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ENERGY SAVING MEANS IN URBAN DEVELOPMENT

Energy saving could become one of the main issues of economic and social development in the coming decades. This is reflected in the growth of prices for energy carriers. Increasing non-rational use of energy carriers becomes ever more evident at the background of growing harm it brings to the environment. Therefore, people, enterprises and society in general should be concerned with economical energy consumption and efficient use of natural resources.

Keywords: *energy sources, energy saving, solar panels, architecture, wind generators.*

Current importance of the problem. At the turn of the millennium the energy saving problem has become one of the most important general human problems. Rational and economical use of natural resources, reduction of harmful emissions to the atmosphere as well as efficient consumption of electrical and heat energy are becoming ever more important in the society. Energy saving is not only crucial, but also the cheapest way to satisfy the needs of economics in energy carriers because specific capital expenditures in energy saving are much lower than investments into the increase of energy deposits development and energy production.

In 2016 "Ukrgasvydobutok" (a joint-stock company, engaged in gas deposits development) set the task of producing 20 billion cubic meters of gas till 2020. In 2015 it was extracted only 14.5 billion m^3 of domestic gas. In 2014 Ukraine consumed 38.7 billion m^3 of gas, from which 14,5 billion m^3 were purchased in RF and 5,1 billion m^3 – in EU, while in 2015 33.7 billion m^3 was consumed and 6,1 billion m^3 was purchased in RF, 10,3 billion m^3 – in EU.

Currently, Ukraine is trying to do completely without Russian gas [1].

Theoretically, there is also huge potential for the use of shale gas in Ukraine. According to the latest data of the USA Energy Information Administration, its deposits could be 3.6 trillion cubic meters. This consumption volume would be enough for Ukraine for 70 years. However, development of deposits of shale and other unconventional gas is at the initial stage in Ukraine [2].

In 2015 25 power engineering objects worked without "green tariff". They produced electricity from renewable sources with installed capacity of 28,4 MW, and 15 objects – from secondary energy sources with total power of 585,9 MW, In the previous years the same objects produced 1486.5 mln. kWh.

Besides, as it was reported by "Ukrenergo", in accordance with the issued standard specifications, in 2015 at the power engineering objects, where electricity is generated from the renewables, capacities with the total power of 2401 KW were connected, of which:

1178 MW – at the windpower engineering objects;

1198 МВт – at the objects of solar power engineering;

5 MW – at the small hydropower objects;

20MW – at the objects of bioenergetics.

At present, there are 885 objects with the installed power of 1558.6 MW in Ukraine, which generate heat energy from the renewable, in particular:

the objects of solar power engineering – 0.8 MW;

heat pumps – 5.5 MW;

the objects of bioenergetics – 1552.3 MW.

In the previous year said objects generated 2173 thousand Gkal, which is 90 % more than in the previous years. As far as heat energy is concerned:

Solar energy objects – 0.87 thousand Gkal;

Heat pumps – 6.4 thousand Gkal;

The bioenergetics objects 165.8 thousand Gkal.

Heat power generation by the objects of renewable energetic has made it possible to replace 253 mln. m^3 of natural gas [3]. This allows making a conclusion that the use of alternative energy sources in urban economics is rather efficient.

Main material presentation. Taking into account global nature of the problem, in many countries (including Ukraine) normative literature on the problems of energy saving in urban development and architecture has started to be developed.

On July 1, 2013 Amendment № 1 to the State Standard Norms B.2.6-31:2006 «Thermal insulation of buildings», elaborated by the state enterprise "State Research Institute of Building Structures" (SRIBS), came into force.

Essential changes, introduced into the State Standard Norms «Thermal insulation of buildings", set increased requirements to the minimum permissible value of the heat transfer resistance of fencing constructions for buildings and structures.

Table 1

Main changes in SCN B.2.6-31:2006 «Thermal Insulation of Buildings" [4, 5]

№	Before changes were introduced	With changes
Temperature zones of Ukraine:		
1	The territory of Ukraine is divided into four temperature zones. The first zone includes Kiev, Zhitomir, Vinnytsia, Rivne, Khmelnytsky, Ternopil, Cherkasy, Sumy, Kharkiv, Luhansk, Donetsk, Chernihiv regions. The second zone includes Zaporizhia, Dniepropetrovsk, Lviv, Lutsk, Ivano-Frankivsk, Chernivtsi regions. The third zone includes Odessa, Mykolaiv, Uzhgorod regions and the fourth zone is Crimea	The territory of Ukraine is divided into two zones. The first temperature zone includes the major part of the territory of Ukraine: Vinnytsia, Volyn, Dniepropetrovsk, Donetsk, Zhytomyr, Ivano-Frankivsk, Kyiv, Kirovohrad, Luhansk, Lviv, Poltava, Rivne, Sumy, Ternopil, Kharkiv, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv regions. Crimea, Transcarpathian, Zaporizhia, Mykolaiv, Odesa, Kherson regions belong to the second temperature zone.
External walls:		
2	1) For the first temperature zone of Ukraine R_{qmin} = 2.5 – 2.8 m^2K/W; 2) For the second zone R_{qmin} = 2.0 – 2.5 m^2K/W.	1) For the first temperature zone R_{qmin} = 3.3 m^2K/W; 2) For the second zone R_{qmin} = 2.8 m^2K/W .
Heat insulation layer for facade structures:		
3	1) For the first temperature zone – 100 – 120 mm; 2) For the second temperature zone the adopted thickness of the insulation layer for facade structures is 50 - 80 mm.	1) Thickness of the layer is no less than 120 – 150 mm 2) For the second temperature zone the adopted thickness of the insulation layer for facade structures should be no less than 100 mm.
Sloping roofs:		
4	1) For the first temperature zone of Ukraine the value was 3.3 m^2K/W; 2) For the second zone this index was 2.6 m^2K/W. For a sloping roof in the first temperature zone the adopted thickness of the insulation layer is 150 – 200 mm. For the second temperature zone the thickness of insulation layer should be 100 – 120 mm.	1) For the first temperature zone of Ukraine - 4.95 m^2K/W; 2) For the second zone – 4.9 m^2K/W. For a sloping roof in the first temperature zone the adopted thickness of the insulation layer should be 250 – 300 mm. For the second temperature zone the thickness of insulation layer should be 150 – 200 mm.

Analysis of the regulatory documents and amendments to them has allowed making a conclusion that in modern urban construction engineering and architecture the following new energy-efficient technologies should be maximally used:

unconventional (alternative) electric energy sources: solar geothermal plants, wind plants, etc.

energy efficient building envelope that provides minimal heat losses and heat transfer;

energy-saving equipment of the building – heat pump, energy saving electric devices, energy-efficient lighting;

ACMS – automatic system of building control and management, etc.

Modern energy-saving buildings of the early twenty first century differ significantly from the buildings of the same purpose, but designed and built at the end of the twentieth century, not only by their architectural and engineering solutions, but also by their design [6]. Let us consider examples of architectural solutions of modern energy-saving buildings where unconventional urban energy sources are used: solar energy, energy of soil, wind, noise, geothermal energy, bioenergy, hydropower.

Solar energy is absorbed by solar plants (solar panels, collectors, etc.), which are used for additional heating of buildings, water heating in buildings and pools, heating of buildings, electric energy generation (for electric appliances), street lighting, creation of solar stations, etc.

In modern city development and architecture solar panels are not only placed separately, but are also mounted into the roofs and facades of the buildings.

SMIT company released a system of solar panels – Solar Ivy, that consists of a great number of leaves (photovoltaic plates) mimicking shoots of ivy. The system clings easily to the walls of buildings, taking the shape of the surface of any relief. Photocells are slightly turned by wind, catching sun rays in different planes, which increases their overall performance. Shape and type of leaves could be chosen in accordance with the building design. Such Sunny Ivy is already used on the facades of two complexes: Orson Spencer Hall in the USA and Montreal Biosphere Environment Museum in Canada [6].

Soil energy is also widely used. Collectors are installed in soil, which makes it possible receive additional electric energy as well as to create geothermal districts and station [6].

Ukraine has certain prospects for the development of geothermal power engineering. This is determined by thermo-geological features of the relief as well as special characteristics of geothermal resources of the country. At present, however, research, geological exploration and practical efforts in Ukraine are focused only on geothermal resources represented by thermal waters. According to various estimates, cost-efficient resource o f thermal waters in Ukraine is up to 8.4 mln. tons of oil equivalent per year.

According to the forecasts of the National Action Plans for Renewable Energy of EU countries, electrical application of geothermal energy should nearly double its production in 2020, i.e. it will be 10.9 TW/year for installed power of 1613 MW. To achieve this goal, not only countries that produce geothermal energy should essentially increase the installed powers (in Italy to 920MW, in Germany to 298 MW, in France to 80 MW and in Portugal to 75 MW), but also other countries should develop their own sectors, e. g. Greece (120 MW), Hungary (57 MW), Spain (50 MW) and Slovakia (4 MW). In most cases such results could be achieved due to application of the double-cycle installations [7].

Wind power engineering is an alternative branch of power engineering specializing in conversion of wind energy into electric energy.

Process of the Ukrainian wind power engineering development started as early as 1996. The Institute of Renewable Energy of the National Academy of Sciences of Ukraine has compiled a map of the wind energy potential of our country. The most attractive regions for wind energy use are the coasts of the Black and Azov seas, mountain areas of the temporarily occupied Crimea, the territory of Carpathian Mountains, Odessa, Kherson and Mykolaiv regions.

According to the report of the World Wind Energy Association, the total power of the wind energy in the world reaches 336 327 MW. In the middle of 2014 total installed capacity of the wind energy was about 4% of the global electric energy needs.

Five traditional wind power countries are China, the USA, Germany, Spain and India, which together represent 72 % of the global wind energy capacities. As far as new added capacities are concerned, the share of Big Five has increased from 57 % to 62 % [8].

The operating principle of the wind generator is as follows: the energy of air masses turns the turbine blades and converts into electric energy, which could be used for lighting homes, streets and other objects. It is preferable to install wind turbines on skyscrapers as wind power is stronger on them.

An example of successful location of air turbine is an egg-shaped skyscraper «Envision Green Hotel», designed by architectural bureau Michael Rosenthal Associates (Miami, USA), The building is a wind tower with urban eco-hotel. Its facades are covered with photovoltaic structures, which enable electricity use and accumulation without interference with central electric network of the city. Wind turbines provide heating of water boilers for water supply and heating of the building. Along the perimeter of the hotel special reservoirs are located for collection and further filtration of rainwater, which will be used for swimming pools.

Italian designers Francesco Colarossi, Giovanna Saracino and Louisa Saracino reconstructed an old worn-out bridge with the length of 20 km between the cities of Bagnara and Scilla (Fig.1) [9]. They proposed an original design where big wind generators, filing free space between the columns, and solar panels on the surface of the road are used as artistic décor elements. Electricity is rather expensive in this part of the country and so the requirements to the project were as follows: beautiful and original design, solution of the strategic problem of the bridge functionality, cost savings during bridge construction and obtaining electricity for at least 15.000 houses located in the district. [6].

Fig. 1. Solar Wind – Bridge with solar panels and wind generators in Calabria (Italy)

Both day and night modern metropolis is permeated with noise vibrations, the energy of which is spent on air fluctuations without any useful application. Today scientists believe that clatter of railroad wheels, the hum of highways, sounds of police sirens, construction noise, feet stamping and human voices – all of this could be made useful for people, if forced to generate electric energy [10]. An example of noise energy application is Soundscraper, a skyscraper covered with noise-sensitive “eye-lashes” which convert city noise into the clean energy source. Such buildings could be built near main highways, railway junctions and other sources of maximal noise pollution in the city. On each skyscraper there are about 84.000 electrically active “eye-lashes,” each of them converting sound vibrations into kinetic energy and then into electricity. One skyscraper could produce 150MW of energy, which is about 10 % of that required for lighting the entire city of Los Angeles. Several such skyscrapers could satisfy the electric energy needs for a metropolis. In addition to obtaining clean energy, carbon emissions are reduced as well as dependence on fossil fuels [6].

Bioenergetics is a branch of power engineering based on the use of biofuel produced from biomass.

Biomass is a biologically renewable substance of organic origin undergoing biological decomposition (agriculture waste – of crops and livestock, of forestry and technologically-related industries as well as organic component of industrial and domestic waste)

For Ukraine bioenergetics is one of the strategic directions in the development of the sector of renewable energy sources, taking into account strong dependence of the country on the imported energy carriers, especially natural gas, and high potential of biomass available for electric energy production. Unfortunately, bioenergetics development rate in Ukraine is far behind that of European countries. Today the share of biomass in gross final energy consumption is 1.78 %. In Ukraine about 2 million tons of fuel equivalent of various types of biomass are used annually. The wood accounts for the highest percentage of the use of economically viable potential – 80%, while for other types of biomass (excluding sunflower husk) this indicator is much lower. Energy potential of the straw of crops and oilseed rape is realized the least actively (at the level of 1 %).

More than 50 million tons of crops are harvested annually in Ukraine. So straw and plant waste is available in great quantities as agricultural by-product. Annual technically-achievable energy potential of solid biomass in Ukraine reaches 18 million tons of oil equivalent and its use would make it possible to save about 22 billion cubic meters of natural gas annually. The highest potential of solid biomass is concentrated in Poltava, Dniepropetrovsk, Vinnytsia and Kirovograd regions, reaching more than 1.0 million tons of oil equivalent per year. To determine the output of straw and plant residues, a waste coefficient is used – the ratio of the yield of straw or plant residues to the yield of crops. According to different estimates, from each ton of grain 1.5 – 2 tons of straw or plant residues could be obtained. 50 – 60 % of the straw of wheat, barley, rye are used for cattle maintenance and soil fertilization while stems of corn and sunflower are left on the fields after harvest. Therefore, there is a sufficient energy potential of straw and plant residues in Ukraine. After harvesting a considerable part of straw is pressed into bales, briquettes, pellets and used for heating. Over 500 thousand tons of sunflower husk is burnt at 14 oil extraction enterprises and 120 thousand tons of it is granulated. About 16 % of the total area of Ukraine is covered with forests. 16 – 17 million tons of commercial timber is harvested annually; the waste of wood processing reaches 10 million cubic meters. Currently, about 70 % of waste wood in the form of sawdust, wood chips, pellets and briquettes is used as biofuel. [11].

Hydropower is a branch of the renewable energy sector specializing in the use of water flow energy [12].

Ukraine has a considerable potential of using the resources of small rivers (mainly in western regions), which constitutes almost 28 % of the total hydraulic potential of all rivers in Ukraine.

Through the use of the potential of small rivers a significant economy of fuel and energy resources could be achieved in Ukraine. Besides, small hydropower development would promote decentralization of the general energy system, which could solve a number of energy supply problems in remote and inaccessible rural areas.

In 2015 there were 102 small hydropower stations in Ukraine with the total installed capacity of about 80 MW, which generated 251 million KWh. of electric energy.

It should be also noted that in 1960s there were more than 1.000 small hydroelectric stations in Ukraine. Some of them are possible to be recovered.

Over 800 GW of hydropower capacities with annual production volume of about 7.080 TW·h are in service today. According to the estimates of International Energy Agency, 5 % of the global hydropower potential is realized through small hydroelectric stations. Technical potential of small hydropower is estimated to be at the level of 150 – 200 GW. In 2020 organic fuel savings through the use of small hydropower potential in the total energy production are predicted to be 69 and 99 tons of equivalent fuel according to pessimistic and optimistic variants of the global power engineering development respectively.

Conclusions

Energy saving is the only right way to survive in the future. Unfortunately, the basic production assets of our country have not been renovated for almost 40 – 50 years. During this period scientific and technical level of the rest of the world went far ahead while we continue to consume three times more energy carriers for manufacturing domestic products than other countries. Their level could be achieved only through the use of new energy-saving technologies and radical reconstruction of engineering networks of the cities, insulation of the houses (walls, foundations, ceilings, attics, basements) as well as through maximal economy of energy resources.

REFRENCES

1. Центр досліджень енергетики [Електронний ресурс] / Україна на узбіччі газового ринку Європи, або що нас очікує після 2020 року? // Режим доступу: http://eircenter.com/ua-analiitika/ukrayina-na-uzbichchi-gazovogo-rinku-yevropi-abo-shho-nas-ochikuye-pislya-2020-rokuo
2. Lb.ua. Вибране для всіх [Електронний ресурс] / Компанія "Укргазвидобування" підрахувала, на скільки років вистачить її запасів газу // Режим доступу: http://ukr.lb.ua/news/2014/04/02/261689_ukrgazdobicha_podschitala.html.
3. Держенергоефективності України [Електронний ресурс] / Сучасний стан // Режим доступу: http://saee.gov.ua/uk/activity/vidnovlyuvana-enerhetyka/suchasny-stan.
4. ДБН В.2.6-31:2006 «Теплова ізоляція будівель» [Електронний ресурс] / Зміна № 1 до ДБН В.2.6-31:2006 «Теплова ізоляція будівель» // Режим доступу: http://teplodim.info/upload/blocks/izmeneniya_k_dbn-v-2-6-31-2006_pdf_1435062541.pdf.
5. ДБН В.2.6-31:2006 «Теплова ізоляція будівель» [Електронний ресурс] / «Теплова ізоляція будівель» // Режим доступу: https://docs.google.com/file/d/0B6RpAgaD6t-iTHlFczMzSnVpTFk/edit.
6. Витвицкая Е. В. Современная энергосберегающая архитектура / Е. В. Витвицкая, Д. О. Бондаренко // Теория градостроительства. – 2013. – Вип. 13. – С. 42 – 48.
7. Держенергоефективності України [Електронний ресурс] / Геотермальна енергія // Режим доступу: http://saee.gov.ua/ae/geoenergy.
8. Держенергоефективності України [Електронний ресурс] / Вітроенергетика // Режим доступу: http://saee.gov.ua/uk/ae/windenergy.
9. Solar Wind - міст з вітрогенераторами і сонячними батареями [Електронний ресурс] / Solar Wind – мост с ветрогенераторами и солнечными батареями // Режим доступу: http://energycraft.ru/nauchnie-dostijeniya/solar-windmost-s-vetrogeneratorami-i-solnechnymi-batarejami.html.
10. Новости Украины [Електронний ресурс] / Чиста енергія з міського шуму // Режим доступу: http://ykrnews.com/nauka-i-tehnologii/chista-energ-ja-z-m-skogo-shumu.html.
11. Держенергоефективності України [Електронний ресурс] / Біоенергетика // Режим доступу: http://saee.gov.ua/uk/ae/bioenergy.
12. Вікіпедія [Електронний ресурс] / Гідроенергетика // Режим доступу: https://uk.wikipedia.org/wiki/%D0%93%D1%96%D0%B4%D1%80%D0%BE%D0%B5%D0%BD%D0%B5%D1%80%D0%B3%D0%B5%D1%82%D0%B8%D0%BA%D0%B0.
13. Держенергоефективності України [Електронний ресурс] / Гідроенергетика // Режим доступу: http://saee.gov.ua/uk/ae/hydroenergy.

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