity even at a temperature of -10°C. The internal heat exchange unit of this air conditioning system is a fan coil. It receives liquid with a low temperature, transfers cold to the air in the room, and returns the heated liquid to the chiller. Fancoils are installed in those rooms where air conditioning is required; each of them works according to an individual program specified by a computer. The fan coil can be installed at a great distance from the chiller - this depends on the power of the pump. Typically, such systems are used in hypermarkets, hopping malls, structures, erected underground, and hotels. In cases where the system is used for heating, heated water is supplied to the fan coil along the second circuit or the system switches to a heating boiler.

Depending on the type of refrigeration cycle, chillers can be conditionally assigned to two classes: “absorption” and “vapor compressor”. In cold weather, the chiller can operate in natural cooling mode, which is called “free cooling"; the coolant cools the outdoor air; theoretically, free cooling can be used at an external temperature of less than 7°C, and practically at 0°C. For automatic operation, the necessary panel temperature is set for a particular room. A specified parameter is maintained through thermostats, which adjust the circulation of coolants - cold and hot. Modern advances in BIM-technologies make it possible to solve the organizational and technological problem of air conditioning of buildings in a single management system for ensuring a given thermal regime - heating and cooling (System Theory Models of Different Types of Heat Pumps; Sekisov, 2019; Sekisov, 2019). Nevertheless, it is advisable to evaluate the effectiveness of the corresponding equipment separately for heating and for cooling rooms. Heat pumps, split systems and other, both cooling and heating equipment are also desirable to compare separately for each of these functions (cooling; heating). In general terms, as a universal indicator of the comparative economic efficiency of the equipment (machinery, unit) for cooling (or heating) the premises, it seems possible to use the cost of providing a given thermal regime per 1 m^3 of premises per year - as the sum of current operating costs and depreciation (Table 2).

The assumptions made in the calculations in relation to the regions of the South of Russia: Number of days of equipment operation per year – 150 days; Number of equipment operation hours per day – 12 days; The cost of one kilowatt-hour of electricity in Russia – 5 rubles. As follows from the data of a comparative assessment of the technical and economic indicators of equipment for air conditioning of large and small rooms in the Krasnodar Territory (Table 2), the main part of the cost of an integrated equipment is depreciation, for simple equipment, current costs. The study shows that the choice of equipment for air conditioning of buildings, along with economic indicators, is significantly affected by the following factors: design features of the building and the composition of the conditioned rooms (with different airspace); the influence of air conditioners on the architectural appearance of the building and the design of the premises; the level of comfort created by air conditioners (noise, vibration, wind, zoning of room temperatures); qualification requirements for air conditioner service staff (start-up, adjustment, repairs); ease of use; the degree of negative impact of air conditioners on the environment (environmental friendliness), etc. In different buildings, the degree of influence of the above factors can vary significantly; however, the main indicator is still the cost. Therefore, it seems appropriate to develop appropriate correction (weight) coefficients within the boundaries of their integrative adjustment for cost (calculated according to Table 2) of no more than 1/3. To determine the size of the weight (correction) coefficients for the cost of air-conditioning of a unit volume of a room by different types of air conditioners, for example, use the Delphi method, according to which invited experts, by repeated questioning, come to the conclusion about the values of such coefficients.

Table 2. Comparative technical and economic indicators of cooling equipment based on 150 days of work per year (based on passport and experimental data)

Nº	Equipment	Cost installation incl., thousand rubles	Lifetime, years	Supplied airspace, m^3	General costs per year, thousand rubles			
					depreciation	Operational costs	total	including per m^3 of premises
1	12K BTU EQUATION Split system, art. MSR1-12 HRN1-QC2 manufacturer “GD Midea Air Conditioning Equipment Co. Ltd”	30	5	100	6	18	24	0.24
2	Geothermal heat pumps Eco Touch DS 50027 Ai	550	25	100	30	90	120	1.2
3	Ice accumulator IVPL-5/97	900	20	300	80	200	280	0.93
4	Powertraveller PTL-FLS040 solar cell	120	10	100	12	30	42	0.42

5	MASTER-BCF Evaporation air conditioner	120	8	250	15	32	47	0.19
6	Hailer FD242AMEAA Compression air conditioner	90	5	100	10	25	35	0.35
7	Exmork S wind power generator	150	10	200	20	50	70	0.35
8	WH20M Chiller-fancoil	50	5	120	20	25	35	0.29

When combining simple (inexpensive) and integrated (expensive) equipment in a single air conditioning system, our comparative assessment method will allow us to select the most preferred synergetic option from the standpoint of economics and technology. As the study shows, the efficiency of combined-type equipment (combined cooling and heating functions) in the room cooling mode differs from the indicators in the heating mode. Therefore, it seems advisable to conduct appropriate comparisons of technical and economic indicators separately (for cooling and heating) and on this basis to evaluate complex functions using an expert method.

CONCLUSION

Based on the foregoing, our findings can be as follows:

1. With the development of technical civilization and the expansion of economic and technological resources, the provision of a favorable indoor microclimate is becoming more and more actualized; in turn, the solution of this problem is associated with the neutralization of side effects and polluting emissions into the environment, the implementation of environmental improvement measures. This requires a reproductive approach to addressing such a permanently developing organizational and technological issue.
2. A favorable microclimate can be achieved in retail and office, sports, entertainment and other large rooms by improving air conditioning systems, built on the basis of the integrated use of technological equipment operating in cooling, heating and ventilation conditions. Thanks to scientific and technological progress, air conditioning technologies are constantly developing; the efficiency of the respective units and machines increases; the range of energy sources used in air conditioning is expanding.
3. A comparative technical and economic assessment of a number of building air conditioning systems operating on various physicochemical principles, carried out in terms of the identified scientific and applied problem, made it possible to formulate the following conclusions for managerial practice:

- Conventional air conditioners are easy to use and cheap, but load heavily the power supply system of the building (room); it is advisable to use them in the form of information-related complexes, the functioning of which is regulated using information technology, ACS;
- Geothermal piles cost much, but also have high energy potential, both for cooling and heating the building;

- It is advisable to use systems with accumulation of cold in buildings located in regions of low temperatures, as well as highlands (northern slope of the Caucasus Mountains, Krasnaya Polyana); they have a high cost, but also a long service life;
- Solar power-based systems are the most “environmentally friendly”, but have a high cost and are difficult to maintain; it can be expected that under the influence of technological progress the cost of the corresponding equipment will decrease; their installation is advisable in the most lighted areas (Anapa, Armavir, Crimea) as the mass production increases, such systems in the future can become commensurate in investment with traditional air conditioning systems;
- Wind turbines have an increased cost and a long payback period, as well as high reliability; for sanitary reasons, their installation is undesirable near residential areas; their location is appropriate in places of traditional wind corridors (Armavir, Novorossiysk, Anapa);
- The chiller-fancoil system is high efficient and easy to install; despite the high cost, such equipment allows the complex to solve the problem of conditioning large and corresponding small rooms all year round in the mode specified by the ACS program.

The presence of a significant variety of air conditioning systems provides for their combined use in buildings and premises and increased technical and economic efficiency due to this. For example, it seems possible to recommend combinations of wind generators, solar panels and geothermal piles in buildings located in the foothills of the Caucasus; such combinations can provide a significant synergistic effect (both technological and economic).

REFERENCES

1. Balian S.V. (1973) Technical thermodynamics and heat engines. - L., Mechanical Engineering, - 141 p.
2. Beliaev Iu.M. (2003) Alternative energy strategy. - Rostov-on-Don: Publishing House of North Caucasus Scientific Center of Higher School.
3. Belova E.M. (2003) Air conditioning systems with chillers and fan coils. - Moscow, Euroclimate, - 400 p.
4. Vasiliev G.P., Khrustachev L.V., Rozin A.G., Abuev I.M. et al. (2001) Guidelines for the use of heat pumps using secondary and non-traditional renewable energy sources // Government of Moscow. Moskomarkhitektura, State Unitary Enterprise “NIATs”.
5. Viitovich O.I., & Teleshov V.G. (2010) New sources of electricity. Scientific notes of the Transbaikal State University. Series: Physics, Mathematics, Engineering, Technology.
6. Krainev A.A. et al. (2012) Efficiency of using natural cold accumulators as part of a refrigeration unit // Scientific journal of National Research University of Information Technology, Mechanics, and Optics; series "Refrigeration and Air Conditioning", 2.
7. Krasnodar Territory in figures. (2018). Stat. Col./ Krasnodarstat - Krasnodar, 2019. - 302 p.
8. Our common future. Report of the United Nations International Commission on Environment and Development (UNCED); trans. from English by S.A. Evteev, R.A. Perelet. - M.: Publishing group "Progress", (1989). - 376 p.

9. Ovchinnikov V.N., & Zhuk E.S. (2009) The imperatives of economic security in the regional development sustainability system: monograph. Rostov-on-Don: Publishing house of SFedU, - 176 p.
10. Plotnikov K.V., Alifanova A.I., & Seminenko A.S. (2014) Air conditioning of buildings through solar energy. Modern high technology, 7-2.
11. Popov A.R. (2011) Resource management of the resort and recreation sphere: organization and financing: monograph / A.R. Popov. - M.: University Book, - 176 p.
12. Agenda 21. UN Document A/CONF.151/26/Rev.1 (Vol.1). [Electronic resource]. – Access mode: http://www.scwpkaz.kepter.kz/centXXI.html.
13. Russian Statistical Yearbook. 2017: Stat. col./ Rosstat. M., 2017. - 686 p.
14. System Theory Models of Different Types of Heat Pumps // WSEAS Conference in Portoroz, Slovenia. 2007. (Eng.) Saati T., Kerne K. Analytical Planning. Organization of systems. / T. Saati, K. Kern; trans. from English - M.: Radio and communications, 1991. - 224 p.
15. Sidorov V.A. (2011) Theory of economic systems: methodology, principles of analysis, and basic concepts. Krasnodar: Research Institute of Economics of the Southern Federal District, - 425 p.
16. Stockholm Declaration (Extract) (adopted in Stockholm on June 16, 1972 at the UN Conference on the Human Environment) (electronic resource).
17. Fateev E.M. (1948) Wind turbines and wind power plants. - M.: State Publishing House of Agricultural Literature, - 544 p.
18. Haken G. Secrets of nature. Synergetics: the doctrine of interaction / Herman Haken; trans. from German by A.R. Logunov. - Moscow-Izhevsk: Institute for Computer Research, 2003. - 320 p.
19. Isard W. Methods of regional analysis: an introduction to the science of regions. M.: "Progress", 1966.
20. Sekisov A.N. Problems of organizing and conducting engineering surveys in construction. IOP Conference Series: Materials Science and Engineering 698 (2019) 055016, Russian Federation (Access mode: https://iopscience.iop.org/article/10.1088/1757-899X/698/5/055016/pdf, doi:10.1088/1757-899X/698/5/055016).
21. Sekisov A.N. Improving the efficiency of the organization of construction production based on the use of BIM-technologies. IOP Conference Series: Materials Science and Engineering 698 (2019) 066005, Russian Federation (Access mode: https://iopscience.iop.org/article/10.1088/1757-899X/698/6/066005/pdf, doi:10.1088/1757-899X/698/6/066005).
22. Ivanov L.A. Establishment of technological startups based on research and development (interview with Polad Malkin, researcher and developer Ph.D., professor, serial technology entrepreneur, CEO of «StartUpLab»). Nanotehnologii v stroitel’stve = Nanotechnologies in Construction. 2019, Vol. 11, no. 2, pp. 207–216. DOI: 10.15828/2075-8545-2019-11-2-207-216.
23. Ivanov L.A., Muminova S.R. New technical solutions in nanotechnology. Part 1. Nanotehnologii v stroitel’stve = Nanotechnologies in Construction. 2016, Vol. 8, no. 2, pp. 52–70. DOI: 10.15828/2075-8545-2016-8-2-52-70. (In Russian).
24. Volkov, AN; Leonova, AN; Karpanina, EN; Gura, DA Energy performance and energy saving of life-support systems in educational institutions // Journal of fundamental and applied sciences, 2017 v 9 pp.: 931-944 SI. DOI: 10.4314/jfas.v9i2s.69.
25. Karpanina, E. N.; Leonova, A. N.; Sirotina, O. V. Gura D. A. Analytical Aspects of Special Purpose Metal Structures Design R EVISTA PUBLICANDO, 2018, T 5, V 14, pp. 735-743.

26. Mikheev, G. V.; Sekisov, A. N.; Gura, Dmitry A. Economic and marketing adaptation of business processes in the modern russian real estate market // Revista inclusiones 2019, Vol. 6, pp. 119-124.
27. Stepanov, R. R.; Sekisov, A. N.; Gura, D. A. "Quick Method" of Map Limit Exact Position Determination by Vertical Planning of Areas // HELIX, 2019, T 9, V 1, pp 4744-4752.
28. Sekisov, A. N.; Varvarkina, A. V.; Gura, D. A. Pit design taking into account water level reduction using the software package midas gts nx // IIOAB journal, 2019, T 10, p 93-100.
29. Merkibayev, T., Seisenbayeva, Z., Bekkozhanova, G., Koblanova, A., & Alikhankyzy, G. (2018). Oppositions in the conceptual and linguistic category of time. Opción, 34(85-2), 116-148.
30. Simamora, R. E., Saragih, S., & Hasratuddin (2019). Improving Students' Mathematical Problem-Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context. International Electronic Journal of Mathematics Education, 14(1), 61-72. https://doi.org/10.12973/iejme/3966.
31. Soleymani, M., Nezhadali, L. H., & Mohammad, B. Z. (2014). Effective indicators in Bank customer satisfaction, UCT Journal of Social Sciences and Humanities Research, 2(1): 1-7.
32. Baykalova, E. D., Artyna, M. K., Dorzhu, N. S., Ochur, T. K., & Mongush, D. S. (2018). Morphological interference in the process of mastering English speech in conditions of interaction of Tuvan, Russian and English as a foreign language. *Opción*, *34*(85-2), 35-60.
33. Barreto, D. M., & Alturas, B. (2018). Quality-in-use app evaluation: case of a recruitment app for Portuguese SMEs. *Quality-in-use app evaluation: case of a recruitment app for Portuguese SMEs*, (1).